

Tubular Steel Structure.

Tubular steel structures are used in truss members, scaffolding of building, stadium, exhibition halls, transmission towers.

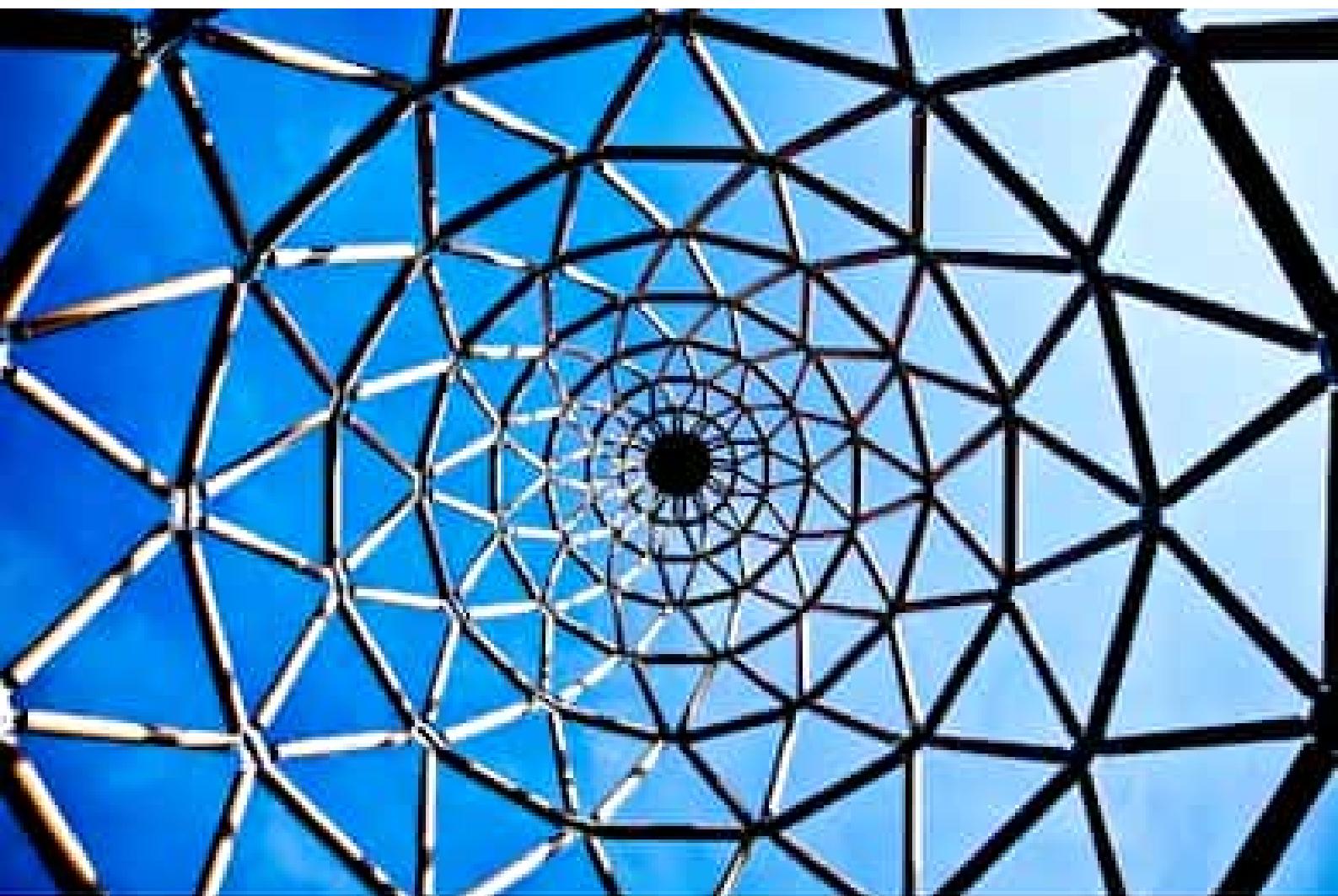
Codes Required: IS 1161.1998, IS 806.1968.

Advantages:-

- (1) They have small self weights. Also because of direct connections, gusset plates are eliminated further reducing dead load.
of these structures
- (2) Torsional strength is more than any other rolled section.
- (3) For the same load, the surface area of a tube is about 60 to 70% of that for other rolled sections. Because of less area economy is achieved in maintenance, painting & fire proofing.
- (4) Due to smooth finished surface, dirt & moisture do not collect over the surface, reducing the possibility of corrosion.
- (5) Due to the change in load with the floor levels can be accommodated by varying the tube thickness & the external tube dimension may be maintained.
- (6) The internal hollow space of tubular columns may be used for carrying drain pipes, wires, cable etc. Also these spaces may



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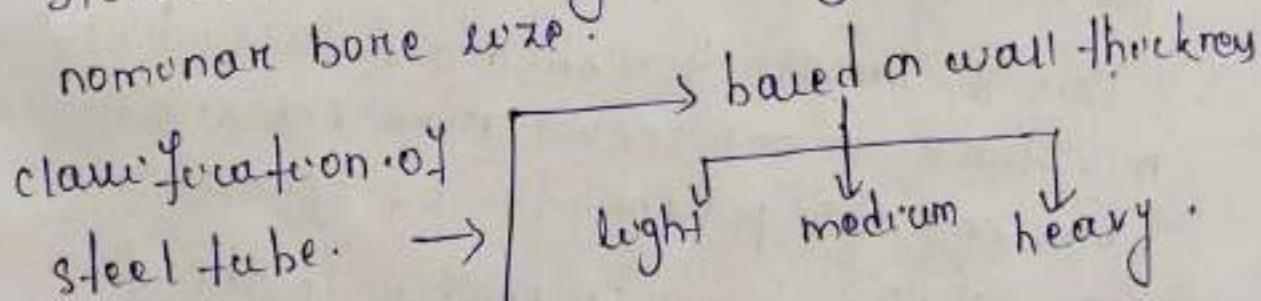
be filled with concrete to increase the load carrying capacity & to improve fire resistance.

Disadvantage:

- (1) They pose difficulty in connection among themselves or to any plate element due to their shape problems.
- (2) Bolting & riveting on those sections are not convenient.
- (3) Their light weight sometimes become responsible for the structural instability.
- (4) Highly skilled man power & special welding techniques are required for their connection.

Designation of steel tubes:

Steel tubes are designated by their nominal bore size.



$\gamma_s \rightarrow$ Yield stress
 $t \rightarrow$ tube.

22, 25, 32 are
in kgf/cm^2 .

\downarrow	\downarrow	\downarrow
\downarrow	\downarrow	\downarrow
\downarrow	\downarrow	\downarrow

YSt 22 YSt 25 YSt 32.
(YSt 210) (YSt 240) (YSt 310)
Mpa Mpa Mpa

Note
 $1 \text{ MPa} = 1 \text{ N/mm}^2 = 0.102 \text{ kg}/\text{mm}^2$

Tensile properties of steel tubes for structural purposes :-

(Table-2, clause -11.2.1., IS code 1161).

Grade	tensile strength (Mn/m)	Yield stress (Mn).
Yu 210	330	210
Yu 240	410	240
Yu 310	450	310

* The standard sizes of tubular sections, their mass/weight, relevant geometrical properties are given in table 10.1 of part 1 of IS : 1161 : 1998.

Behaviour of tubular Sections :

(1) Compression member :-

depends upon slenderness ratio.

$$\text{Slenderness ratio } \lambda = \frac{\text{L}_{\text{eff}}}{r_e}$$

L_{eff} → depends on end conditions.
 $= kL$ (Table-1, cl 2.6.4, IS 808)

r_e = we will get from section properties given in IS 1161 : 1998.

maximum limit of slenderness ratio:

type of member.

$$\lambda = \frac{l}{r}$$

- (a) carrying loads resulting from Dead Load & superimposed load. 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

Axial stress in compression: The direct stress in compression on the cross-sectional area of axially loaded steel tubes shall not exceed the value of f_c given in table - Q of IS 806:1968.

Permissible axial stress in compression (f_c) .
(table 2, clause 5.2)
(IS 806)

the cross-sectional area of axially loaded steel tubes shall not exceed the values of F_c given in Table 2 in which I/r is equal to the effective length of the inmember divided by the radius of gyration.

*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).

IS : 806 - 1968

TABLE 2 PERMISSIBLE AXIAL STRESS IN COMPRESSION
(Clause 5.2)

I/r	F_c		
	GRADE YSt 22 kgf/cm ²	GRADE YSt 25 kgf/cm ²	GRADE YSt 32 kgf/cm ²
(1)	(2)	(3)	(4)
0	1 250	1 500	1 900
10	1 217	1 448	1 821
20	1 176	1 400	1 760
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	1 156	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	685
140	540	565	564
150	480	503	517
160	432	443	450
170	381	392	396
180	339	348	358
190	304	311	316
200	271	278	280
210	243	249	250
220	219	225	227
230	198	204	203
240	180	186	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.

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

Table 1 Sizes and Properties of Steel Tubes for Structural Purposes

(Clauses 3.1, 6.1, 6.1.1 and 6.1.2)

Nominal Diameter	Outside Diameter	Class	Thickness	Weight	Area of Cross Section	Internal Volume	Surface		Moment of Inertia	Modulus of Section	Radius of Gyration	Square of Radius of Gyration
							External	Internal				
mm (1)	mm (2)		mm (3)	kg/m (4)	cm ² (5)	cm ³ /m (6)			cm ⁴ (10)	cm ³ (11)	cm (12)	cm ² (13)
15	21.3	Light	2.0	0.947	1.21	235			543	0.57	0.54	0.69
		Medium	2.6	1.21	1.53	203	669	506	0.69	0.64	0.66	0.44
		Heavy	3.2	1.44	1.82	174		468	0.73	0.70	0.55	0.42
20	26.9	Light	2.3	1.38	1.78	399			700	1.36	1.01	0.87
		Medium	2.6	1.56	1.98	370	845	681	1.48	1.10	0.86	0.74
		Heavy	3.2	1.87	2.38	330		644	1.70	1.26	0.84	0.71
25	33.7	Light	2.6	1.98	2.34	638			895	3.09	1.83	1.10
		Medium	3.2	2.41	3.06	585	1 059	857	3.61	2.14	1.08	1.17
		Heavy	4.0	2.93	3.73	518		807	4.19	2.48	1.05	1.11
32	42.4	Light	2.6	2.54	3.25	1 086			1 168	6.47	3.05	1.41
		Medium	3.2	3.10	3.94	1 017	1 332	1 130	7.62	3.59	1.39	1.93
		Heavy	4.0	3.79	4.82	929		1 080	8.99	4.24	1.36	1.86
40	48.3	Light	2.9	3.23	4.13	1 418			1 335	10.70	4.43	1.61
		Medium	3.2	3.56	4.53	1 378	1 517	1 316	11.59	4.80	1.59	2.54
		Heavy	4.0	4.37	5.56	1 275		1 265	13.77	5.70	1.57	2.47
50	60.1	Light	2.9	4.08	5.21	2 132			1 711	21.59	7.16	2.03
		Medium	3.6	5.03	6.41	2 213		1 667	25.88	8.58	2.09	4.02
		Heavy	4.5	6.19	7.88	2 066		1 611	30.90	10.2	1.98	3.92
65	76.1	Light	3.2	5.71	7.32	3 814			2 189	48.79	12.82	2.58
		Medium	3.6	6.42	8.20	3 727	2 191	2 163	54.92	14.20	2.57	6.60
		Heavy	4.3	7.93	10.1	3 534		2 107	61.12	17.1	2.54	6.43
80	88.9	Light	3.2	6.72	8.61	5 343			2 591	79.23	17.82	3.03
		Medium	4.0	8.36	10.7	5 138	2 793	2 540	96.36	21.68	3.00	9.00
		Heavy	4.8	9.90	12.7	4 930		2 490	112.52	23.31	2.98	8.88
90	101.6	Light	3.6	8.70	11.1	6 993			2 964	133.27	20.23	3.47
		Medium	4.0	9.63	12.3	6 877	3 192	2 939	146.32	28.80	3.45	11.91
		Heavy	4.8	11.5	14.6	6 644		2 889	171.44	33.73	3.43	11.76

100	114.3	Light	3.6	9.75	12.5	9 084			3 363	192.03	33.60	3.92	15.36	
		Medium	4.5	12.2	15.5	8 704	3 591	3 306	234.3	41.0	3.89	15.10		
		Heavy	5.4	14.5	18.5	8 409		3 250	274.5	48.0	3.85	14.86		
110	127.0	Light	4.5	13.6	17.3	10 930			3 205	325.3	51.2	4.33	18.78	
		Medium	4.8	14.5	18.4	10 819	3 990	3 686	344.58	54.27	4.32	18.69		
		Heavy	5.4	16.2	20.0	10 599		3 649	382.0	60.2	4.30	18.32		
125	139.7	Light	4.5	15.0	19.1	13 410			4 104	437.2	62.6	4.78	22.87	
		Medium	4.8	15.9	20.3	13 287	4 389	4 085	463.44	66.35	4.77	22.76		
		Heavy	5.4	17.9	22.8	13 063		4 047	514.5	73.7	4.75	22.58		
135	152.4	Light	4.5	16.4	20.9	16 142			4 503	572.2	75.1	5.23	27.37	
		Medium	4.8	17.5	22.2	16 008	4 788	4 484	606.92	79.65	5.22	27.25		
		Heavy	5.4	19.6	23.0	15 740		4 446	674.3	88.3	5.20	27.03		
150	165.1	Light	4.5	17.8	22.7	19 128			4 902	732.6	88.7	5.68	32.27	
		Medium	4.8	18.9	24.2	18 981	5 187	4 883	777.32	94.16	5.67	32.14		
		Heavy	5.4	21.3	27.1	18 690		4 843	894.7	103.0	5.65	31.92		
160	168.3	Light	4.5	18.2	23.1	19 921			5 062	777.2	92.4	5.70	33.56	
		Medium	4.8	19.4	24.7	19 771	5 287	4 983	824.78	98.01	5.78	33.42		
		Heavy 1	5.4	21.7	27.6	19 473		4 946	917.7	109.0	5.76	33.21		
		Heavy 2	6.3	23.2	32.0	19 030		4 889	1 053	125.0	5.73	32.85		
175	193.7	Light	4.8	22.4	28.5	26 606			5 781	1 271.71	131.31	6.68	44.63	
		Medium	5.4	25.1	32.0	26 260	6 085	5 743	1 417	146	6.66	44.36		
		Heavy	5.9	27.3	34.8	25 974		5 712	1 535.2	158.65	6.64	41.11		
200	219.1	Light	4.8	25.4	32.3	34 454			6 578	1 856.51	169.47	7.58	57.45	
		Medium	5.6	29.5	37.5	33 930	6 883	6 528	2 141	195	7.55	57.02		
		Heavy	5.9	31.0	39.5	33 734		6 509	2 247	205	7.54	56.80		
225	244.5	Heavy	5.9	34.7	44.2	42 507			7 681	7 307	3 149	258	8.44	71.21
250	273.0	Heavy	5.9	38.9	49.5	53 557			8 578	8 202	4 412	323	9.45	89.30
300	323.9	Heavy	6.3	49.3	62.8	76 073	10 177	9 775	7 992	493	11.2	125.64		
350	355.6	Heavy	8.0	68.0	87.3	90 533	11 173	10 663	13 111	737	12.3	151.29		

Q-1 A tubular steel column of 4.8m Length is hinged at both ends. It has nominal dva of 225mm & of Yut 25 grade. Determine the safe load carrying capacity of column.

Solution:-

Step-1 Given data's section properties:-

- thickness = 5.9mm, weight = 34.7 kg/m.

Area of cross section = 44.2 cm^2

radius of gyration (cm) = 8.44 cm.

nominal dva = 225mm. Yut = 25

outside dva = 244.5mm.

Length of column @ (L) = 4.8m.

as both the ends are hinged, effective length
 $(L_e) = kL$
 $= 1 \times L = 4.8 \text{ m.}$

(Table-7, IS 806).

Step(2)

calculation of slenderness ratio:-

$$\lambda = \frac{kL}{r} \quad \lambda = \frac{4.8 \times 10^3}{8.44 \times 10} = 56.87 \times 180 \quad (\text{CL-6.42})$$

(IS 806)
(cm)

Step-3 permissible stress in compression.
 (Yut = 25) $\frac{F_c}{S} \text{ (kg/cm}^2)$ (from Table-2)
 (IS 806)

$$\lambda_1 = 50 \rightarrow 1255$$

$$\lambda = 56.87 \rightarrow ?$$

$$\lambda_2 = 60 \rightarrow 1207$$

by interpolating we will get value of permissible compressive stress.

$$\frac{56.87 - 60}{50 - 60} \times (1255 - 1207) + 1207$$

$\therefore f_c = 1222.024 \text{ kg/cm}^2$

$$= \frac{1222.024 \text{ kg/cm}^2}{1000} = \frac{1222.024 \text{ N/cm}^2}{1000} = 1.2220.24 \text{ N/cm}^2$$

safe load carrying capacity :-

$$A \times f_c$$

$$P = 44.2 \times 1.2220.24$$

$$= 5401.35 \text{ N}$$

$$= 540134 \text{ N} \approx 540.134 \text{ kN}$$

Assignment:-

Q-2) A tubular column consists of IS 1161 grade 32 steel. The column is hinged at both the ends. The outside diameter of tube is 219.1mm. The weight of 1m length of tube is 310N. The length of column is 9.5m. Determine the safe load carrying capacity of column.

Minimum thickness of material:

For tubes painted with one prime coat of red
oxides then periodically painted, the
thickness should not be less than:

(c) For construction exposed to weather ->

38mm

(ii) For construction not exposed to weather \rightarrow 29 mm

3.2 mm.

(v) For members not readily accessible
For maintenance = 5mm.

for maintenance = 5mm.

For tubes painted with one coat of zinc
primer followed by two coats of paint,
the thickness should not be less than:

(i) For construction exposed to weather = 3.2 mm

(iv) For construction not exposed to weather = 2.6 mm.

Permeable area at sea on Tenison (table-1) is 806

<u>Grade</u>	<u>F_t (kgf/cm²)</u>
Yd 22	1250
Yt 25	1500
Yt 32	1900

Yat 32	1900	per 95806 (Table-3, 4, 5)	
Grade	Permissible bending stress (F _b) kN/m ²	Permissible shear stress (F _s)	Permissible maximum bearing stress (F _P)

Grade	permissible stresses or per IS 806 (Table-3, 4b5)		permissible maximum bearing stress (FP)
	Permissible bending stress (N/mm ²)	Permissible shear stress (N/mm ²)	
YU 22	1400	900	1700
YU 25	1655	1100	1900
YU 32	2050	1350	2500

Connection:- cl-5.7.2, appendix B, 15806).

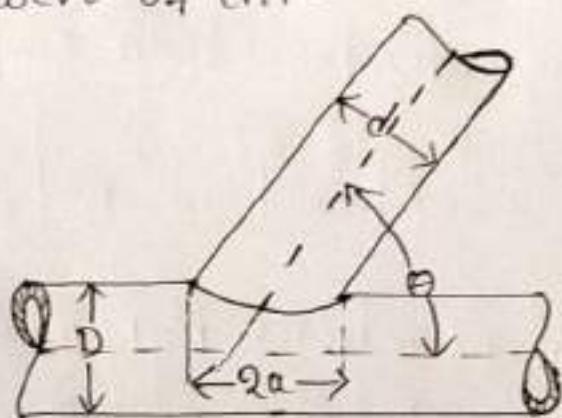
Determination of the length of the curve of intersection of a tube with another tube or with a flat plate:-

The Length of the curve of intersection may be taken as:-

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

$$a = \frac{d}{2} \cos \theta$$

$$b = \frac{d}{3} \times \frac{3 - (d/D)^2}{2 - (d/D)^2}$$



↳ for intersection with a tube.

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

d = outside diameter of branch tube

θ = angle between branch & main tube

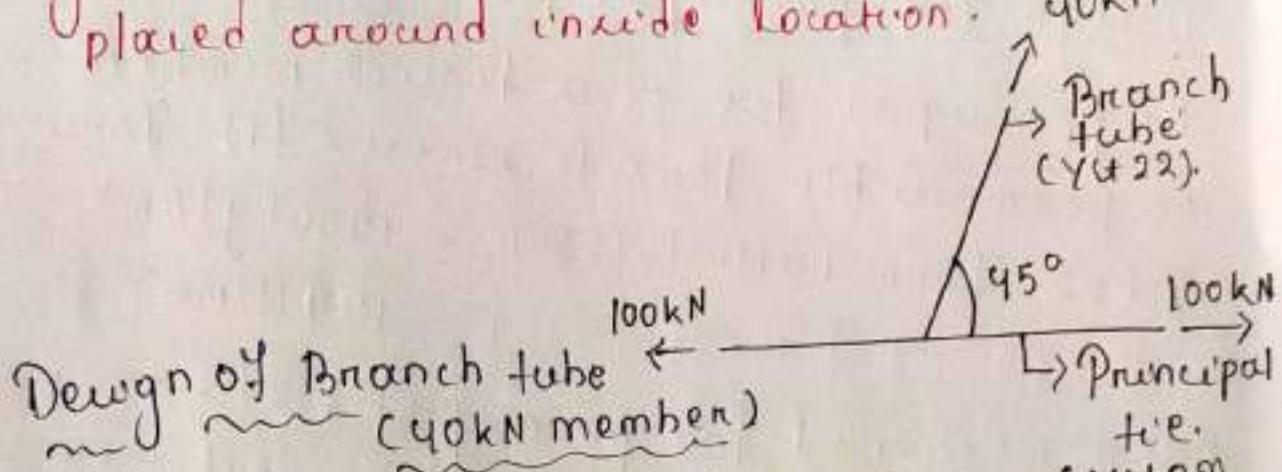
D = outside diameter of main tube.

Permissible stresses on welds: (cl: 5.7)

* For butt weld, the allowable tensile, compressive & shear stresses shall not exceed the stresses respectively permissible in Yt25 tubes or on the parent metal, whichever is less.

* In a fillet weld or in a fillet butt weld, the permissible stress shall not exceed the shear stress permissible in Yt25 tubes or on the parent metal, whichever is less.

Q A tension member carrying a force of 40kN meets the principal tie of tubular frame at an angle of 45° . If the force in principal tie is 100kN, Design the members & welded joint between the two tube. Use Y屈22 grade of steel. Assume these member are placed around inside location.



As the branch tube is a tension member, so permissible tensile on main tube.

then $\frac{F}{A} \text{ for Y屈22 } (\frac{F}{t}) = 1250 \text{ kgf/cm}^2$ (Table-1)
 $= 125 \text{ N/mm}^2$ (IS806)

→ Load coming on the branch tube (P) = $40 \text{ kN} = 40 \times 10^3 \text{ N}$.

$$\rightarrow \text{Area of the branch tube} = \frac{P}{\frac{F}{t}} = \frac{40 \times 10^3}{125}$$

$$= 320 \text{ mm}^2$$

Let choose cross-sectional area = 373 mm^2

so let us provide steel tube of nominal bore size 25mm (class heavy) & outside diameter of 33.7mm & area of cross section 373 mm^2 .

check the minimum thickness from durability consideration ->

we provide thickness of member = 4mm > 3.2mm.

(as this member is located outside, minimum thickness should be 3.2 mm as per cl 6.3.1).

Design for principal tie (100kN for member)

As principal tie is a tension member
so permissible tensile stress (σ_t) for
Yut 22 from table-1, IS 806 = 1250 kg/cm^2
 $= 125 \text{ N/mm}^2$

Area required for principal tie :-
Load on principal tie

$$= \frac{100 \times 10^3}{125} = 800 \text{ mm}^2$$

Let provided area = 820 mm^2 (choose from table-1, IS 1161).

so let us provide a steel tube of nominal bore of 65mm (medium class) & outside dia of 76.1mm & provide thickness of 3.6mm.

check for thickness-

provided thickness (3.6mm) > 3.2mm.

By minimum thickness required as per cl 6.3.1 for durability consideration.

so it is ok.

Design of connection :- (refer appendix B of IS 806).

Length of connection =

$$p = a + b + 3\sqrt{a^2 + b^2}$$

$$a = \frac{d}{2} \cos\theta$$

$$= \frac{33.7}{2} \cos 45$$

$$= 23.83.$$

$$b = \frac{d}{3} \times \frac{3 - (\frac{d}{D})^2}{2 - (\frac{d}{D})^2}$$

$$\Rightarrow \frac{33.7}{3} \times \frac{3 - \left(\frac{33.7}{76.1}\right)^2}{2 - \left(\frac{33.7}{76.1}\right)^2} = 17.46$$

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

$$= 23.83 + 17.46 + 3 \sqrt{(23.83)^2 + (17.46)^2}$$

$$= 129.91 \text{ mm}$$

Let us assume fillet weld:-
permissible shear stress on weld:-

(i) permeable shear stress $\tau_{\text{permeable}}$

(i) permeable shear stress in parent material (Yst 22) = q_{0N}/mm^2 (table - 4)

(i) permeable shear stress in parent material ($yd\ 22$) = 90 N/mm^2 (table - 4)

(ii) for $yd\ 25$, permeable shear stress = 100 N/mm^2

} minimum will be taken.

$$\text{allowable shear stress in weld: } q_0 \text{ N/mm}^2$$

$$\text{Required area of weld} = \frac{40 \times 10^3}{90} = 444.44 \text{ mm}^2$$

Area of weld = effective throat thickness \times length of weld

$$444.44 = t_e \times 129.91$$

$$\Rightarrow t_e = 3.42 \text{ mm.}$$

effective throat thickness (t_e) = $0.7 \times$ size of weld

$$3.42 = 0.7 \times s$$

$$\Rightarrow s = \frac{3.42}{0.7} = 4.88 \text{ mm.}$$

so provide size of weld = 4.88 mm.

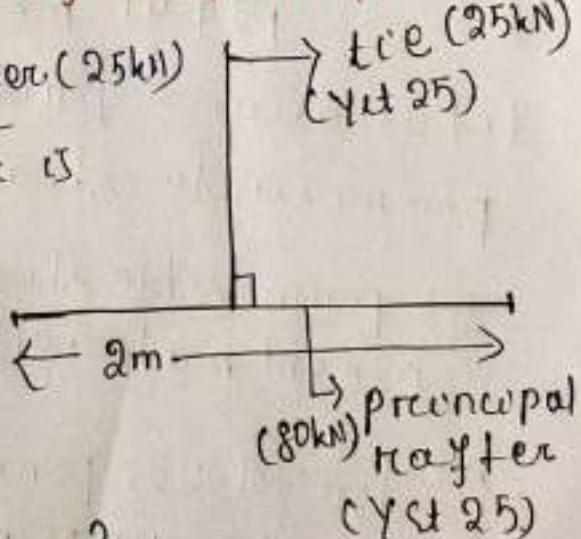
(compressing member).
On the principal rafter in round tubular frame

carries maximum force of 80kN. A tie member meeting at a joint at right angle to carry a force of 25kN. If the panel length of principal rafter is 2m. Design the member as well as welded joint. Assume outside location & Yst 25 grade of material.

Design of branch tie member (25kN)

As the branch tie member is tension member, so permissible tensile stress for Yst 25 from table 1 (IS 80) :-

$$\sigma_t = 1500 \text{ kgf/cm}^2 \\ = 150 \text{ N/mm}^2$$



Area required for branch tie:-

Load on branch tie

$$= \frac{25 \times 10^3}{150} = 166.67 \text{ mm}^2.$$

So provide a section of 373 mm^2 (claw heavy) of nominal bore size 25 mm & of outside diameter of 33.7 mm & thickness 4 mm to satisfy durability requirements.

② Design of principal rafter.

Let assume slenderness ratio $\lambda = 100$

so for $\lambda = 100$, the safe compressive stress $(f_c) = 90 \text{ N/mm}^2$

Required area = $\frac{\text{Load on principal rafter}}{(f_c)}$ (from table-2)

$$= \frac{80 \times 10^3}{90} = 879.12 \text{ mm}^2$$

Let us provide a steel tube of nominal bore of 76.1 mm of heavy claw having cross section area 1010 mm^2 , outside dia 76.1 mm & the thickness 4.5 mm which is more than 4 mm .

as per 3.6.3.1. (hence ok).

as nothing is given about end support condition, let assume effective length of principal rafter (leg) = $0.85L$.

$$30, L_e = 0.85 \times 2 \\ = 1.7 \text{ m.}$$

radius of gyration of chosen section (r) = 2.54 cm.

$$\text{slenderness ratio} (\lambda) = \frac{1.7 \times 10^3}{2.54}$$

$$= 66.92$$

permissible stress according to $\lambda = 66.92$.
(from table-2 IS 806)

$$\lambda = \frac{L}{r}$$

$$f_c (\text{kg/cm}^2) (\text{for } Y+25)$$

$\lambda = 66.92$	1002	1207
70	950	1155
70	950	1155

by interpolation,

$$f_c = \frac{66.92 - 70}{60 - 70} \times (1207 - 1155) + 1155 \\ = 1171.016 \text{ N/mm}^2 \text{ or } \text{kg/cm}^2 = 117.1016 \text{ N/mm}^2$$

Load = $f_c \times \text{Area provided}$

$$= 1171.016 \times 1010 \\ = 117.1016 \times 1010 \\ = 118273 \text{ N} = 118.273 \text{ kN} > 80 \text{ kN} \\ (\text{OK})$$

Design of connection:- (appendix B of IS 806).

Length of connection:-

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

$$d = 33.7 \text{ mm}$$

$$a = \frac{d}{2} \text{ where } 0$$

$$D = 76.1 \text{ mm.}$$

$$= \frac{33.7}{2} \text{ where } 90^\circ$$

$$= 16.85$$

$$b = \frac{d}{3} \times \frac{3 - (d/D)^2}{2 - (d/D)^2}$$

$$= \frac{\cancel{76.1}}{3} \times \frac{33.7}{3} \times \frac{3 - \left(\frac{33.7}{76.1}\right)^2}{2 - \left(\frac{33.7}{76.1}\right)^2} = 17.46$$

Length of weld $P = a + b + 3\sqrt{a^2 + b^2}$

$$P = 16.85 + 17.46 + 3\sqrt{(16.85)^2 + (17.46)^2}$$

$$= 107.104 \text{ mm}$$

Let us assume fillet weld:

permissible shear stress in weld:-

(i) permissible shear stress in parent material (Yt 25) = ~~110~~ N/mm² (Table-4)

(ii) For Yt 25, permissible shear stress = 110 N/mm² } minimum will be taken.

So permissible shear stress in weld = 110 N/mm²
Required area of weld = $\frac{\text{Load on branch tube}}{\text{permissible shear stress in weld}}$

$$= \frac{25 \times 10^3}{110} = 227.27 \text{ mm}^2$$

Area of weld = effective throat thickness \times length of weld

$$227.27 = t_e \times 107.14$$

$$\Rightarrow t_e = 2.12 \text{ mm.}$$

$$t_e = 0.7 \times \text{size of weld (S)}$$

$$\Rightarrow 2.12 = 0.7 \times S \Rightarrow S = 3.028 \text{ mm.}$$

So provide size of weld = 3.028 mm

④ Tubular beam:

limiting deflection of beam:-

The maximum deflection should not exceed $1/325$ of the span for simply supported members. This requirement may be satisfied if the bending stress in compression or tension does not exceed $31500 \frac{D}{L} \text{ kg/cm}^2$, where 'D' is the outer diameter of the tube in cm & 'L' is the effective length of beam in cm.

Q. A medium steel tubular section of 200mm nominal diameter is simply supported as a beam over effective span of 4.5m. Determine the safe uniformly distributed super imposed load which can be placed over it? Assume Y=25 grade of steel.
Section properties of 200mm nominal dia medium class steel tube :-
(from table)

$$\text{thickness } (t) = 5.6 \text{ mm}, \gamma = 29.5 \text{ kg/m.} \\ = 289.395 \text{ N/m.}$$

$$E = 2 \times 10^5 \text{ MPa.}$$

$$\text{Area of cross section } (A) = 37.5 \text{ cm}^2 \\ = 3750 \text{ mm}^2$$

$$\text{modulus of reaction } (Z) = 195 \text{ cm}^3 \\ = 195000 \text{ mm}^3$$

$$\text{moment of Inertia } (I) = 2141 \text{ cm}^4 \\ = 2141 \times 10^4 \text{ mm}^4$$

$$b = \frac{d}{3} \times \frac{3 - (d/D)^2}{2 - (d/D)^2}$$

$$= \frac{76.1}{3} \times \frac{3 - \left(\frac{33.7}{76.1}\right)^2}{2 - \left(\frac{33.7}{76.1}\right)^2} = 17.46$$

Length of weld $P = a + b + 3\sqrt{a^2 + b^2}$

$$P = 16.85 + 17.46 + 3\sqrt{(16.85)^2 + (17.46)^2}$$

$$= 107.104 \text{ mm}$$

Let us assume fillet weld:-

permissible shear stress in weld:-

(i) permissible shear stress in parent material (yt 25) = ~~110~~ N/mm² (Table-4)

(ii) for yt 25, permissible shear stress = 110 N/mm²

So permissible shear stress in weld = 110 N/mm²
Required area of weld = $\frac{\text{load on branch tube}}{\text{permissible shear stress in weld}}$

$$= \frac{25 \times 10^3}{110} = 227.27 \text{ mm}^2$$

Area of weld = effective throat thickness \times length of weld

$$227.27 = t_e \times 107.14$$

$$\Rightarrow t_e = 2.12 \text{ mm}$$

$t_e = 0.7 \times \text{size of weld (S)}$

$$\Rightarrow 2.12 = 0.7 \times S \Rightarrow S = 3.028 \text{ mm}$$

(i) load carrying capacity based on bending stress-

permissible bending stress for Yut 25 (γ_b) =
 1655 kg/cm^2
 $= 165.5 \text{ N/mm}^2$

allowable bending stress due to load
 applied (γ_{ab}) $\Rightarrow \frac{M}{Z}$.

For simply supported beam, ① bending moment due to uniformly distributed load (M) = $\frac{wL^2}{8}$ (leg given = 4.5m)

$$= \frac{w(4.5)^2}{8} = 2.53w\text{Nm}$$

reaction modulus (α) from reaction properties
 reaction modulus (α) = 19500 mm^{-3}

$$\gamma_{ab} = \frac{\gamma_b}{\alpha} = \frac{165.5}{19500} = 0.00844 \text{ N/mm}$$

$$\Rightarrow w = 12755.928 \text{ N/m.}$$

$$= \boxed{12.756 \text{ KN/m.}}$$

(2) based on shear stress :-

For Yut 25, permissible maximum shear stress (γ_s) = 110 N/mm^2

allowable shear stress due to applied load (γ_{as}) = $2 \times \frac{\text{maximum shear force (V)}}{\text{Area of reaction}}$

maximum shear force (V) due to applied load = $\frac{w_{\text{left}}}{2} = \frac{w \times 4.5}{2} = 2.25w \text{ N}$ (in N/m)

Area of section from section properties:
 $A = 3750 \text{ mm}^2$

Now, $\frac{V}{A} = f_s$

$$\Rightarrow 2 \times \frac{V}{A} = f_s \Rightarrow 2 \times \frac{2.25w}{3750} = 110$$

$$\Rightarrow w = 91667 \text{ N/m}$$

$= 91.667 \text{ kN/m.}$

(B) Load carrying capacity in view of deflection:

Maximum permissible deflection for simple supported beam $\delta_{\text{max}} =$

$$\frac{1}{325} \times 4.5 \times 10^4$$

$$= \frac{1}{325} \times 4.5 \times 10^3$$

$$= 13.85 \text{ mm.}$$

(when w is in N/mm)

Deflection due to applied load:

$$\delta = \frac{5}{384} \cdot \frac{w l^4}{E I}$$

$$= \frac{5}{384} \cdot \frac{w \times (4.5 \times 10^3)^4}{2 \times 10^5 \times 2141 \times 10^4 \times 10^3}$$

$$= 1246.93w$$

Now $\delta = \delta_{\text{max}}$

$$\Rightarrow 1.25w = 13.85 \Rightarrow w = 11.08 \text{ N/mm.}$$

$= 11.08 \text{ kN/m.}$

load carrying capacity = minimum of
above 3 loads
calculated

$$w = 11.08 \text{ kN/m.}$$

self wt. of member (dead load) OR =

$$289.395 \text{ N/m.} \\ = 0.289 \text{ kN/m.}$$

w = super imposed load + dead load.
load (wave load)

$$\Rightarrow \text{super imposed load} = \\ w - \text{dead load} \\ = 11.08 - 0.289 \\ = 10.79 \text{ kN/m.}$$