

Steel is an alloy of iron and iron and carbon.

Structural Steel : The manufactured steel rolled to sections and weights as specified by Bureau of Indian standards is called structural steel. The rolled sections should be free from defects and structural steel flaws like cracks, roughness and sharp edges etc. The Standards for Structural of different qualities are

- i) IS : 226 - 1975 (Standard quality)
- ii) IS : 1977 - 1975 (Ordinary quality)
- iii) IS : 2062 - 1984 (Fusion welding quality)
- iv) IS : 961 - 1975 (High tensile structural steel)
- v) IS : 8500 - 1977 (Weldable medium and high strength)

Standard quality steel is the most commonly used steel for general construction purposes of buildings, bridges, transmission line towers, industrial structures etc. (ii)

Advantages of Structural steel :- (i)

The Steel members have high strength. These for Steel member can resist heavy loads.

- i) The Steel members are light in weight so easy in transport. Properly maintained steel structures have a long life. (ii)
- ii) Additions and alterations can be made easily to S.S. The prop. of steel mostly do not change with time.
- i) It also gives visible evidence and good appearance.
- ii) Steel member can be erected at a faster rate.
- ii) Steel has high scrap value.
- i) The steel member are gas and water tight, because high density.

Disadvantage :- (i) Steel members are costly.

(ii) Steel members are subjected to corrosion,

(iii) Due to low fire resistance they deformed due to high temp.

Properties of structural steel :- (i) Chemical properties

Constituents	Maximum %	Variation over Specified
		Max. limit (Maximum %)
Carbon (dia ≤ 20 mm)	0.23	0.02
Carbon (dia > 20 mm)	0.25	0.03
Sulphur	0.055	0.005
Phosphorus	0.055	0.005

i) Mechanical Properties :-

Steel products	Nominal thickness or dia	Tensile Strength	Yield Stren	% Elongation min.
Plates, sections	Up to 20	410 - 530	250	23
	over 20	410 - 530	240	23
	Up to 40	"	"	"
	over 40	410 - 530	230	23
	Up to 20	410 - 530	250	23
Bars	over 20	410 - 530	240	23

- ii) Physical properties :-
- (i) Unit weight of steel = 78430 to 79000 N/m^3
 - (ii) Young's modulus of elasticity = 2.04×10^5 to $2.18 \times 10^5 \text{ N/mm}^2$
 - (iii) Modulus of rigidity = 0.84×10^5 to $0.98 \times 10^5 \text{ N/mm}^2$
 - (iv) Co-efficient of thermal expansion or contraction = $12 \times 10^{-6} / ^\circ\text{C}$

I.S. Rolled Sections

Steel structures are built with hot-rolled steel sections.

The following sections are standardized by the Indian Standards Institution (ISI).

1) I-section or Beams

- i) Indian Standard Junior Beams (ISJB)
- ii) Indian Standard Light Beams (ISLB)
- iii) Indian standard weight Beams (ISWB)
- iv) I.S. Column section.

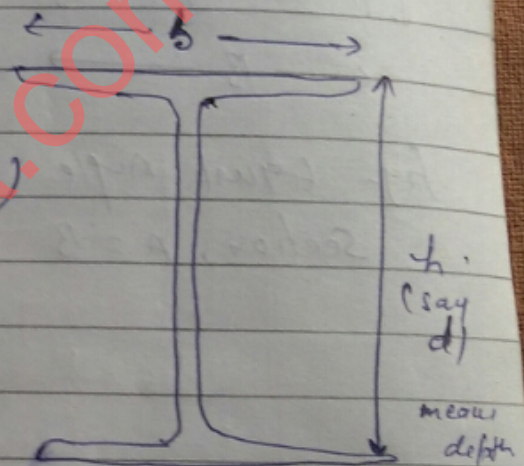


Fig - Beam section.

Channel Sections :-

- i) Indian standard junior channel
- ii) Gate channel
- iii) Light channel
- iv) Weight channel.

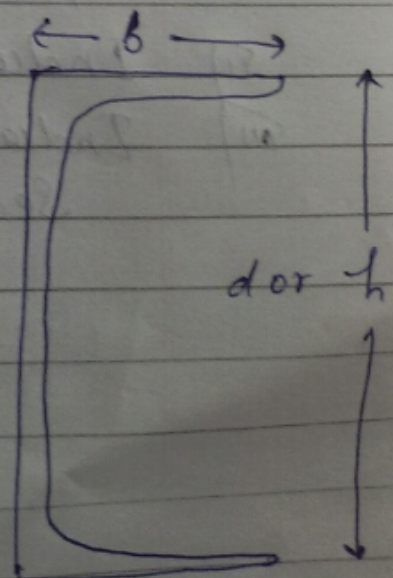


Fig - Channel

3)

Angle Sections

- i) Indian standard Equal Angles
- ii) Indian standard Unequal Angles

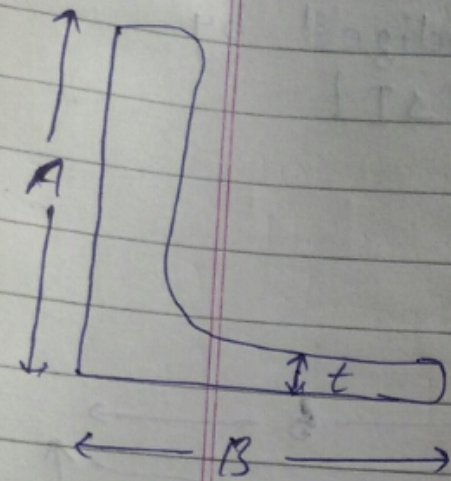


Fig - Equal Angle Section, $A = B$

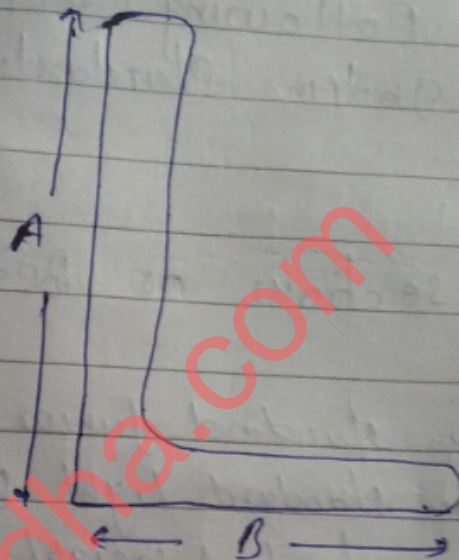
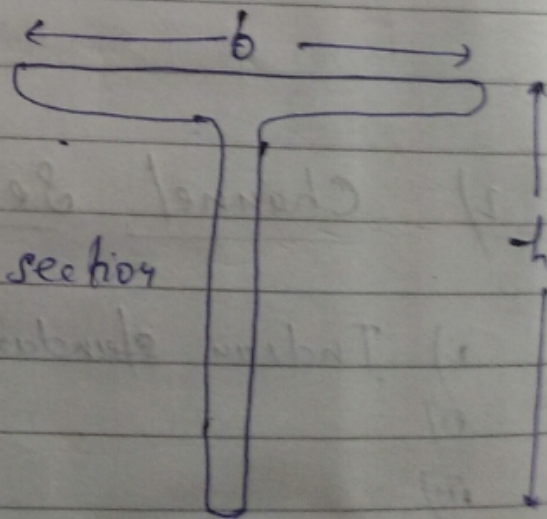


Fig - Unequal angle section. $A \neq B$

4) T-Sections

- i) Indian standard Normal Tee-section
- ii) Indian standard Light Tee section
- iii) Indian standard Slit Tee-section.



Connections

What is a Rivet ?

It is a permanent fastening which connects two members.

Type of Rivet joints :-

- i) Lap lifted joint
- ii) Butt joint.

Lap joint :- When one metal lap with another metal and connected together is called lap joint.

Ex- A single Riveted lap joint and double lifted lap joint.

Butt joint :- The two members connected end to end is called butt joint. and for connecting, additional plate is required. This is called cover plate.

Strength of joint :-

This is a safe load which a lap lifted joint or a butt joint is subjected.

It is the least of the following -

- i) strength of plate in Tearing (tension).
- ii) strength of joints in shear (shear stress)
- iii) strength of joints in Bearing (Bearing stress)

Rivet value :-

It is a strength which a rivet gives to the joint.

It is equal to least of

- i) strength of Rivet in shear
- ii) strength of Rivet in Bearing.

Efficiency of a joint :- (η)

The original strength of the section is reduced by rivet holes.

The efficiency of a joint is the ratio of the strength of the joint and the original strength of the member without rivet holes

$$\eta = \frac{\text{strength of joint}}{\text{strength of solid plate}}$$

It is expressed in percentage.

Nominal Diameter

It is the diameter of rivet ~~hole~~. (denoted by ϕ).
 $\phi = 20, 25, 30$ etc.

Gross Diameter

It is denoted by d .
It is the diameter of rivet hole and slightly more than the ~~the~~ nominal diameter.

Case-I $d = \phi + 1.5 \text{ (mm)}$ \Rightarrow when ϕ is less than 25 mm \leq
 $\phi \leq 25$

Case-II $d = \phi + 2 \text{ (mm)}$ \Rightarrow when $\phi \geq 25$

Pitch of Rivet :-

It is the vertical distance b/w adjacent rivet in a row.

Gauge line :-

It is an imaginary line which joins centre of rivet in a direction parallel to the direction of tensile stress.


Gauge distance :- vertical distance b/w adjacent gauge lines.

Diamond formation of Rivet :-

In this, one rivet is provided in the outermost section and max. no. of rivets provided at inner section.

Ex- If there are 10 rivets, it will be arranged as 1, 2, 3, 4.



shape is  Diamond

To Find No. of Rivet for lifted joint :-

$$N = \frac{\text{Strength Given load}}{\text{Rivet value.}}$$

To Find Pitch of Rivet - (P)

- i) Calculate strength of plate in tearing per pitch length.
- ii) Calculate Rivet value per pitch length.

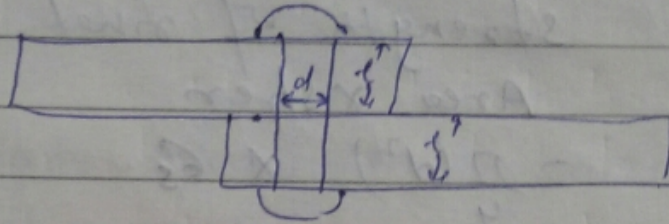
Step ① = Step ②
we find Pitch

Assumptions in Rivet Analysis

- i) Tensile stress in plate are uniform
- ii) Friction of plate is neglected.
- iii) Shear stress are uniformly distributed
- iv) Bearing stress are evenly spread.
- v) All rivets are subjected to equal load.
- vi) Bending stress are negligible.
- vii) A rivet is completely fixed at a rivet hole.

To determine the strength And Efficiency of the joint. —

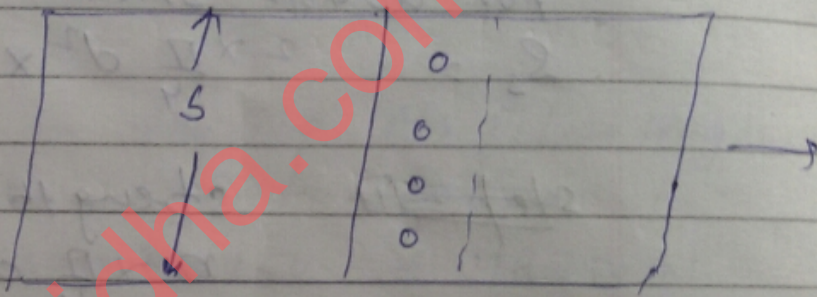
Consider a single rified lap joint.



Let b = width of each plate

t = thickness of plate

d = dia of rivet holes



σ_t = max. permissible tensile stress for plate

σ_s = max. permissible shear stress for rivet material

σ_b = max. " bearing stress " " "

Plate in tension

Area of plate — $b \times t$

Area of rivet hole — $d \times t$

No. of rivet (n) = 4

Area of plate in tearing at section ①-①

$$bt - ndt \\ = (b - nd)t$$

Step-I strength of plate in tearing at section -

$$S_t = \text{Area} \times \sigma_{\text{ten}} \\ = (b - nd) t \times \sigma_t$$

Step-II strength of rivet in shearing -

$$S_s = \text{Area} \times \sigma_{\text{shear}} \\ = \frac{\pi (d^2)}{4} \times \sigma_s$$

for double shear.

$$S_s = 2 \times \frac{\pi d^2}{4} \times \sigma_s$$

Step-III strength of joint in shearing -

$$n \times \frac{\pi d^2}{4} \times \sigma_s$$

Step-IV

strength of Rivet in bearing -

$$S_b = \text{Area} \times \sigma_{\text{shear}} \\ = d \times t \times \sigma_b$$

$$\text{strength of joint} = \\ = n \times d \times t \times \sigma_b$$

Note - strength of joint is the least in one of these three values

The least of last two values is called Rivet value.

Efficiency of joint -

$$\eta = \frac{\text{strength of joint}}{\text{strength of solid plate}} \times 100$$

$$\text{Strength of solid plate} = \text{Area} \times \text{tensile stress} \\ b \times t \times \sigma_t$$

$$\Rightarrow \text{gross dia} = 16 + 1.5 = 17.5 \text{ mm}$$

Qum Two plates 12mm and 10mm thick are jointed by double riveted lap joint. Dia of rivet is 16mm and pitch of the rivet is 80mm. Determine the strength and efficiency when $G_t = 150 \text{ N/mm}^2$, $G_s = 90 \text{ N/mm}^2$, $G_b = 270 \text{ N/mm}^2$.

Solⁿ:-

strength of plate in tearing -
 $\text{Area} \times \text{spen}$
 $= \text{Area} \times G_t$

strength of plate in tearing per pitch length
 $(p-d) \times t \times G_t$
 $S_t = (80 - 17.5) \times 10 \times 150 = 48750 \text{ N.}$

strength of rivet in double shearing
 $S_s = 2 \times \frac{\pi}{4} d^2 \times G_s$
 $= 2 \times \frac{\pi}{4} (17.5)^2 \times 90 = 43296 \text{ N.}$

strength of Rivet in bearing -
 $\text{Area} \times \text{spen}$
 $S_b = d \times t \times G_b$
 $= 17.5 \times 10 \times 270 = 44500 \text{ N}$

Least is 43296 N.
 Rivet value is 43296 N

strength of joint -
 least in one of these three values i.e.
43296 N

Efficiency - (η)

$$\frac{\text{strength of joint}}{\text{strength of solid}}$$

Bst for per pitch length

$$\eta = \frac{P-d}{P} \times 100$$

$$= \frac{50 - 17.5}{50} \times 100$$

$$= 65\%$$

Qum :- A single Rivet lap joint with two plates of 10 mm and 12 mm. Determine the dia of rivet and Pitch of plate and efficiency -

$$G_s = 90 \text{ N/mm}^2, G_b = 270 \text{ N/mm}^2, G_t = 170 \text{ N/mm}^2$$

Soln :-

Nominal dia of rivet

$$\phi = 6.05 \sqrt{t}$$

$$= \phi = 6.05 \sqrt{10} = 20 \text{ mm.}$$

$$\text{Gross Diameter} = 20 + 1.5 = 21.5 \text{ mm}$$

Strength of Plate in-tearing

$$(P-d) \times t \times G_t$$

$$S_t = (P - 21.5) \times 1500 \quad \text{--- (1)}$$

For Rivet value -
strength in shear -

$$\frac{\pi}{4} \times (21.5)^2 \times 90 = 32675 \text{ N}$$

strength in bearing

$$d \times 21.5 \times 10 \times 270 = 58050 \text{ N}$$

Hence

$$\text{Rivet value} = \boxed{32675 \text{ N}}$$

Rivet value per pitch length -

Rivet value \times No. of pitch

$$= 32675 \times 1 = 32675 \text{ N} \quad \text{--- (2)}$$

Compare eqⁿ (1) and eqⁿ (2)

$$(p - 21.5) \times 1500 = 32675$$
$$p = 43.3 \text{ mm}$$

But pitch does not less than

$$2.5 \phi = 2.5 \times 20 = 50$$

Pitch is less than 2.5ϕ

So, we adopt pitch of 50 mm or greater

Thus,

$$\text{pitch } (p) = 50 \text{ mm}$$

Efficiency - (η)

$$= \frac{p - d}{p} \times 100 =$$

$$\frac{50 - 21.5}{50} \times 100$$

$$\eta = \boxed{57\%}$$