Notes by-

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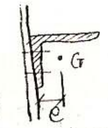
SS-II

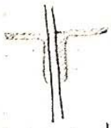
[TENSION MEMBER] (TT)

(Interview)

* Steel sections such as angle, I, channel, T provides more rigidity towards buckling in compression than circular or rectangular section of same area; this is very important when "Reversal of stress" takes place under wind load.
* Single angle develops "bending stress" due to eccentricity betn end connection & C.G. of angle section.



Bending stresses in single angle



Relatively less bending stresses

⊛ Net Sectional area :-

Tension member is designed for its net sectional area at the joint. When tension member is joined to G.P. by "rivets" or "bolts" the gross sectional area is reduced due to rivet holes.

∴ Net sectional area is calculated as per case according to IS 800-1984 as –

a] For Plates :-

i] Chain Riveting

$$A_{net} = b \times t - n \times d \times t$$
$$A_{net} = t \times (b - n \times d)$$

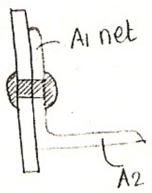
where b = width of plate
t = Thk. of plate
d = gross dia. of rivet hole
n = No. of rivets.

2] Zig-zag or diagonal chain,

$$A_{net} = t\left[b - nd + \frac{s^2}{4g}\right]$$

s = staggered pitch
= Dist. betn two consecutive rivets measured ‖el to stress direction.
g = gauge dist
= Dist. betn two consecutive rivets measured ⊥ar to stress direction.

b] For Single angle connected by one leg only :-



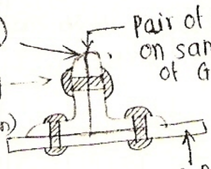
$$A_{net} = A_1 + A_2 \cdot K_1$$

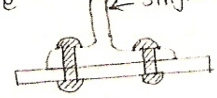
A_1 = Net c/s area of connected leg.
A_2 = gross c/s area of unconnected leg.

$$K_1 = \frac{3A_1}{3A_1 + A_2}$$

Area of leg of angle = Thk. of angle × (Length of leg – 0.5 thk. of leg)

c] For pair of angles placed back to back (or Single T) connected by only one leg of each angle (by Flange of T) to the same side of G.P :-





$$A_{net} = A_1 + A_2 K_2$$

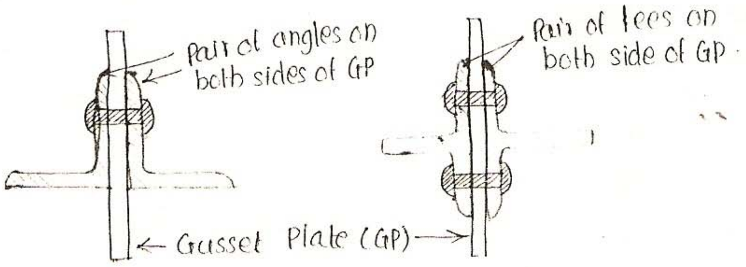
A_1 = Net sectional area of connected Legs* (Flange of T)
A_2 = Area of outstanding leg (Web of T)

$$K_2 = \frac{5A_1}{5A_1 + A_2}$$

Area of web of Tee = Thk. of web × (depth – thk. of flange)

× Outstanding legs of pairs of angles should be tacked by rivets at a pitch not exceeding 1m

(d) Double angle or tees carrying direct tension placed back to back & connected to each side of G.P. or to each side of rolled section.



A_{net} = Gross area − deduction for holes → only for tank Riveted.

V.Imp * Provided that angles & tees are "tack riveted" along their length at a pitch not exceeding 1m.

(GATE) * When two angles or tees placed back to back are not tack riveted, the provision under (c) & (d) does not apply & each angle or tee is designed as a single angle or tee connected to one side of gusset.

* Permissible stresses:-

"Direct stresses in axial tension on effective net area should not exceed σ_{at}"

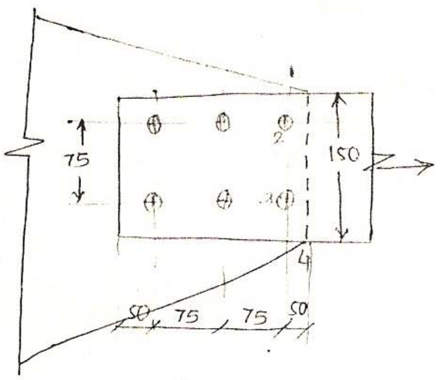
where $\sigma_{at} = 0.6\, f_y$.

f_y = Min. yield stress of steel in MPa.

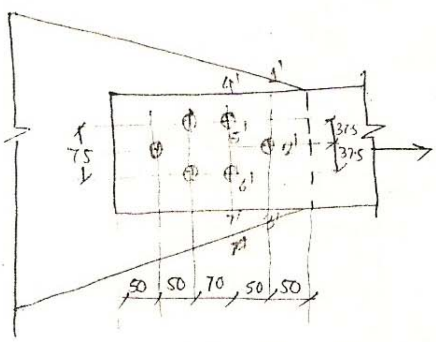
∴ Allowable stress σ_{at} in direct tension for steel conforming to IS 226-1975

Form	Thk. / Dia.	σ_{at} (MPa)
① Plates, angles, Tees, I, channel, Flats	up to 20 mm	150
	21 − 40 mm	144
	> 41 mm	138
② Bars (Round, Square, hexagonal)	up to 20 mm	150
	> 21 mm	144

Pro-1] A flat of size 15×1.2 cm is used as a tension member in roof truss. It can be connected to a GP by two alternate methods of riveting as shown in fig. Calculate max. tension that the flat can carry in both cases if the dia. of rivet is 22 mm & per. stresses in the flat is 150 MPa.



(a)



(b)

Sol^n:- Gross dia of rivet = 22+1.5 = 23.5 mm.

Case (a) - Chain Riveting:-

For most critical sectional area of plate along 1,2,3,4.

$\therefore$ $\boxed{A_{net} = t(b - nd)}$

$\therefore A_{net} = 12(150 - 2\times 23.5)$
$= 1236\ mm^2$

$\therefore$ Max. Tension in flat $= \sigma at \times A_{net}$
$= 150 \times 1236$
$= 185.4$ kN

Case (b):- Staggered Riveting:-

For most critical section consider different sections as,

1) Section 1'-2'-3
2) Section - 1'-2'-6'-7' or section 4'-5'-2'-3'
3) Section - 4'-5'-2'-6'-7'
4) Section 4'-5'-6'-7' - will not be critical as rivet 2' will add strength.

$\therefore$ ① Section 1'-2'-3':-

$\boxed{A_{net} = t\left(b - nd + \frac{s^2}{4g}\right)}$

as s = staggered pitch
= Dist. bet^n two consecutive rivets measured ||el to strain direct^n.
g = Gauge dist.
= Dist. bet^n two consecutive rivets measured ⊥ar to stress direct^n.

$\therefore A_{net} = 12(150 - 1\times 23.5 + 0)$
$= 1518\ mm^2$

In this case s = 0 [for this section]

② Section 1'-2'-6'-7' or 4'-5'-2'-3'.

$A_{net} = t\left(b - nd + \frac{s^2}{4g}\right)$ — 1 Rivet in one line.

$= 12\left(150 - 2\times 23.5 + \frac{150^2}{4\times 37.5}\right)$

$= 1436\ mm^2$

③ Section 4'-5'-2'-6'-7'.

$A_{net} = t\left(b - nd + \frac{s^2}{4g}\right)$

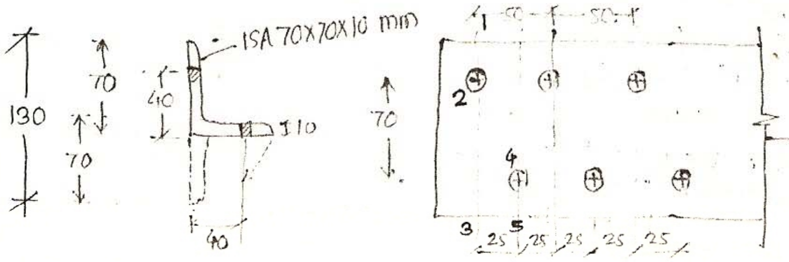
$= 12\left(150 - 3\times 23.5 + \frac{50^2 \times 2}{4\times 37.5}\right) =$ → 2 Rivets in series

$= 1354\ mm^2$

$\therefore$ From 1, 2, 3, Critical section is 4'-5'-2'-6'-7', having $A_{net} = 1354\ mm^2$

$\therefore$ Max. Tension in flat $= \sigma at \times A_{net}$
$= 150 \times 1354$
$= 203.1$ kN

Pro:2] An angle iron ISA 7070x10 mm thk. is used as a tension member connected to a GP by 16 mm dia. rivets through both legs. The rivets are pitched at 50 mm on each leg. The rivets on two legs are staggered by 25 mm as shown in fig. Find the allowable axial tension in the angle section if the per. stresses in tension in 150 MPa.



NOTE :-
Here for simplicity angle section is rotated such that it becomes a plate
∵ as angle is 70X70X10
Total B = 70 + 70 − 10 = 130 mm.
Thk = 10 mm
∴ Dist betn rivets in two legs = 40 + 40 − 30 = 70 mm.

Soln:- Gross dia. of rivet = 16 + 1.5 = 17.5 mm.

consider two cases of critical section as - section 1-2-3 & section 1-2-4-5

① **section 1-2-3**

$$A_{net} = t(b - nd)$$
$$= 10(130 - 1 \times 17.5) = 1125\ mm^2$$

② **Section 1-2-4-5 :-**

For two lies.

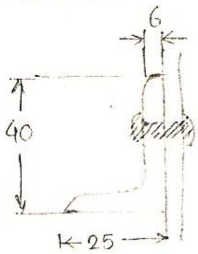
$$A_{net} = t\left(b - nd + \frac{s^2}{4g}\right) + \frac{s^2}{4g}$$
$$= 10\left(130 - 2 \times 17.5 + \frac{1 \times 25^2}{4 \times 70}\right)$$
$$= 972.32\ mm^2$$

∴ Most critical section is 1-2-4-5 having $A_{net} = 972.32\ mm^2$

∴ strength of member = Permissible Tensile load = $\sigma_{at} \times A_{net}$
$= 972.32 \times 150$
$= 145.85\ kN$

Pro:3] Calculate the strength of ISA 40x25x6 mm thk when used as a tension member with its longer leg connected by -

① 14 mm dia. rivet
② Fillet weld



case ① : 14 mm dia Rivet :-

∴ Cross dia = 15.5 mm

∴ $A_{net} = A_1 + A_2 K_1$; A_1 = Net area of connected leg.

$$K_1 = \frac{3A_1}{3A_1 + A_2}$$

$= t(b - nd) - t/2)$
$= 6(40 - 15.5) - 6/2)$
$= 129\ mm^2$

A_2 = ~~Ar~~ Cross area of unconnected leg.

$= \cancel{6(25} \; t\,(b - t/2)$

$= 6(25-3)$

$= 132\ mm^2$

$\therefore K_1 = \dfrac{3A_1}{3A_1 + A_2} = \dfrac{3\times129}{3\times129 + 132} = 0.75$

$\therefore A_{net} = A_1 + A_2 K$

$\therefore A_{net} = 227\ mm^2$

$\therefore$ strength of member $= \sigma_{at} \times A_{net}$

$= 150 \times 227$

$= 34.11\ kN.$

case (II) Fillet weld is used

For fillet weld no deductions for holes.

$\therefore A_{net} = A_1 + A_2 K_1$

$A_1 = t\,(b - t/2) = 6\,(40-3) = 222\ mm^2$

$A_2 = t\,(b - t/2) = 6\,(25 - 6/2) = 132\ mm^2$

$K_1 = \dfrac{3\times222}{3\times222 + 132} = 0.835$

$\therefore A_{net} = 332\ mm^2$

$\therefore$ strength of member $= 150 \times 332$

$= 49.83\ kN.$

Typical Pro.

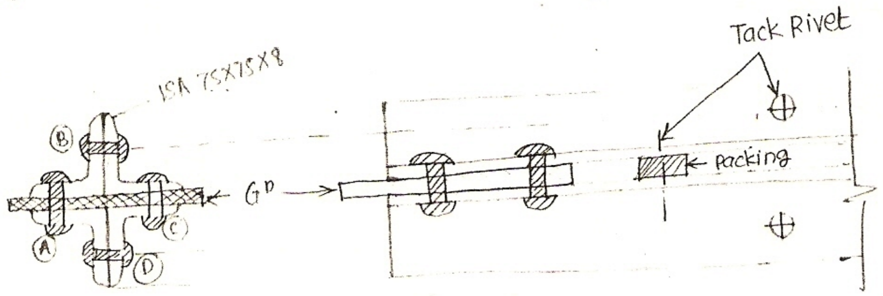
Pro. 4) Calculate the permissible tension in tie member consisting of 4 ISA 75x75, 8 mm thk. connected by 18 mm dia. rivets as shown in fig. when

GATE → (1) - No tacking Rivets are used.

(2) - Tack riveting is done along A & C only.

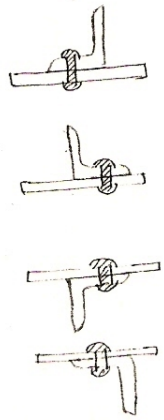
(3) - Tack riveting is done along A, B, C & D

(4) - Tack riveting is done along B & D only



Soln. Case 1: No tacking Rivets are used:-

All angles acts individually. —— as shown →



$\therefore$ It acts as single angle connected by one leg only.

$\therefore$ $\boxed{A_{net} = A_1 + A_2 \cdot K}$

Where A_1 = Net c/s area of connected leg.

$= t\,(b - nd - t/2)$

$= 8\,(75 - 19.5 - 8/2)$

$=$ ~~476 mm²~~ $412\ mm^2$

A_2 = Gross area of connected leg.
$= t(b-nd)$ ~~t~~ $= t(b-t/2)$
$=$ ~~8(75-19.5)~~ $= 8(75-8/2)$
$= 568\ mm^2$

$$K_1 = \frac{3A_1}{3A_1+A_2} = 0.685$$

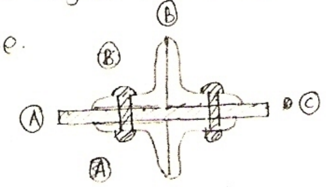
$\therefore A_{net} = 801.16\ mm^2$

$\therefore$ strength of one leg $= \sigma_{at} \times A_{net}$
$= 150 \times 801.16$
$= 120$ kN.

$\therefore$ strength of 4 legs $= 4 \times 120$
$= 480.7$ kN

② When tacking rivets are provided along A & C only.
The angles A & C will acts as in pair on both side of GP.

i.e.



$\therefore$ Angles will acts in pair on both side of GP

$\therefore A_{net}$ = Gross area - deduction for holes.
But; gross area $= 1138\ mm^2$ — steel table
Deduction for hole $= (d \times t) = 19.5 \times 8 = 156\ mm^2$

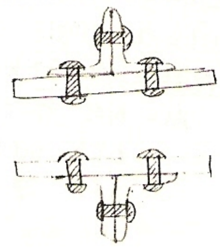
$\therefore A_{net} = 1138 - 156$
$= 980\ mm^2$

$\therefore$ Strength of one leg $= 150 \times 980$
$= 147$ kN.

$\therefore$ Strength of 4 legs $= 4 \times 147$
$= 588$ kN.

③ When tacking riveting is done along A, B, C & D:-
The A_{net} will be same as case (II)
i.e. when taking riveting is done along A & C only.
$\therefore$ strength of 4 legs $= 588$ kN.

④ When tack riveting is done along B & D only.
$\therefore$ This acts as pair of angles placed back to back connected by only one side to the same side of GP.



$\therefore A_{net} = A_1 + A_2 k_2$
A_1 = Net c/s area of connected leg
$= t(b - nd - t/2) = 8(75 - 19.5 - 8/2) = 412\ mm^2$
A_2 = Gross c/s area of outstanding leg
$= t(b - t/2) = 8(75-4) = 568\ mm^2$

$$k_2 = \frac{5A_1}{5A_1 + A_2} = 0.789$$

$\therefore A_{net} = 857.23\ mm^2$
$\therefore$ strength of one ~~leg~~ angle $= 150 \times 857.23 = 128.$ ~~86~~ 59 kN.
$\therefore$ Strength of 4 angles $= 514.34$ kN

* Design of axially loaded Tension member :-

① A_{net} reqd = $\frac{\text{axial load}}{\sigma_{at}}$

② Try suitable section having sectional area 20-40% more than A_{net} reqd.

③ Calculate A_{net} available in the trial section.

Following deductions for rivets holes may be assumed.

ⓐ Flat & plates → 1 rivet hole from 150 mm width.

ⓑ Single angle & Double angle pair → 1 rivet hole from each angle.

ⓒ Four angles forming box → 2 Rivet holes from each angle.

ⓓ Double channel → 2 Rivet holes from each channel web. or 1 rivet hole from each flange.

④ channel section will be safe if,

A_{net} available ≥ A_{net} reqd.

(GATE) → ⑤ check for slenderness Ratio - when reversal of stresses may occur (load*)

According to IS: 800-1984 - Cl. 3.7-

(V. Imp)

ⓐ In any tension member in which reversal of direct stresses due to "load" other than "wind or EQ" forces occurs,	$\lambda = \frac{l_e}{r_{min}} \not> 180$
ⓑ A member normally acting as a "tie" in a roof truss or bracing system but subjected to possible reversal of stress due to action of "wind or EQ" forces	$\lambda = \frac{l_e}{r_{min}} \not> 350$

In short :- stresses { load without WL or EQ ; $\lambda \not> 180$
load due to WL or EQ ; $\lambda \not> 350$ }

⑥ Design end condition connections → Rivet → Rivet Value < Min. of shearing / Min. of bearing
→ weld → l P_q = $0.707\, s \times l \times 108$.
find l_{reqd} assuming size of weld.

⑦ Arrange rivets as far as possible, such the "C.G of section co-insides with CG of rivet group." → Refer ISI Recommendations.

⑧ For weld ; weld should be distributed such that there is no eccentricity bet^n CG of weld & CG of member ⇒ i.e. they must coinsides.

Pro: 1] Design an unequal angle section to act as a tie member 1.56 m long in a roof truss if it is to carry an axial load of 120 kN.

use - ① Hand driven rivets at joints.
② Fillet weld at joint

Design:- Given :- l_e = 1.56 m = 1560 mm.
P = 120 kN.
assume : σ_{at} = 150 MPa

① Riveted connection

① ∴ A_{net} reqd = $\frac{P}{\sigma_{at}}$ = $\frac{120 \times 10^3}{150}$ = 800 mm^2.

∴ Increase A_{net} reqd by 20% as - 960 mm^2

from steel table try for ISA 70×45, 10 mm thick, having A_{pro} = 1052 mm^2 connected by 18 mm dia. rivet to longer leg.

∴ Gross dia = 18+1.5 = 19.5 mm.

② ∴ $A_{net} = A_1 + A_2 \cdot K$

A_1 = Net c/s area of connected leg.

$= 10(70 - 19.5 - 5)$

$= 455\ mm^2$

A_2 = Cross c/s area of outstanding leg

$= 10(45 - 5)$ → b

$= 400\ mm^2$

∴ $K = \frac{3A_1}{3A_1 + A_2} = 0.77$

∴ $A_{net\ pro_1} = 764\ mm^2 < 800\ mm^2$ $A_{net\ reqd}$ ⇒ Hence unsafe. "No need to go for checking strength"

③ ∴ strength of member $= 150 \times 764$
$= 114.65\ kN < 120\ kN$

Revise section

∴ **Unsafe.**

∴ Generally increase A_{net} reqd by 30 %

∴ Try for ISA 75×50×10
having sectional area = 1152 mm^2.

④ $A_1 = 10(75 - 19.5 - 5)$
$= 505\ mm^2$

$A_2 = 10(50 - 5)$
$= 450\ mm^2$

$K_1 = \frac{3 \times 505}{3 \times 505 + 450} = 0.77$

∴ $A_{net\ pro_2} = A_1 + A_2 K_1$
$= 852\ mm^2$

⑤ ∴ strength of member $= 150 \times 852$
$= 127.79\ kN > 120\ kN$

∴ O.K.

⑥ Check for slenderness Ratio:

$\lambda = \frac{le}{r_{min}} = \frac{1560 \rightarrow \text{given}}{10.6 \rightarrow \text{steel table}} = 147 \not> 350$ → for WL & EQ considered
$\not> 180$ → WL & EQ not considered

∴ O.K.

∴ ~~Use ISA 75×10×5 mm~~

∴ **Use ISA 75×50×10 mm thk, @ 9 kgf/m**

⑦ Design of end connection:

Strength of 18 mm ~~of~~ net dia. rivet (hand driven)

ⓐ In shearing $= \tau_{vf} \times \frac{\pi}{4} d^2 = 80 \times \frac{\pi}{4}(19.5)^2 = 23.89\ kN$.

ⓑ In bearing $= \sigma_{bf} \times d \times t = 250 \times 19.5 \times 10 = 48.75\ kN$.

∴ Rivet value = least of ⓐ & ⓑ
$= 23.89\ kN$.

∴ No. of rivets reqd $= \frac{120}{23.89} = 5.02$
≃ 5 Rivets.

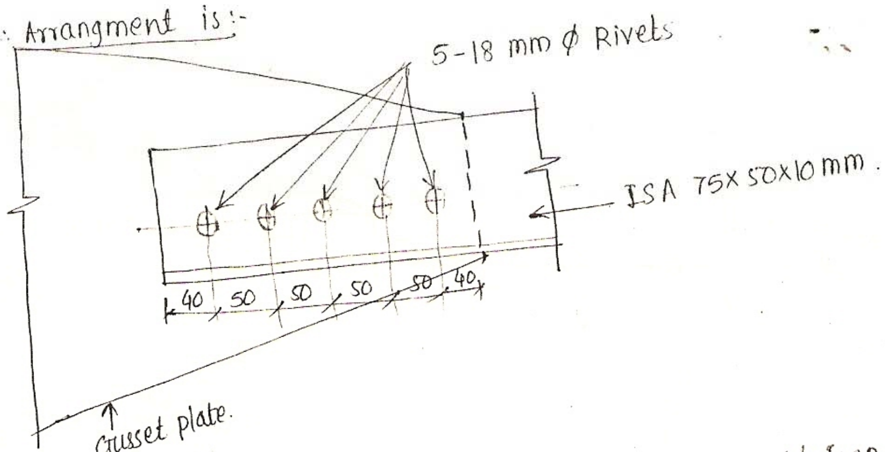
① Connections
② Beam
③ Tension member
④ comp. member
⑤ Footing
⑥ Gantry girder.

(a) ∴ Pitch = 2.5 × d = 48.75 } whichever is lesser
= 200 mm

∴ Provide pitch = 50 mm c/c.

(b) Edge dist = 2d
= 2 × 19.5
= ~~48.75~~ 39 mm
≃ 40 mm.

∴ Arrangment is :-



Case II : Welded member :

① A_{net} reqd = $\frac{P}{6at} = \frac{120\times10^3}{150} = 800\ mm^2$.

Provide Anet more than 10% than Anet reqd.

∴ Try for ISA 90X60X6 mm ;
Gross area = 865 mm²
with longer leg welded to GP.

② ∴ Anet pro = $A_1 + A_2 k_1$

$A_1 = 6(90 - 6/2) = 522\ mm^2$

$A_2 = 6(60 - 6/2) = 342\ mm^2$

$k_1 = \frac{3\times522}{3\times522 + 342} = 0.82$

∴ Anet = 802.69 > 800 mm² ⇒ O.K. → Anetreqd.

③ check for slenderness ratio :-

∴ $\lambda = \frac{le}{r_{min}} = \frac{1560}{12.8} = 121.8 \ngtr 350$

∴ O.K.

∴ **Use ISA 90X60X6 mm @ 6.8 kgf/m** → Ans.

V. Imp. Notes

For Rivet connection Increase Anetreqd by 30%
For welded connection Increase Anetreqd by 10%.
check is given for Ast net reqd & Ast net pro. to save time; no need to calculate strength of member
$l/r = \lambda \ngtr 180$ - NO WL & EQ $l/r = \lambda \ngtr 350$ - WL & EQ consider

④ End connections :-

Size of weld = (Nominal ~~dia~~ thk. - 1.5) → Square edge
= ¾ × thk. of of plate → Rouded edge } See SS: Eccentric connectⁿ notes.

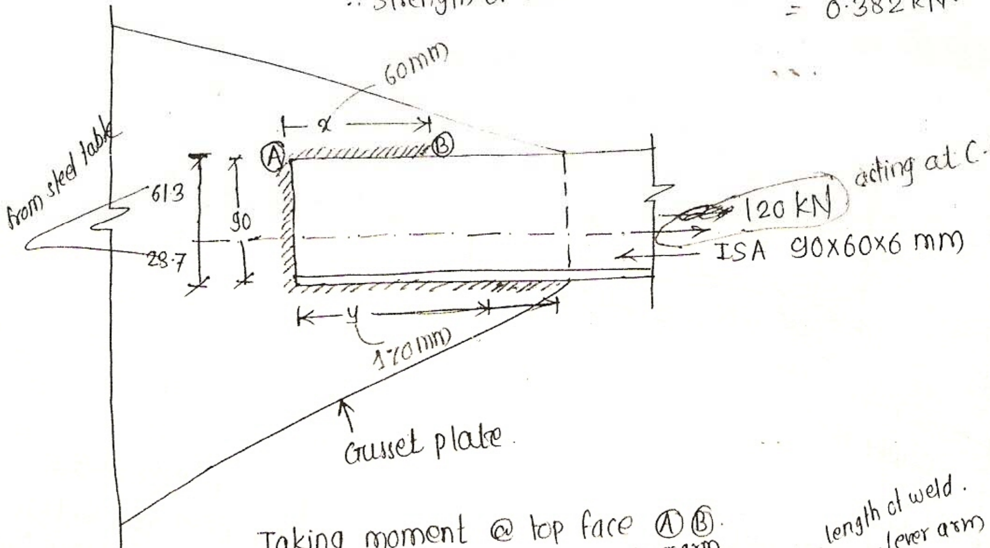
∴ Size of weld = ¾ × 6 = 4.5 mm
say 5 mm.

∴ Equating ; Tensile force = ~~Fe~~ strength of weld / mm length.
~~α~~ 10³ × 120 = 0.707 × S × l × 6at ⟶ see ecc. connectⁿ.
120 × 10³ = 0.707 × 5 × l × 108

∴ length of weld reqd = 314 mm
≈ 320 mm

∴ * This length is distributed in such a way that CG of weld coinsides with CG of angle section –

∴ strength of weld per mm length = 0.707 × 5 × 108
= 0.382 kN.



Taking moment @ top face Ⓐ Ⓑ.

$$\therefore \; 120 \times 10^3 \times 61.3 = 0.382 \times y \times 90 + 0.382 \times 90 \times \frac{90}{2}$$

(length of weld; lever arm)

$\therefore \; y = 168.96$ mm

Provide $y = 170$ mm

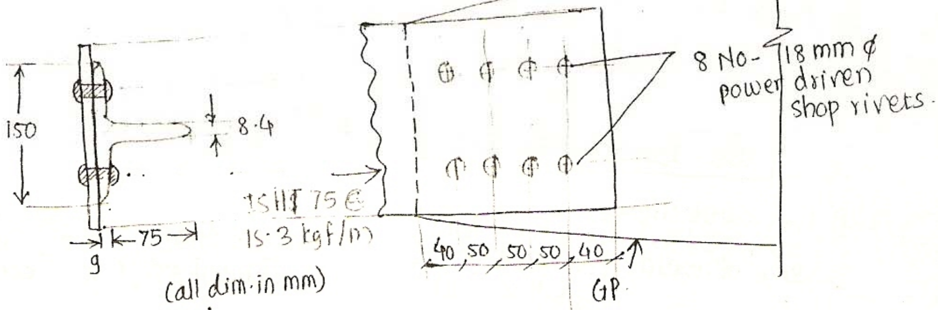
$\therefore \; x = 320 - 90 - 170$
$= 60$ mm

Pro: 2] Design a T section to act as a tension member carrying an axial tension of 220 kN.

Soln :- ① A_{net} reqd $= \dfrac{P}{\sigma_{at}} = \dfrac{220 \times 10^3}{150} = 1467 \text{ mm}^2$

Try ISHT 75 @ 15.3 kgf/m having Gross Area = 1949 mm²
connected by 18 mm dia. power driven shop rivets, as shown in fig.

∴



∴ $A_{net} = A_1 + A_2 K_2$.

A_1 = Net c/s area of connected leg (Flange of T)
$= 9(150 - 2 \times 19.5)$
$= 999 \text{ mm}^2$

A_2 = Area of outstanding leg (web of T)
$= 8.4(75 - 9)$
$= 554.4 \text{ mm}^2$

$\therefore K_1 = \frac{5 \times 999}{5 \times 999 + 554.4} = 0.9$

$\therefore A_{net} = 1498\ mm^2 > 1467\ mm^2$

$\therefore$ O.K.

$\therefore$ Use ISHT 75 @ 15.3 kgf/m

* End connections:-

strength of rivet (18 mm dia. power driven shop rivet)

① In shearing = $\tau_{vf} \cdot \frac{\pi}{4}(d^2)$ ($\tau_{vf} = 100$ MPa)

$= 100 \times \frac{\pi}{4}(19.5)^2$

$= 29.86$ kN

② In bearing = $\sigma_{at} \times d \times t$

$= 300 \times 19.5 \times 9$

$= 52.65$ kN

$\therefore$ Rivet value = 29.86 kN.

$\therefore$ No. of Rivets reqd = $\frac{220}{29.86} = 7.36 \simeq 8$ No's.

= 8 No's.

Pitch = 2.5 d = $2.5 \times 19.5 = 48.75$ mm

Say 50 mm. c/c.

Edge dist = 2d = $2 \times 19.5 = 39$ mm

say 40 mm.

[Draw fig]

Prob 3] Pro: 3] Design a tension member using a channel section to carry an axial tension of 220 kN.

Soln:- A_{net} reqd = $\frac{220 \times 10^3}{150} = 1467\ mm^2$

Try ISJC 200 @ 14.0 kgf/m having sectional area of 1777 mm^2

connected by 16 mm ø power driven shop rivets.

$\therefore$ Gross dia = 17.5 mm.

strength of bolt in -

① Shearing = $\tau_{vf} \times \frac{\pi}{4} d^2 = 100 \times \frac{\pi}{4} \times 17.5^2 = 24.05$ kN

② Bearing = $\sigma_{tf} \times d \times t = 300 \times 17.5 \times 4.1 = 21.52$ kN.

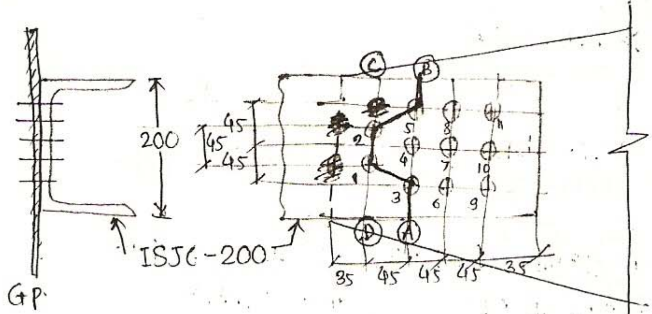
$\therefore$ Rivet value = 21.52 kN.

$\therefore$ No. of rivets reqd = $\frac{\text{Tensile load}}{\text{Rivet Value}} = \frac{220}{21.52} = 10.22 \simeq 11$ No's.

$\therefore$ Pitch = $2.5 \times d = 2.5 \times 17.5 = 43.75 \simeq 45$ mm c/c.

edge dist = 2d = $2 \times 17.5 = 35$ mm $\simeq$ 35 mm.

$\therefore$ Draw fig.



Trial critical section are ① A-3-1-2-5-B.
② C-2-1-3-A
③ C-2-1-D.

① ∴ strength of section A3125B $= \frac{150}{1000}\left[1777-\left(5\times17.5-\frac{4\times45^2}{4\times22.5}\right)\times4.1\right]$

$= 268$ kN.

② strength of section C213A $= \frac{150}{1000}\left[1777-\left(3\times17.5-\frac{45^2}{4\times22.5}\right)\times4.1\right]$

$= 248$ kN

③ strength of section C21D $= \frac{150}{100}\left[1777-2\times17.5\times4.1\right]$

$= 245$ kN.

∴ Critical section is C21D, having strength $= 245\text{kN} > 220$ kN

∴ Safe.

Truss Pro

Pro: 4] Design a tension member using two angle sections to carry 180 kN when both angles connected

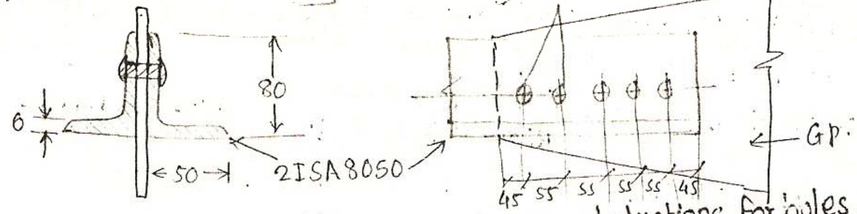
① on both sides of GP

② on same side of GP.

Soln:- Anet reqd $= \frac{P}{\sigma at} = \frac{180\times10^3}{150} = 1200\,mm^2$

① Try 2 ISA 8050, 6 mm thk. angle section having sectional area of $2\times746 = 1492\,mm^2$ connected by 20 mm dia. power driven shop rivets ; angles connected on the side of GP.

[Rivet in double shear]



∴ Anet = ~~A1+A2k~~. Gross area − deductions for holes.

~~=2[746 − 6(21+6 80−21.5)(6+6)21.5]~~

$= 2\,[746 - 21.5\times6] \Rightarrow 2\,[A_g - d.t]$ ↑ double angle

$= 1234\,mm^2 > 1200\,mm^2$ ∴ O.K

∴ strength of member $= \frac{1234\times150}{10^3} = 185.1 > 180$ kN

∴ Safe.

∴ Rivet Value ≠ min. of ⟨ ~~shearing = $\tau_{vf} \times \frac{\pi}{4} d^2 = 100 \times \frac{\pi}{4} \times 21.5^2 = 36.3$ kN~~ $\frac{55}{20}$
Bearing $= \sigma_{tf} \times bd \cdot x t = 300 \times 21.5 \times 6 = 38.7$ kN

∴ Rivet Value = 38.7 kN. Double shear = 2×36.3 kN = 72.6 kN.

∴ No. of Rivets Reqd $= \frac{180}{38.7} = 4.65 \simeq 5$ No's.

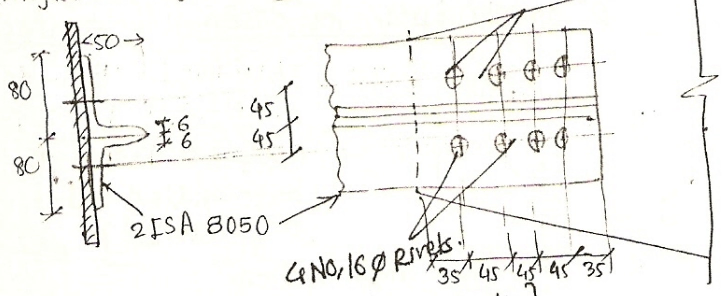
∴ Pitch = 2.5 d = 2.5×21.5 = 53.75 ≃ 55 mm c/c
~~End~~ edge dist = 2.0 d = 2×21.5 = 43 ≃ 45 mm.

v.Imp. * Angles will be taked together along their length by ~~rev~~ rivets at 1m c/c.

Case ii) Try 2 ISA 8050, 6 mm thk. angle section having sectional area = 2×746 = 1492 mm² connected on same side of GP through longer leg by 16 mm dia. power driven rivet.

∴ Gross dia = 17.5 mm

NOTE [Rivet ~~Angles~~ in single shear]



∴ Anet pro = ~~Gross~~ $2[A_1 + A_2 k_2]$

∴ $A_1 = [80 - \cancel{21.5}\ 17.5 - \frac{6}{2}] \times 6 = 357$ mm²

$A_2 = [50 - 6/2] \times 6 = 282$ mm²

$k_2 = \frac{5A_1}{5A_1 + A_2} = 0.86$

∴ Anet pro = 2 [600.5] = 1201.0 mm² > 1200 mm²

Which is safe & Proper.

∴ Rivet value = min. of ⟨ ~~Double shearing = $2 \times 100 \times \frac{\pi}{4} (17.5)^2 = 24.05$~~ 48.1 kN
Bearing = 300×17.5×6 = 31.5 kN.
Single shear $= 100 \times \frac{\pi}{4} (17.5)^2 = 24.05$ kN

∴ Rivet value = 24.05 kN.

∴ No. of Rivets reqd $= \frac{180}{24.05} = 7.48 \simeq 8$ Nos.

∴ Pitch = 2.5 d = 2.5×17.5 = 43.75 ≃ 45 mm c/c.
Edge dist = 2d = 2×17.5 = 35 mm.

v.Imp * ~~Rivets~~ Angles should be tacked together at a pitch of 1000 mm c/c.

∴ Provide 4 rivets for each angle.

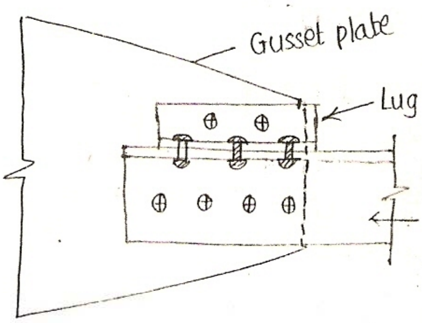
(Aplitute)

[LUG ANGLE]

The lug angle is a short length of an angle section used at a joint to connect the outstanding leg of a member, thereby reducing the length of joint. Gusset plate matl. is saved by using lug angle but extra matl. is reqd. for lug andle & for their connection. Lug angles are also not very effective in transmiting loads & a certain eccentricity is caused betn the load & CG of the rivet group. Therefore use of lug angle is avoided.

A lug angle is provided at the begining of a joint so that it can be effective in shearing load.

★ IS: 800-1984 : Cl. 8.8 : Recommendation for design of lug angles:-



① Lug angle connecting channel section should place symmetrically w.r.t. section of member.

(GATE) ② Lugg angle connecting angle section; or supported member:-

⇒ Strength in lug angle ≮ 1.2 x strength of outstanding leg.
actual wording is → (20% excess of force in outstanding led)

⇒ Attachment of lug angle to angle member ≮ 1.4 x force.
actual wording is (40% excess of that force)

(GATE) ③ Lug angle connecting to channel section; & connection of lug angle to GP or any other supporting member should be capable of developing strength ≮ 1.1 times the force, which is not accounted for by directn connectn of member, and the attachment of lug angle to member should be capable of developing a strength 20% more than that of force.

⇒ [0.5 Times Angle section] —— Please Note. for GATE exam.

④ In no case, should fewer than 2 bolts or rivets be used (i.e. min. 2 No's.) for attaching lug angle to GP or any other member.

⑤ The effective connectn of the lug angle should terminate at end of member connected & fastening of lug angle to member should preferably start in advance of direct connectn of member to GP or any other supporting member. [In fig. both condn unsatisfied]
See Book - Negi - LS.

⑥ When lug angles are used to connect an angle member the whole area of the member should be taken as effective. i.e.

Anet = Gross area − deduction for holes

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TENSION SPLICE

A tension member is spliced when the length of the section available is less than that of tension member reqd. A tension splices is also used when the size of member changes at diff. lengths. Tension splices are the cover plates used on both sides of butt welded jointed members. The area of splices should be slightly more than that that of member joined.

When No. of diff. thk. are spliced ; packing is reqd. to fill the gap. Rivets or bolts carrying a calculated shear stress through a packing more than 6mm thk. should be increased above the no. reqd. by normal calculation by 2.5% ~~each~~ for each 2mm thk. of packing. For double shear connections packed on both sides, the No. of additional rivets or bolts is reqd. to determined from the thk. of ~~thinner~~ thicker packing. The additional Rivets or bolts ~~cot~~ should preferably be placed in an extension of packing.

For problems on "Lug angle" & "Tension splice" see L.S. Negi.

Area of u
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Notes by-

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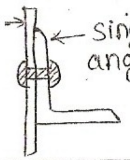
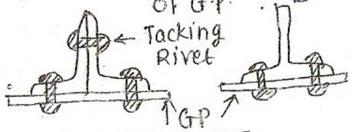
Tension Member

...t Sectional Area:-

...late: a] chain Rivet	$A_{net} = (b-nd) \times t$ b = Width of plate n = No. of Rivets. d = Gross dia. of Rivet t = Thk. of plate.
b] zig-zag	$A_{net} = (b-nd)\cdot t + \frac{s^2 \cdot t}{4g}$ s = staggared Pitch. (∥el to stress) g = Gauge dist. (⊥ar to stress)
...ingle angle ...nected by one ...g only.	$A_{net} = A_1 + A_2K$ A_1 = Anet of connected leg. A_2 = Agross of unconnected leg. $K_1 = \frac{3A_1}{3A_1 + A_2}$



...ir of angles ...aced back to ...ack [or single T] ...nected by only ...e leg of each ...gle (flange of T) the same side GP.



$A_{net} = A_1 + A_2K$

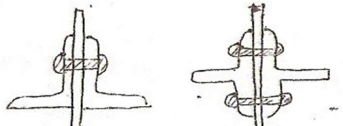
A_1 = Anet of connected leg

A_2 = Agross of unconnected leg. (outstanding)

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

Tacking is must

4] Double angle or T, back to back one each side of GP.



$A_{net} = A_g - \text{Deduct}^n$ for holes

Tack Riveting is must

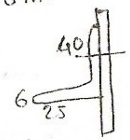
Special Note:- If tacking is not done, $A_{net} \Rightarrow$ case ②

$\sigma_{at} = 0.6 f_y$

$\sigma_{at} = 150\,MPa$

Eg:- ISA ~~70×70×10 mm~~ 40×25×6 mm.

$d = 1~~6~~4 + 1.5 = 15.5$ mm



$\therefore$ case ②

$A_{net} = A_1 + A_2K$

A_1 = Anet of connected leg

$= (b - nd - t/2) \times t$

$= (40 - 15.5 - 6/2) \times 6$

$= 129\ mm^2$

A_2 = Agross of unconnected leg

$= (b - t/2) \times t$

$= (25 - 6/2) \times 6$

$= 132\ mm^2$

$K = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 129}{3 \times 129 + 132} = 0.746$

$\therefore A_{net} = A_1 + A_2K = 129 + 0.746 \times 132$

$= 227\ mm^2$

$\therefore$ strength of member $= \sigma_{at} \times A_{net}$

$= 150 \times 227 \times 10^{-3}$

$= 34.11$ kN.

② When welding is done, no deduction for hole.

$\therefore A_1 = (b - t/2) \times t$

$= (40 - 3) \times 6$

$= 222\ mm^2$

$A_2 = (b - t/2)t$

$= (25 - 3) \times 6$

$= 132\ mm^2$

$\therefore K = \frac{3A_1}{3A_1 + A_2} = 0.835$

$A_{net} = A_1 + A_2K$

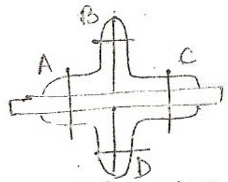
$= 332.16\ mm^2$

$\therefore P = \sigma_{at} \times A_{net}$

$= 49.82$ kN.

Pro:- 4 ISA 75×75×8 mm

$d = 18 + 1.5 = 19.5$ mm.



① No tacking

② A, C tacking

③ A, B, C, D tacking.

④ B, D tacking.

① No tacking:- Each angle acts seperately.

$\therefore A_{net} = A_1 + A_2K$

$A_1 = (b - d - t/2) \times t$

$= (75 - 19.5 - 4) \times 8$

$= 412\ mm^2$

$A_2 = (b - t/2)\,t$
$= (75-4)\times 8$
$= 568\ mm^2$

$\therefore$ ~~Anet~~ $k = \dfrac{3A_1}{3A_1 + A_2}$
$= 0.685$

$\therefore A_{net} = A_1 + A_2 k$
$= 801.16\ mm^2$

$\therefore$ Area of 4 angles $= 3204.6\ mm^2$

$\therefore P = \sigma_{at} \times A_{net}$
$= 150 \times 3204.6 \times 10^{-3}$
$= 480.7\ kN$

② Tacking is done along ~~A & C~~ B & D

$\therefore A_1 = (b - d - t/2)\,t$
$= 412\ mm^2$
$A_2 = 568\ mm^2$

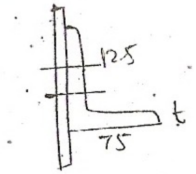
K ~~Anet~~ $= \dfrac{5A_1}{5A_1 + A_2}$
$= 0.789$

$\therefore A_{net} = A_1 + A_2 k$
$= 857.23\ mm^2$

$\therefore P = 857.23 \times 4 \times 150 \times 10^{-3}$
$= 514.34\ kN$

③ If A & C are tacked.
They acts as double angle section connected back to back:
$\therefore A_{net} = A_g -$ deduction for hole
$= 1138 - 19.5 \times 8$
$= 982\ mm^2$
$\therefore P = 982 \times 150 \times 10^{-3} \times 4$
$= 589.2\ kN$

④ Tacking is done to all ~~rivet~~ angles, same as above.



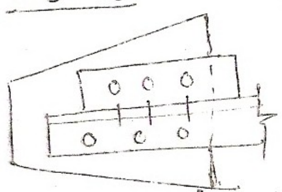
$P = 160\ kN$
$d = 18 + 1.5 = 19.5\ mm$
$t = ?$

Design :- ① $A_{net\,reqd} = \dfrac{P}{\sigma_{at}}$ ⇒ Try for section.

② Find $A_{net\,pro} > A_{net\,reqd}$ ∴ OK

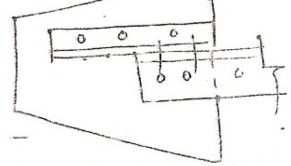
③ check of $\lambda := \dfrac{l_e}{r_{min}} \not> 350$ ∴ O.K.

Lug angle :-



Transfer load to save length of G.P.

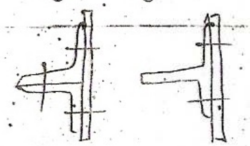
Tension splice



Length of Tension member is less.

① Area of Plate : $A_{net} = (b - nd)\times t$
If joints are staggered, add $\left(\dfrac{s^2 t}{4g}\right)$.

② ~~Single~~ Double angles on same side of GP (back to back)

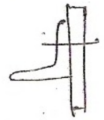


$A_1 = A_{net}$ of connected leg
$= (b - d - t/2)\,t$
$A_2 = A_{gross}$ of connected leg
$= (b - \frac{t}{2}) \times t$

~~Anet = A1~~ $K = \dfrac{5A_1}{5A_1 + A_2}$

$A_{net} = A_1 + A_2 K$

③ Single angle connected to GP



$A_{net} = A_1 + A_2 K$
$A_1 = (b - d - t/2)\,t$
$A_2 = (b - t/2)\,t$
$K = \dfrac{3A_1}{3A_1 + A_2}$

$A_{net} = A_1 + A_2 K$.

④ Double angle on either side of GP.
$A_{net} = A_g -$ deduct^n for hole.