Tension Member

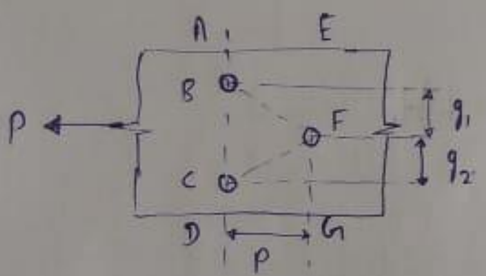
- Pulling force is applied in the opposite dir^n at the two ends of the member.
- Bending stress due to self wt. is neglected.

Critical tensile stress and critical c/s area →

- Critical tensile stress in a tension member occurs at the section where the c/s area is minimum. So No. of Bolts / Rivets and arrangement of them affect the c/s area.

Area Calculation →

Net Area Calculation for plate section →



Possible failure Plane

- ✓ ABCD
- ✓ ABFCD

] → Possible

- × EFG
- × ABFCD

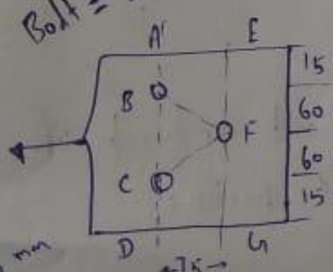
$$ABCD \rightarrow (B - 2d_o)t \quad (A_1)$$

$$ABFCD \rightarrow \left(B - 3d_o + \frac{p^2}{4g_1} + \frac{p^2}{4g_2}\right)t \quad (A_2)$$

(A_1), (A_2) } min. ✓

[From IS 800 : 2007
Pg. = 33]

eg:- Bolt dia. = 20 mm



B = 150 mm
t = 10 mm

Gross Area = 150 × 10 = 1500 mm²

ABCD = (150 − 2 × 21.5) × 10 = 1070 mm²

(d_o = 1.5 + d)

$$ABFCD = \left(150 - 3 \times 21.5 + \frac{75^2}{4 \times 60} + \frac{75^2}{4 \times 60}\right) \times 10$$

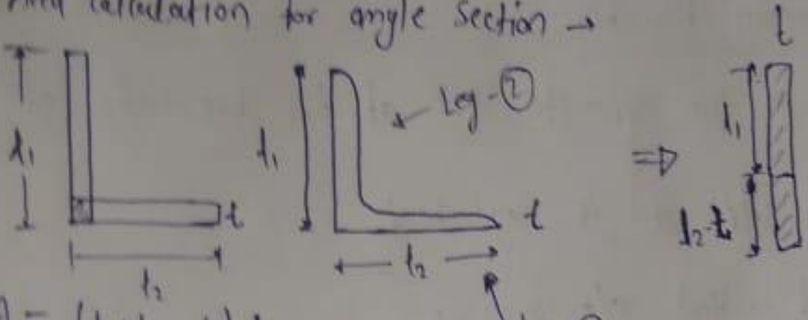
= 1323.75 mm²

EFG = (150 − 21.5) × 10

= 1285 mm²

So A_{net} = 1070 mm² / And for critical c/s = ABCD

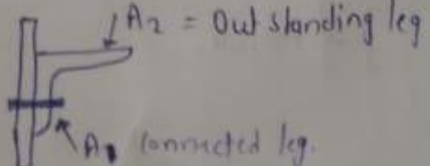
Area calculation for angle section →



$A = (l_1 + l_2 - t)\,t$

$$A_1 = l_1 \times t - \frac{t \times t}{2} = (l_1 - t/2)\,t$$
$$A_2 = l_2 \times t - \frac{t \times t}{2} = (l_2 - t/2)\,t$$
$$\text{Total Area } A = A_1 + A_2 = (l_1 + l_2 - t)\,t$$

eg:- ISA : $l_1 \times l_2 \times t$



$$A_1 = \left(l_1 - \frac{t}{2} - d_0\right)t$$
$$A_2 = \left(l_2 - \frac{t}{2}\right)t$$

Shear leg Effect → Non unifor stress distribution near the connection in case of angle sections is called as shear leg effect.

- To reduce it length of connection should be increased or unequal angle section should be provided.
- Provide gussel two gusset plates to eliminate shear leg.

Types of failure in tension members.

(1) Yielding of gross section (T_{dg}) → Significant amount of deformation before ~~failure~~. fracture.

(2) Rupture or fracture of net section (T_{dn})

(3) Block shear failure (T_{db})

(1) T_{dg} The design strength due to Yeilding of the gross Section is given by →

$$\left[T_{dg} = \frac{A_g f_y}{\gamma_{mo}} \right]$$

{ IS: 800 : 2007 Cl. 6.2 Pg = 32 }

f_y → Yeild stress of material

A_g → Gross area of c/s

γ_{mo} → Partial safety factor [Table - No. = 5 IS : 800]

(2) Design strength due to rupture of Net section (T_{dn})

(i) In case of plates →

$$\left[T_{dn} = 0.9\, A_n \frac{f_u}{\gamma_{m_1}} \right]$$

{ IS 800 : 2007 Pg. 32 }

f_u → Ultimate stress of material

A_n → Net eff. area

(

$$A_n = \left[b - n d_o + \sum_i \frac{P_{si}^2}{4 g_i} \right] t$$

P → Pitch

g → Gauge

(ii) Single angle →

$$\left[T_{dn} = 0.9\, \frac{A_{nc} f_u}{\gamma_{m_1}} + \beta A_{go} \frac{f_y}{\gamma_{mo}} \right]$$

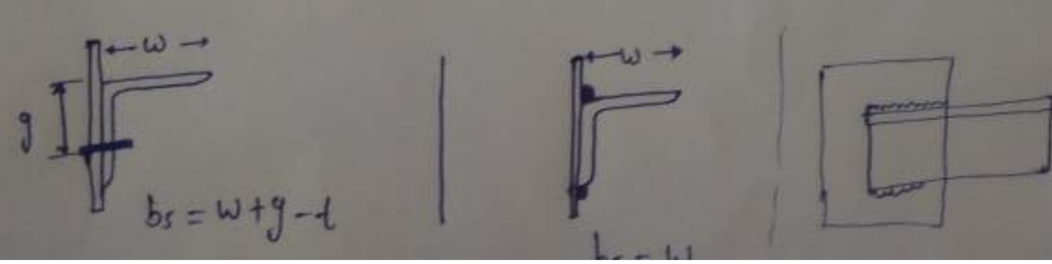
where $\beta = 1.4 - 0.076\, (w/t)\, (f_y/f_u)\, (b_s/L_c) \leq \left(f_u \gamma_{mo} / f_y \gamma_{m_1} \right)$ 0.9

≥ 0.7

w → Out standing leg width

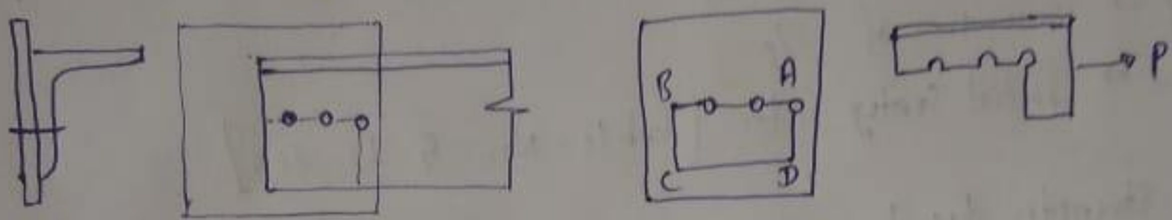
b_s → Shear leg width

Case - I



(1) Block Shear Strength → (T_{db})

- It is combination of shear and tensile strength of a member under tensile forces.
- Block shear strength depends upon end distance & pitch distance.



Bolt Shear Strength →

$$\left[T_{db} = \frac{A_{vg} f_y}{\sqrt{3}\, \gamma_{m0}} + 0.9\, A_{TN} \frac{f_u}{\gamma_{m1}}\right]$$

$$\left[T_{db} = 0.9 \frac{A_{vn} f_u}{\sqrt{3}\, \gamma_{m1}} + A_{ty} \frac{f_y}{\gamma_{m0}}\right]$$

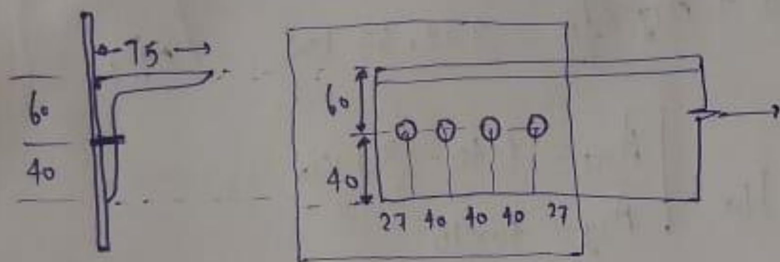
} min^m

$$\left.\begin{aligned} A_{vy} &= AB \times t \\ A_{SN} &= \left(AB - d_o - d_o - \frac{d_o}{2}\right) t \\ A_{Ty} &= AD \times t \\ A_{TN} &= \left(AD - \frac{d_o}{2}\right) t \end{aligned}\right]$$ → from above diagram.

⇒ Tensile strength of member (T_d) is the min^m of T_{dy}, T_{dn} & T_{db}.

~~LSM~~

Q. Calculate tensile strength of the angle ISA 100×75×10 for the given arrangement. 16 mm dia bolts are used to make the connection.



$d = 16\,mm$

So $d_0 = 18\,mm$

(1) Yeilding of gross section

{IS : 800 : 2007}
Pg- 32

$$\text{Gross Strength} = A_g \times \frac{f_y}{1.1}$$

$$= (l_1 + l_2 - t)\,t \times \frac{250}{1.1} = (100 + 75 - 10) \times 10 \times \frac{250}{1.1}$$

$$T_{dg} = 375\ KN$$

(2) Net tensile strength

$$T_{dN} = A_{Nc} \times \frac{f_{up}}{1.25} \times 0.9 + \beta\, A_{go} \times \frac{f_y}{1.1}$$

$$A_{Nc} = \left(l_1 - \frac{t}{2} - d_0\right) t$$

$$= \left(100 - \frac{10}{2} - 18\right) 10 = 1130\ mm^2$$

$$A_{go} = \left(l_2 - \frac{t}{2}\right) t = (75 - 5) \times 10 = 700\ mm^2$$

$$\beta = 1.4 - 0.076 \left(\frac{w}{t}\right)\left(\frac{f_y}{f_u}\right)\left(\frac{b_s}{L_c}\right)$$

$b_s = w + g - t$, $L_c = 120\ mm$

$= 75 + 60 - 10$

$= 125\ mm$

$$\beta = 1.4 - 0.076 \left(\frac{75}{10}\right)\left(\frac{250}{410}\right)\left(\frac{125}{120}\right)$$

$$\beta = 1.037$$

$$T_{dN} = 1130 \times \frac{410}{1.25} \times 0.9 + 1.037 \times 700 \times \frac{250}{1.1}$$

$$= 392.5\ KN$$

(3) Block Shear Strength

$$T_{db} = \frac{A_{sv}}{\sqrt{3}} \times \frac{f_y}{1.1} + A_{TN} \times \frac{f_{up}}{1.25} \times 0.9 = 284.39 \text{ kN}$$

(or)

$$= \frac{A_{SN}}{\sqrt{3}} \times \frac{f_{up}}{1.25} \times 0.9 + A_{Ty} \times \frac{f_y}{1.1} = 234.07 \text{ kN}$$

} min.

$A_{sv} = 147 \times 10$

$A_{SN} = (147 - 18 - 18 - 18 - \frac{18}{2})10$

$A_{TN} = (40 - \frac{18}{2}) \times 10$

$A_{Ty} = 40 \times 10$

$$T_{db} = 234.07 \text{ kN}$$

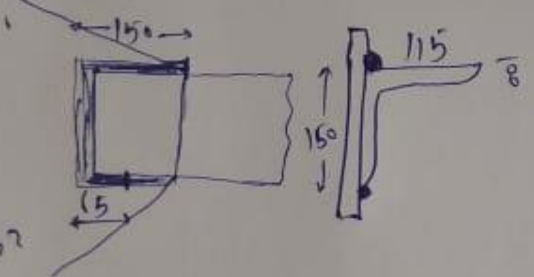
So Design tensile strength $T_d = 234.07 \text{ kN}$

Q. Determine the tensile strength of an angle section ISA 150×115×8 which is connected to gusset plate for the following cases: Use Fe410

(1) Yeilding of gross-section

(2) Rupture strength of critical section

Sol^n:-



$A_g = 150 \times 115 \times 8 = 2058\ mm^2$

(1) T_{dg} = Tensile strength due to gross-section →

$$T_{dg} = \frac{A_g f_y}{\gamma_{m0}} = \frac{2058 \times 250}{1.1} = 467.73\ KN$$

(2) Rupture strength (T_{dn}) →

$$T_{dn} = \frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \beta \frac{A_{go} f_y}{\gamma_{m0}} =$$

$A_{nc} = (150 - \frac{8}{2})8 = 1168\ mm^2$

$A_{go} = (115 - \frac{8}{2})8 = 888\ mm^2$

$$\beta = 1.4 - 0.076(w/t)(f_y/f_u)(b_s/L_c) \le \frac{0.9 f_u \gamma_{m0}}{f_y \gamma_{m1}} \ge 0.7$$

$$= 1.4 - 0.076\left(\frac{115}{8}\right)\left(\frac{250}{410}\right)\left(\frac{115}{150}\right) = 0.8893$$

$$\frac{0.9 f_u \gamma_{m0}}{f_y \gamma_{m1}} = \frac{0.9 \times 410 \times 1.1}{250 \times 1.25} = 1.2988 > 0.7$$

$\beta = 0.8893$

$T_{dn} = 524.27\ kN$