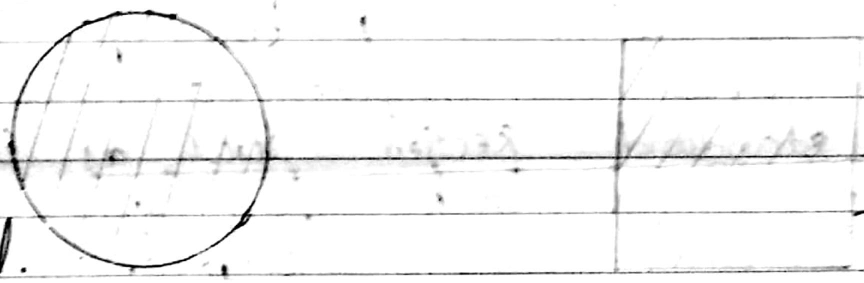
Tension Members:-

Unit → 4.

Tension Members: → Tension members which are subjected to direct tension are called Tension members or tie members. Commonly used in roof truss.

Types of Tension Members:- The various types of section used as tension members are :-

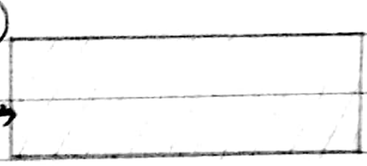
1. **Rods** :- These are the simplest form of tension members. Rods are round or square in section.



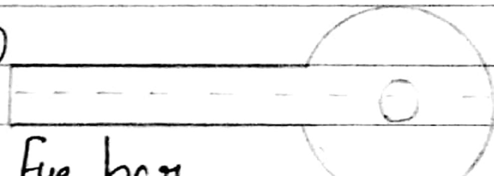
Round. → Square.

2. **Flats** :- Flats are generally used as tension members in light trusses.

(2) Flat Bar



(3)

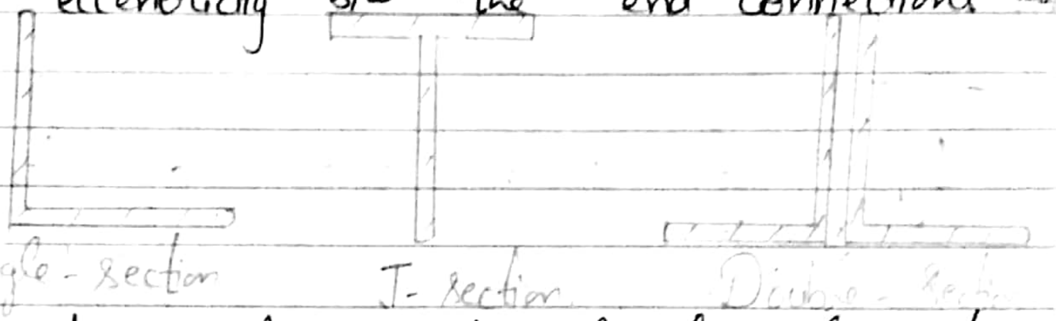


Eye bar.

3. **Eye bars** :- Eye bar is a rectangular bar with head forged at each end. They are used generally as tension members in pin joined roof truss.

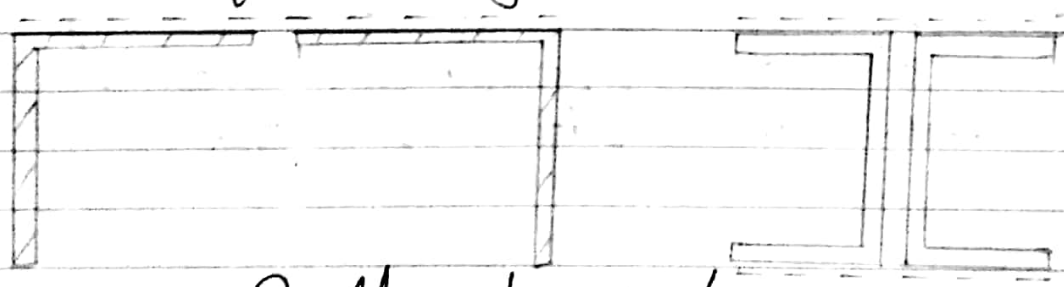
4. **I- section**:- It is used as tension members in trusses of medium capacity.

(5) <u>Single angle section</u>:- The single str. shape <u>like</u> angle and tee - section are normally used as tension member in light roof truss. A single section develops bending stress due to eccentricity b/w the end connections



and centre of gravity of the angle section.

(6) <u>Built - up members</u>:- A built up - section is one which is composed of two or more standard section such as two channels placed back to back etc. <u>used</u> for <u>heavy</u> structures.



Built - up section :-

* <u>Net - Sectional Area</u>:- It is defined as gross - area of the member less deduction for holes (rivet hole, pin hole) etc.

<u>Case → I.</u> (For Plates) :-

(1) Chain riveting.
(2) Zig - zag riveting.

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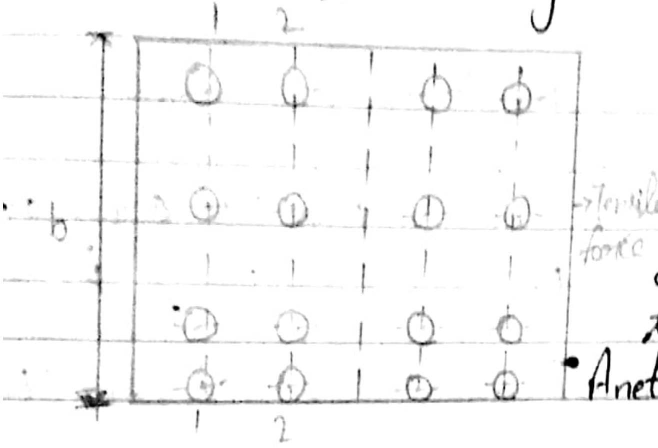
diameter - 0 to 14 = Diameter. 1mm.
18 to 22 = 2mm.
case → I. 24 upto = 3mm.

1.) Plates connected by chain riveting.

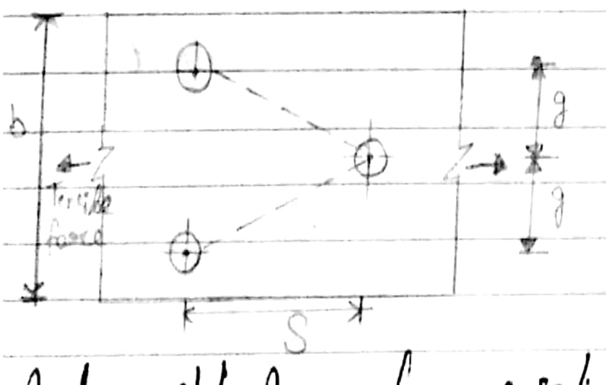


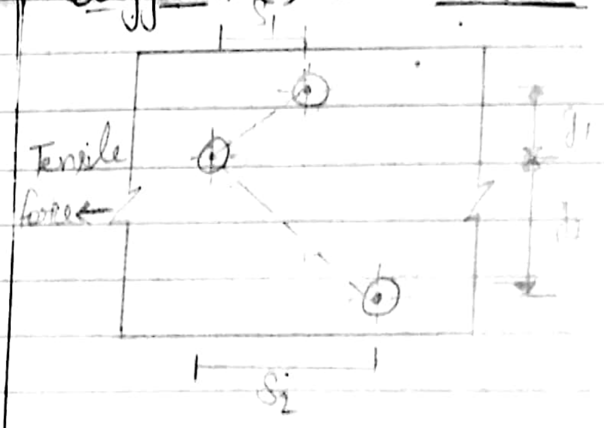
Anet - Net cross sectional area.
b = width of Plates.
n = No. of rivets
d = Gross diameters of a rivets
t = Thickness of Plates.

Anet = Gross Area - Area of Plates lost in the process of making holes
⇒ $bt - ndt$.

$$\boxed{A_{net} \Rightarrow (b - nd)\,t.}$$

2.) Plates connected by zig-zag or Staggered riveting.
If staggered Pitch same. Staggered (S) is not same.





Anet = Net Area of cross section
b = width of Plates.
n = No. of rivets in plate
n' = No. of gauge distance.
S = Staggered pitch.
g = Gauge distance.
t = Thickness of Plates.

$$\boxed{A_{net} \Rightarrow \left[b - nd + \frac{n'S^2}{4g}\right]t}$$

All same symbol.

S_1 and S_2 are staggered pitch
g_1 and g_2 are corresponding gauge distance.

$$\boxed{A_{net} \Rightarrow t\left[b - nd + \left(\frac{S_1^2}{4g_1} + \frac{S_2^2}{4g_2}\right)\right]}$$

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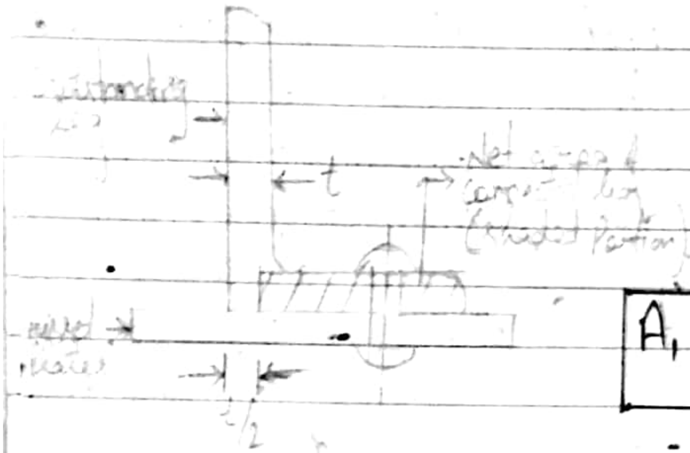
Case – II.

For single angle connected by one leg only



$$A_{net} \Rightarrow A_1 + A_2 k$$

where,

A_{net} = ~~Area~~ Net cross area

A_1 = Net cross area of connected leg. (shaded)

$$\boxed{A_1 \Rightarrow \text{Thickness of angle}\left[\text{length of leg} - \frac{1}{2}t - nd\right]}$$

$$\Rightarrow t\left[b - \frac{1}{2}t - nd\right]$$

A_2 = Gross cross area outstanding leg.

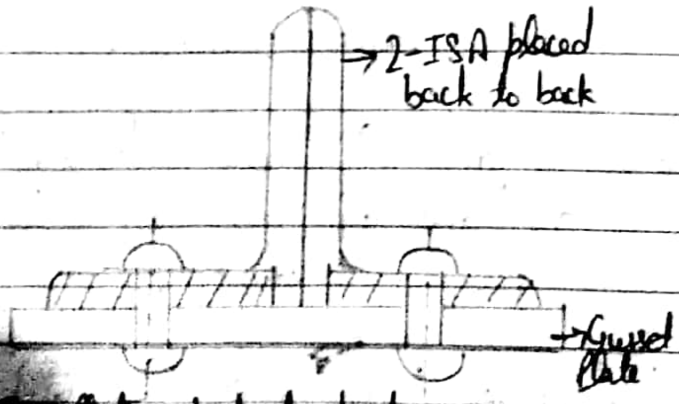
$$\boxed{A_2 = \text{Thickness of angle}\left[\text{length of leg} - \frac{1}{2}\text{thickness}\right]}$$

$$\Rightarrow t\left[b - \frac{t}{2}\right].$$

$$\boxed{K = \frac{3A_1}{3A_1 + A_2}}, \quad K = \text{Constant}.$$

Case – III.)

Angle placed back to back only one leg of each angle to the same side of a gusset plate.



Plates back to back on same side of the gusset plate.

$$\boxed{A_{net} = A_1 + A_2 k}$$

A_1 = Net area of connected leg.

A_2 = Gross-cross area outstanding leg.

K = Constant.

$$\boxed{K = \frac{5A_1}{5A_1 + A_2}}$$

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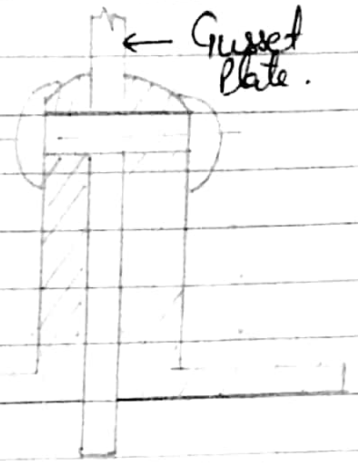
Case - IV

Angle placed back to back and connected each side of a gusset plate.



Deduction $\Rightarrow n \times d \times t$.

$$\boxed{A_{net} \Rightarrow \underbrace{\text{Gross area}}_{\text{from steel table}} - \text{Deduction for rivet hole.}}$$

Angle placed back to back on both side of the gusset plate.

⊛ Permissible stress in tension :-

The permissible stress in axial tension (σ_{at}) on net effective area of the section shall not exceed 0.6 times the minimum yield stress of steel. (in N/mm^2).

$$\sigma_{at} = 0.6\, f_y$$

where,

σ_{at} = Permissible tensile stress

f_y = Minimum yield stress in N/mm^2 (MPa).

for example :-

Minimum yield stress (f_y) = $250\ N/mm^2$.

$$\sigma_{at} = 0.6 \times f_y$$
$$= 0.6 \times 250$$
$$= 150\ N/mm^2.$$

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Strength of a Tension Member :-

↳ Tensile strength of a member subjected to axial tension is given by relation.

Tensile strength = Net area × Permissible tensile stress

$$\boxed{\text{Tensile strength} = A_{net} \times \sigma_{at}}$$ ($\because$ Load = stress × area)

Single angle

Design of Members Subjected to Axial Tension :-

Step - 1.) Calculation of the required net area :-

$$A_{net}\ \text{reqd.} = \frac{\text{Axial load}}{\sigma_{at}}$$

where,

σ_{at} = Permissible tensile stress = $150\ N/mm^2$ (if not given)

Step → 2.) Selection of suitable section :-

From steel table having sectional area about 20 to 40% greater (in case of riveted joint and 10% greater (" " " welded ") req. net area.

Gross Section area of member from steel table (case rivetd joint) = A_{net} reqd. × 1.20 to 1.40.

Gross section area of member from steel table (case welded joint) = A_{net} reqd. × 1.10

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Step-3) Calculate the net sectional (effective) area of the selected section.

(a) Single angle and double angle – one rivet hole from each angle.

(b) Flat or plate – one rivet hole for 15cm width of member

(c) Double channels – two rivet holes from each channel web or one rivet hole from each flange.

(d) Four angle (ISA) forming box – two rivet holes from each angle.

Step-4.) Check for net Sectional area :- in step-3.

Net area of Trial section > Net area required (OK)

Step :- 5) Check for Slenderness ratio (λ) :-

$$\text{Slenderness ratio } (\lambda) = \frac{l_{eff.}}{r_{min.}}$$

The value of radius of gyration (r_{min}) can be obtained from steel table.

Step → 6.) Design of end connection :-

(a) **Riveted connection** :- (i) Select suitable size of rivet and determine the rivet value.

ii) No. of rivets reqd. :- $\dfrac{\text{Max. load or force in the member}}{\text{Rivet value.}}$

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(b) **Welded connections:-** (i) Assume the suitable size of fillet weld.

(ii) Calculate the strength of weld length.

(iii) Required length of weld $\Rightarrow \dfrac{\text{Max. load or force in member}}{\text{Strength of weld / mm length}}$

(iv) Arrange the length of the weld in such a manner that it does not cause any eccentricity of loading.

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