Indian Standard
CODE OF PRACTICE FOR
USE OF STEEL TUBES IN GENERAL
BUILDING CONSTRUCTION

(First Revision)

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

Gr 5

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Indian Standard

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BUILDING CONSTRUCTION

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0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 5 January 1968, after the draft finalized by the Structural Engineering Sectional Committee had been approved by the Structural and Metals Division Council and the Civil Engineering Division Council.

0.2 This standard is one of a series of Indian Standards being published under the 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 sections; 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.

0.3 This standard was first published in 1957. Since its publication four amendments have been issued. In this revision, the following modifications have been incorporated:

   a) Amendments No. 1, 2, 3 and 4 have been incorporated.

   b) References to latest Indian Standards have been given.

   c) The standard has been completely metricized.

   d) Minimum wall thicknesses of tubes have been reduced based on evidence obtained as a result of recent experimental and other investigations, subject to certain minimum maintenance conditions being observed.

0.4 This code is complementary to IS : 800-1962*. The use of tubular steel in structural work would result in considerable savings, particularly in the case of roof trusses, latticed girders and compression members

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*Code of practice for use of structural steel in general building construction (*revised*).

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in general. It would, therefore, be recognized that large scale use of tubular steel in structural work is of considerable importance in the interest of steel economy.

0.5 In order to popularize the use of tubular construction, it is also proposed to compile design handbooks, typical designs and other aids to design which, when they become available, would be of assistance to those not previously experienced in tubular design and construction.

0.6 Grades YSt 22, YSt 25 and YSt 32 of steel tubes mentioned in this standard are covered in IS : 1161-1963*.

0.7 In the formulation of this code, assistance has been derived from B.S. 449 : 1959 ' Use of structural steel in building ', issued by the British Standards Institution.

0.8 This standard contains clause **7.8** which calls for agreement between the purchaser and the manufacturer.

0.9 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 : 2-1962†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This code deals with the use of structural steel tubes in general building construction and is complementary to IS : 800-1962‡. Provisions which are of special application to construction using steel tubes are included in this code.

2. GENERAL

2.1 Unless otherwise specified in this code, provisions of IS : 800-1962‡ with regard to terminology, plans and drawings, loads and general considerations for the design, fabrication and erection are applicable in the use of steel tubes in general building construction.

3. MATERIALS

3.1 Steel Tubes -- Steel tubes used in building construction shall be hot finished tubes conforming to the requirements specified in IS : 1161-1963*

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*Specification for steel tubes for structural purposes (*revised*) (*Second revision* in 1968).

†Rules for rounding off numerical values (*revised*).

‡Code of practice for use of structural steel in general building construction (*revised*).

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

NOTE — Grade ERW YSt 22 tubes specified in IS : 1161-1963* with a carbon content less than 0·30 percent, may be considered as hot finished for the purposes of **3.1.1**.

3.2 Electrodes — The electrodes used for welding steel tubes shall conform to the requirements of IS : 814-1963†.

4. WIND PRESSURE

4.1 In calculating the effective wind pressure on exposed circular tube members of a structure, the effective area shall be taken as 0·6 times the projected area of the member. (Refer to IS : 875-1964‡ for values of wind pressure.)

5. PERMISSIBLE STRESSES

5.0 The provision as regards permissible stresses on the net or gross cross-sectional areas, as the case may be, in **5.1** to **5.8** of this code, is applicable to steel tubes for which the minus tolerance on the weight per unit length of tube is not more than 4 percent. If on the steel tubes used the minus tolerances on the weight per unit length are larger than 4 percent, a corresponding reduction in cross-sectional areas is required to be made in applying the permissible stresses.

5.1 Axial Stress in Tension — The direct stress in axial tension on the net cross-sectional area of tubes shall not exceed the values of F_t given in Table 1.

TABLE 1 PERMISSIBLE AXIAL STRESS IN TENSION

GRADE	F_t
(1)	(2)
	kgf/cm²
YSt 22	1 250
YSt 25	1 500
YSt 32	1 900

5.2 Axial Stress in Compression — The direct stress in compression on the cross-sectional area of axially loaded steel tubes shall not exceed the values of F_c given in Table 2 in which l/r is equal to the effective length of the member divided by the radius of gyration.

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*Specification for steel tubes for structural purposes (*revised*) (*Second revision* in 1968).

†Specification for covered electrodes for metal arc welding of mild steel (*revised*) (*Third* revision in 1970).

‡Code of practice for structural safety of buildings: Loading standards (*revised*).

TABLE 2   PERMISSIBLE AXIAL STRESS IN COMPRESSION

(*Clause* 5.2)

l/r	F_c		
	GRADE YSt 22 kgf/cm²	GRADE YSt 25 kgf/cm²	GRADE YSt 32 kgf/cm²
(1)	(2)	(3)	(4)
0	1 250	1 500	1 900
10	1 217	1 448	1 821
20	1 175	1 400	1 750
30	1 131	1 352	1 679
40	1 088	1 303	1 610
50	1 046	1 255	1 539
60	1 002	1 207	1 468
70	970	1 155	1 375
80	929	1 088	1 263
90	876	1 003	1 128
100	814	910	989
110	745	813	869
120	674	721	758
130	603	638	665
140	540	565	584
150	490	503	517
160	432	443	450
170	381	392	398
180	339	348	353
190	304	311	315
200	271	278	280
210	243	249	250
220	219	225	227
230	198	204	205
240	180	185	187
250	162	167	167
300	106	106	106
350	71	71	72

NOTE 1 — Intermediate values may be obtained by linear interpolation.

NOTE 2 — The formula, from which these values have been derived, is given in Appendix A.

5.3 Bending Stresses — In tubes, the tensile bending stress and the compressive bending stress in the extreme fibres shall not exceed the values of F_b given in Table 3.

TABLE 3 PERMISSIBLE BENDING STRESS IN EXTREME FIBRES IN TENSION AND COMPRESSION

(*Clause* 5.3)

GRADE	F_b
(1)	(2)
	kgf/cm²
YSt 22	1 400
YSt 25	1 655
YSt 32	2 050

5.4 Shear Stress — The maximum shear stress in a tube calculated by dividing the total shear by an area equal to half the net cross-sectional area of the tube shall not exceed the values of F_s given in Table 4. The net cross-sectional area shall be derived by deducting areas of all holes from the gross cross-sectional area.

TABLE 4 PERMISSIBLE MAXIMUM SHEAR STRESS

GRADE	F_s
(1)	(2)
	kgf/cm²
YSt 22	900
YSt 25	1 100
YSt 32	1 350

5.5 Bearing Stress — The average bearing stress on the net projected area of contact shall not exceed the values of F_p given in Table 5.

TABLE 5 PERMISSIBLE MAXIMUM BEARING STRESS

GRADE	F_p
(1)	(2)
	kgf/cm²
YSt 22	1 700
YSt 25	1 900
YSt 32	2 500

5.6 Combined Bending and Axial Stresses — Members subject to both bending and axial stresses shall be so proportioned that the quantity:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \text{ does not exceed unity,}$$

where

f_a = calculated axial stress, that is, axial load divided by appropriate area of member;

F_a = permissible stress in member for axial load;

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f_b = calculated bending stress in the extreme fibre; and

F_b = permissible bending stress in the extreme fibre.

5.6.1 When bending occurs about both axes of the member, f_b shall be taken as:

$$f_b = \sqrt{(f_{bx})^2 + (f_{by})^2}$$

where f_{bx} and f_{by} are the two calculated unit fibre stresses.

5.7 Permissible Stresses in Welds

5.7.1 *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 centre of its thickness. In a butt weld the allowable tensile, compressive and shear stresses shall not exceed the stresses respectively permissible in YSt 25 tubes or in the parent metal, whichever is less.

5.7.2 *Fillet Welds and Fillet-Butt Welds* — [see **6.7.3.2**(c)] — 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 of the weld. A method of calculating the length of the weld is given in Appendix B. In a fillet weld or in a fillet-butt weld, the permissible stress shall not exceed the shear stress permissible in YSt 25 tubes or in the parent metal, whichever is less.

5.7.2.1 *Combined stresses in a fillet or 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 **5.7.2**.

5.8 Increase of Stresses

5.8.1 Increase of permissible stresses for occasional loads may be allowed according to the provisions of IS : 800-1962*

5.8.2 Irrespective of any permissible increase of allowable stress, the equivalent stress, f_e due to co-existent bending and shear stresses shall not exceed the values given in Table 6.

TABLE 6	MAXIMUM ALLOWABLE EQUIVALENT STRESS
GRADE	F_e
(1)	(2)
	kgf/cm^2
YSt 22	1 900
YSt 25	2 285
YSt 32	2 900

*Code of practice for use of structu ral steel in general building construction (*revised*).

5.8.2.1 The equivalent stress f_e is obtained from the following formula:

$$f_e = \sqrt{f_b^2 + 3f_s^2}$$

where

f_b = the calculated bending stresses (compression or tension) at the point under consideration, and

f_s = the calculated actual co-existent shear stress at the point under consideration.

6. DESIGN

6.1 General — The principles and procedures of design contained in Section IV of IS : 800-1962* generally applicable to structures using steel tubes.

6.2 Basis of Design — The basic methods of design for structures using steel tubes are generally similar to those for other types of elastic structures. Welding is generally adopted for connections in tubular steel construction. Since the connections in such cases give rigid joints, it is desirable to design such welded structures taking into consideration the actual condition 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.

6.2.1 Structural frameworks using steel tubes including those with welded connections may, however, be designed on a simple design basis, comparable with that given in IS : 800-1962*. In such cases, secondary stresses may be neglected in the design of trussed girders or roof trusses, except where the axes of the members do not meet at a point. Where there is such eccentricity, the effects of the eccentricity should also be considered.

6.2.2 *Curved Members and Bends* — 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.

6.3 Minimum Thickness of Metals

6.3.1 For tubular steelwork painted with one priming coat of red oxidezinc chromate paint after fabrication and periodically painted and maintained regularly, wall thickness of tubes used for construction exposed to weather shall be not less than 4 mm, and for construction not exposed to weather it shall be not less than 3·2 mm; where structures are not readily accessible for maintenance, the minimum thickness shall be 5 mm.

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*Code of practice for use of structural steel in general building construction (*revised*).

6.3.2 Steel tubes used for construction exposed to weather shall be not less than 3·2 mm thick and for construction not exposed to weather shall be not less than 2·6 mm thick, provided in each case the tube is applied with:

    a) one coat of zinc primer conforming to IS : 104-1962* followed by a coat of paint conforming to IS : 2074-1962†, and

    b) two coats of paint conforming to IS : 123-1962‡.

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

6.4 Compression Members

6.4.1 *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 7, where L is the actual length of the strut, measured between the centres 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 7 EFFECTIVE LENGTH OF COMPRESSION MEMBERS

Type	Effective Length
Effectively held in position and restrained in direction at both ends	$0·67\ L$
Effectively held in position at both ends and restrained in direction at one end	$0·85\ L$
Effectively held in position at both ends but not restrained in direction	L
Effectively held in position and restrained in direction at one end, and at the other end effectively restrained in direction but not held in position	L
Effectively held in position and restrained in direction at one end, and at the other end partially restrained in direction but not held in position	$1·5\ L$
Effectively held in position and restrained in direction at one end but not held in position or restrained in direction at the other end	$2·0\ L$

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*Specification for ready mixed paint, brushing, zinc chrome, priming, for use on aluminium and light alloys (*revised*).

†Specification for ready mixed paint, red oxide-zinc chrome, priming.

‡Specification for ready mixed paint, brushing finishing, semi-gloss, for general purposes, to Indian Standard colours No. 445 Venetian red, No 448 Deep Indian red, No. 451 Chocolate, No. 446 Red oxide, No. 449 Light purple brown, No. 473 Gulf red and red oxide (colour unspecified) (*revised*).

6.4.1.1 *Members of trusses* — In the case of bolted, riveted 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 centres of intersections, depending on the degree of end restraint provided.

6.4.2 *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 following values:

Type of Member	*l/r*
a) Carrying loads resulting from dead loads and superimposed loads	180
b) 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
c) Normally acting as a tie in a roof truss but subject to possible reversal of stress resulting from the action of wind	350

6.4.3 *Eccentricity of Beam Reactions on Columns* — For the purpose of determining the eccentricity of beam reactions or similar loads on a column in simple design procedure, the load shall be assumed to be applied as given in Table 8.

TABLE 8   ASSUMED ECCENTRICITY OF LOADS IN COLUMNS

SL No.	TYPE OF CONNECTION	ASSUMED POINT OF APPLICATION
(1)	(2)	(3)
i)	Stiffened bracket	Mid-point of stiffened seating
ii)	Unstiffened bracket	Outer face of vertical leg of bracket
iii)	Cleats on tube	Outside of tube
iv)	Cap:	
	a) Beams 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 roof truss bearings
	c) Roof truss bearings	No eccentricity for simple bearing without connections capable of developing an appreciable moment

6.4.4 *Joints*

6.4.4.1 Where in joints in compression members, the ends of the members are faced for bearing over their whole area, the welding and joining material shall be sufficient to retain the members accurately in

place and to resist all forces other than direct compression, including those arising during transit, unloading and erection.

6.4.4.2 Where such members are not faced for complete bearing, the welding and joining material shall be sufficient to transmit all the forces to which the joint is subjected.

6.4.4.3 Wherever possible, joints shall be proportioned and arranged so that gravity axes of the members and the joints are in line, so as to avoid eccentricity.

6.4.5 *Column Bases*

6.4.5.1 *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 base plate.

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 and 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 is subjected.

6.4.5.2 *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 resist all forces other than direct compression including those arising during transit, unloading and erection. (For the design of slab bases *see* 19.8.2 of IS : 800-1962*.)

6.4.6 *Latticing and Battening of Compression Members*

6.4.6.1 Latticing and battening where necessary shall be proportioned according to the appropriate clauses of IS : 800-1962*.

6.4.6.2 Whenever possible, lattices and battens shall be so arranged that their gravity axes are in line with gravity axes of the main members to which they are connected.

6.5 Design of Beams

6.5.1 The tensile and compressive stresses in the extreme fibres of tubes in bending shall not exceed the values prescribed under 5.3.

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*Code of practice for use of structural steel in general building construction (*revised*).

6.5.2 The maximum shear stress in tubes in flexure, calculated by dividing the total shear by an area equal to half to the net cross-sectional area of the tube, shall not exceed the values prescribed under **5.4**.

6.5.3 *Stiffeners for Tubes* — Where the tubular steel beam rests on abutment or other supporting member, it shall be provided with a shoe adequate to transmit the load to the abutment and to stiffen the end of the tube.

6.5.3.1 Where a concentrated load is applied to a tubular 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 concentrated loads is particularly marked if either the diameter of connected member or the connected length of a gusset or the like is small in relation to the diameter of the tubular member to which it is connected.

6.5.4 *Limiting Deflections of Beams* — The deflection of a member shall not be such as to impair the strength, efficiency or appearance of the structure or lead to damage to fittings and finishings. Generally, the maximum deflection should not exceed 1/325 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 $\dfrac{31\,500\ D}{l}$ kgf/cm^2, where D is the outer diameter of the tube in cm and l is the effective length of the beam in cm.

6.5.4.1 *Purlins*

a) The requirements under **6.5.4** regarding limiting deflection may be waived in the design of simple tubular purlins provided that the following requirements are satisfied:

NATURE OF END FIXING	MINIMUM VALUE OF SECTION MODULUS			MINIMUM OUTSIDE DIAMETER FOR GRADES YSt 22, YSt 25 AND YSt 32 cm
	Grade YSt 22 cm^3	Grade YSt 25 cm^3	Grade YSt 32 cm^3	
Simply supported	$WL/11\,200$	$WL/13\,230$	$WL/16\,400$	$L/40$
Effectively continuous	$WL/16\,800$	$WL/19\,840$	$WL/24\,600$	$L/70$

where

W = the total distributed load in kg on the purlins arising from dead load and snow but excluding wind, and

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   L = the distance in cm between the centres of the steel princi-
      pals or other supports.

b) A purlin shall be considered as effectively continuous at any
   intermediate point of support if it is actually continuous over
   that 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.

6.6 Separators and Diaphragms — When loads are required to be
carried from one tube to another or are required to be distributed
between tubes, diaphragms which may be tubular, designed with suffi-
cient stiffness to distribute the load between the tubes, shall be used.

6.7 Connections

   6.7.1 *General* — Connections in structures using steel tubes shall be
provided by welding, riveting or bolting. Wherever possible, connec-
tions between tubes shall be made directly tube to tube without gusset
plates and other attachments. Ends of tubes may be flattened as specified
in **7.7** or otherwise formed to provide for welded, riveted or bolted
connections.

   6.7.2 *Eccentricity of Members* — Tubes meeting at a point shall,
wherever practicable, have their gravity axes meeting at a point so as
to avoid eccentricity.

   6.7.2.1 *Eccentricity of connections* — Wherever practicable, the
centre of resistance of the connection shall lie on the line of action of
the load so as to avoid eccentricity moment of the connection.

   6.7.3 *Welded Connections*

   6.7.3.1 A weld connecting two tubes end to end shall be full pene-
tration butt weld. The effective throat thickness of the weld shall be
taken as the thickness of the thinner part joined.

   6.7.3.2 A weld connecting the end of one tube (branch tube) to
the surface of another tube (main tube) with their axes at an angle of
not less than 30° 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 in 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 diameters of the
tubes 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 type (b) should be used where the diameter of the
branch tube is less than one-third of the diameter of the main tube, and

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type (c) should be used where the diameter of the branch tube is equal to or greater than one-third of the diameter of the main tube.

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 o fillet-butt weld.

6.7.3.3 *Angle between tubes* — A weld connecting the end of one tube to the surface of another, with the axes of the tubes intersecting at an angle of less than 30°, shall be permitted only if adequate efficiency of the junction has been demonstrated.

6.7.3.4 *Connections where the axes of the two tubes do not intersect* — A weld connecting the end of one tube to the surface of another where the axes of the two tubes do not intersect, shall be subject to the provisions under **5.7, 6.7.3.2** and **6.7.3.3**, provided that no part of the curve of intersection of the eccentric tube with the main tube lies outside the curve of intersection of the corresponding largest permissible non-eccentric tube with the main tube (*see* Fig. 1).

6.7.3.5 *Connections of tubes with flattened ends* — Where the end of the branch tube is flattened to an elliptical shape **5.7, 6.7.3.2** to **6.7.3.4** shall apply, and for the application of **6.7.3.2** and **6.7.3.4** the diameter of the flattened tube shall be measured in a plane perpendicular to the axis of the main tube.

7. FABRICATION

7.1 General

7.1.1 The general provisions in Section V of IS : 800-1962* are also applicable to the fabrication of structures using steel tubes. Where welding is adopted, reference to appropriate provision of IS : 820- † (*see* Note) and IS : 816-1956‡ shall be made.

NOTE — Until this standard is published, provisions for welding in tubular construction shall be as agreed to between the concerned parties.

7.1.2 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.

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*Code of pract: e for use of structural steel in general building construction (*revised*).
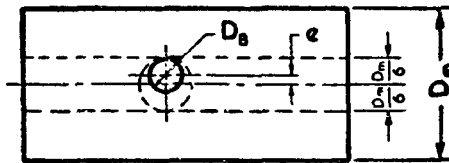
†Code of practice for use of welding in tubular construction (*under preparation*).

‡Code of practice for use of metal are welding for general construction in mild steel. (Since revised).
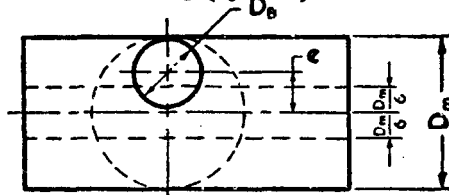
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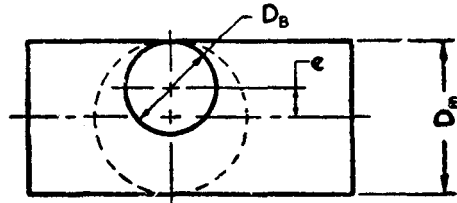
TYPE I Butt Weld

$$e_{max} = \tfrac{1}{2}(D_m - D_B)$$

TYPE II Fillet Weld

$$e_{max} = \tfrac{1}{2}\left(\tfrac{D_m}{3} - D_B\right)$$

TYPE III Fillet – Butt Weld

$$e_{max} = \tfrac{1}{2}\left(D_m - D_B\right)$$

$$e_{min} = \tfrac{1}{2}\left(\tfrac{D_m}{3} - D_B\right)$$

NOTE — Dotted circle shows curve of intersection of largest permissible non-eccentric tube with main. Solid circle indicates curve of intersection of eccentric branch.

FIG. 1   DIAGRAM SHOWING LIMITS OF ECCENTRICITY FOR TUBE CONNECTIONS

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

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7.3 Bolting

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

7.3.2 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.

7.4 Cut Edges — Edges should be dressed to a neat and workmanlike finish and be free from distortion where parts are to be in contact metal-to-metal.

7.5 Caps and Bases for Columns — The ends of all tubes for columns, transmitting loads through the ends, should be true and square to the axis of the tube and should be provided with a cap or base accurately fitted to the end of the tube and screwed, welded or shrunk on.

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

7.6 Sealing of Tubes — When the end of a tube is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed.

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

7.7 Flattened Ends — In tubular construction, the ends of tubes may be flattened or otherwise formed to provide for welded, riveted or bolted connections provided that the methods adopted for such flattening do not injure the material. The change of section shall be gradual.

7.8 Oiling and Painting — If not galvanized, all tubes 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.

7.9 Marking, Shop Erection and Packing — Appropriate provisions of IS : 800-1962* shall apply.

8. INSPECTION AND TESTING

8.1 Appropriate provisions of IS : 800-1962* shall apply.

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*Code of practice for use of structural steel in general building construction (*revised*).

APPENDIX A

(*Table* 2, *Note* 2)

FORMULA FOR DERIVING PERMISSIBLE AXIAL STRESS IN COMPRESSION

A-1. For values of l/r less than 60, the value of F_c shall not exceed that obtained from linear interpolation between the value of F_c for $l/r = 60$ as found under **A-2** and a value of $0.6 f_y$ for $l/r = 0$.

A-2. For values of l/r from 60 to 150, the average axial stress on the cross-sectional area of a strut or other compression member shall not exceed the value of F_c obtained by the formula given below:

$$F_c = \frac{f_y/m}{1 + 0.15 \sec \left(l/r \sqrt{\frac{mF_c}{4E}} \right) \text{radians}}$$

where

F_c = the permissible average axial compressive stress;

f_y = the guaranteed minimum yield stress;

m = factor of safety taken as 1·67;

l/r = slenderness ratio, 'l' being the effective length and 'r' radius of gyration; and

E = modulus of elasticity 2 047 000 kgf/cm².

A-3. For values of l/r greater than 150, the average axial stress on the cross-sectional area of a strut or other compression member shall not exceed the value $F_c \left(1.2 - \dfrac{1}{750r} \right)$ where F_c is obtained as given under **A-2.**

APPENDIX B

(*Clause* 5.7.2)

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

B-1. The length of the curve of intersection (*see* Fig. 2) may be taken as:
$$P = a + b + 3\sqrt{a^2 + b^2}$$

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where

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

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

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

$d = $ outside diameter of branch;

$\theta = $ angle between branch and main; and

$D = $ outside diameter of main.

NOTE — Alternatively, $b = \frac{D}{4}\phi$, where ϕ is measured in radians and $\sin\frac{\phi}{2} = \frac{d}{D}$.
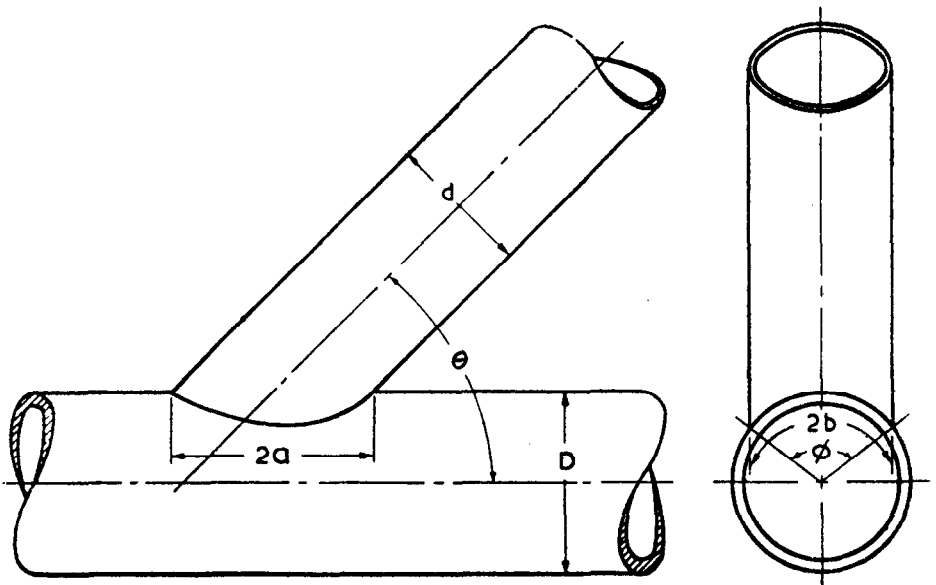

FIG. 2 LENGTH OF THE CURVE OF INTERSECTION OF A TUBE
WITH ANOTHER TUBE OR WITH A FLAT PLATE

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