IAT-2 → SOLUTION & SCHEME

DESIGN OF STEEL STRUCTURE

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PART - A

Design an unequal angle single angle section to act as a tie member of length 1.56m in a roof truss, if it is to carry an axial load of 60kN when subjected to possible reversal of stress into compression resulting from the action of wind or earthquake. use 4.6 grade of bo.

Given $L = 1.56m$

load = 60kN

4.6 grade of bolt

Assume $f_y = 250 mpa$

$f_u = 410 mpa$

factored load $= 1.5 \times P = 90kN$

$$T_{dg} = \frac{A_g f_y}{\gamma_{m0}} \quad Pg\ 32 \cdot Cl \cdot 6 \cdot 2$$

$$90 \times 10^3 = \frac{A_g \times 250}{1.1}$$

$$A_g = 396 mm^2 \text{ or } 3.96 cm^2$$

provide 65x45x5 from steel table

$$A_g = 5.26 cm^2 = 526 mm^2$$

$$r_{min} = 0.96 cm \text{ or } 9.6 mm$$

$$\text{slenderness ratio} = \lambda = \frac{l}{r_{min}} = \frac{1590}{9.6}$$

$$102.8 < 180 mm$$

Hence safe

$T_{dg} = \frac{A_g f_y}{\gamma_{m0}} = \frac{526 \times 250}{1.1} = 119.5 \text{ kN} > 90 \text{ kN}$

Hence safe

To find bolt value

· shear capacity of bolt (Pg 75, c/s 10.3.3)

d = 16 mm

d_0 = 18 mm

f_{ub} = 400 mpa

$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} (n_n A_{nb} + n_s A_{sb})$

$= \frac{400}{\sqrt{3}} (0.78 \times \frac{\pi}{4} \times 16^2 \times 1)$

$V_{dsb} = 45.27 \text{ kN}$

Bearing capacity of bolt (Pg 72 c/s 10.3.4)

$V_{dpb} = \frac{2.5 K_b \, d t \, f_u}{\gamma_{mb}}$

$e = 1.7 \times d_0 = 1.7 \times 18 = 30.5 \approx 35 \text{ mm}$

$P = 2.5 \times d = 40 \approx 50 \text{ mm}$.

$\frac{e}{3d_0}, \quad \frac{P}{3d_0} - 0.25, \quad \frac{f_{ub}}{f_u}, \quad 1$

$\frac{35}{3 \times 18}, \quad \frac{50}{3 \times 18} - 0.25, \quad \frac{400}{410}, 1$

0.64, 0.67, 0.97, 1

$\therefore K_b = 0.64$

$V_{dpb} = \frac{2.5 \times 0.64 \times 16 \times 5 \times 410}{1.25} = 41.96 \text{ k}$

Bolt value = min (V_{dpb}, V_{dsb})

= 41.98 kN

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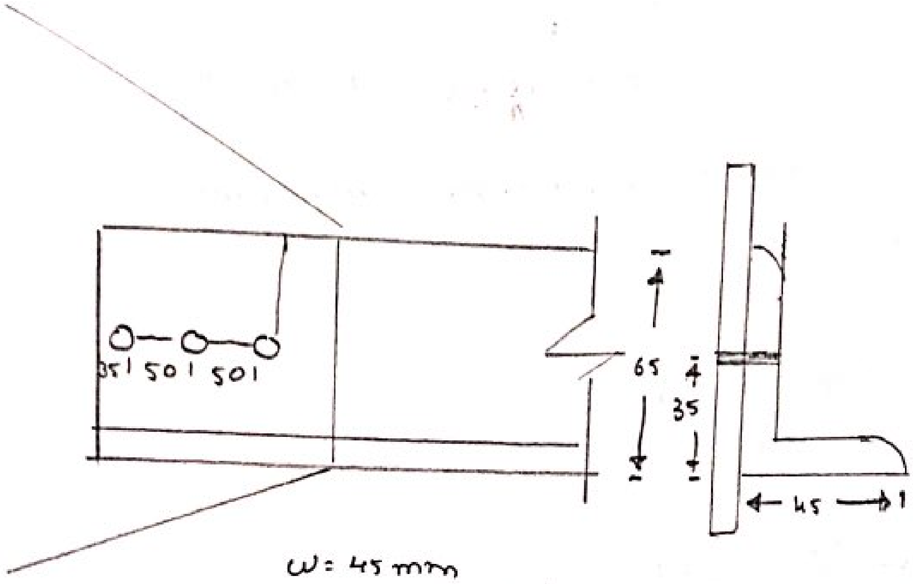
No of bolts $= \frac{90}{41.98} = 2.14 \approx 3$ NO's



$w = 45$ mm

$b_s = 45 + 35 - 5$

$= 75$ mm

$L_c = 2 \times 50 = 100$ mm

$L_v = 2 \times 50 + 35 = 135$ mm

$L_t = 65 - 35 = 30$ mm

Design strength due to rupture [Pg 33 cls 6.3.3]

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

$$= 1.4 - 0.076 \times \left(\frac{45}{5}\right) \times \frac{250}{410} \times \frac{75}{100} \le \frac{410 \times 1.1}{250 \times 1.25} \ge 0.7$$

$$1.087 \le 1.44 \ge 0.9$$

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

$A_{nc} = \left(65 - \frac{5}{2} - 18\right) \times 5$

$= 222.5$ mm^2

$$= \frac{0.9 \times 222.5 \times 410}{1.25} + \frac{1.087 \times 212.5 \times 250}{1.1}$$

$A_{go} = \left(45 - \frac{5}{2}\right) \times 5$

$= 212.5$ mm^2

$T_{dn} = 118.179$ kN

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Design strength due to block shear   Pg 93 Cls 6.4

$A_{vg} = L_v \times t = 135 \times 5 = 675\ mm^2$

$A_{tn} = L_t \times t - n d_n \times t = 30 \times 5 - 0.5 \times 18 \times 5 = 105\ mm^2$

$A_{vn} = L_v \times t - n d_n \times t = 135 \times 5 - 2.5 \times 18 \times 5 = 450\ mm^2$

$A_{tg} = L_t \times t = 30 \times 5 = 150\ mm^2$

$$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\, \gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$$

$$= \frac{675 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 105 \times 410}{1.25} = 162.3\ kN$$

$$T_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\, \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$

$$= \frac{0.9 \times 450 \times 410}{\sqrt{3} \times 1.25} + \frac{150 \times 250}{1.1}$$

$T_{db2} = 110.78\ kN$

$T_{db} = \min(T_{db1}, T_{db2}) = 110.78\ kN$

$T_d = \min$ of T_{dg}, T_{db}, T_{dn}

$T_d = 110.716\ kN$

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n angle section ISA 80x50x8mm is used as a tension member with its longer leg connected by 4mm fillet weld to the 8mm thick gusset plate. determine the tensile strength

ISA 80x5x8

t = 4mm

Ag from steel table = 9.78cm² = 978mm²

$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ (Pg32 . cl 6.2)

$C_x = 2.73cm$
$= 273$ mm.

$= \frac{978 \times 250}{1.1}$

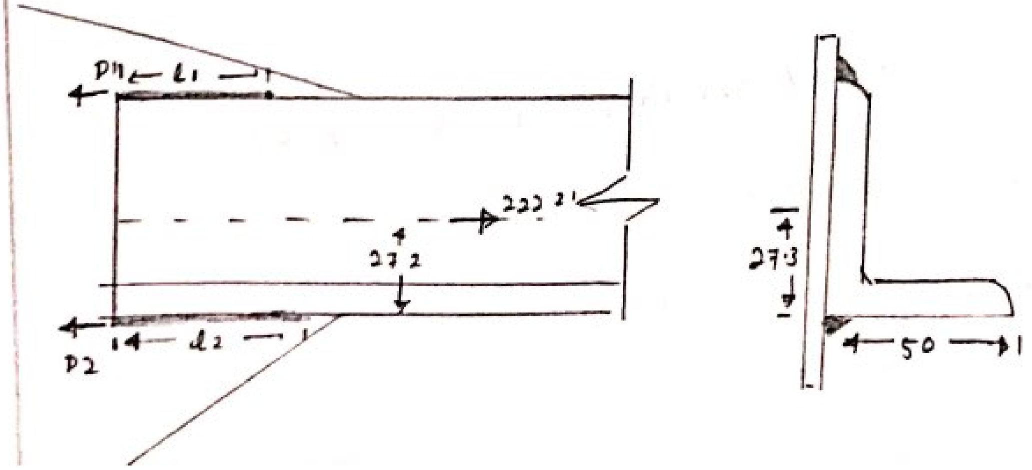
$= 222.22$ KN

Assume shop weld.

strength of weld = $\frac{0.707 \times b d f_u}{\sqrt{3} \times \gamma_{mw}}$ Pg79 . cls . 10.5.7

$P_1 = \frac{0.707 \times l_1 \times 4 \times 410}{\sqrt{3} \times 1.25} = 535.54 l_1$

$P_2 = \frac{0.707 \times l_2 \times 4 \times 410}{\sqrt{3} \times 1.25} = 535.5 l_2$



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Taking moment about P2

$P_1 \times 80 = 222.22 \times 10^3 \times 27.3$

$535.54 \times l_1 \times 80 = 222.22 \times 10^3 \times 27.3$

$l_1 = 141.6 \approx 150mm$

$P = P_1 + P_2$

$222.22 \times 10^3 = 535.54 \times 150 + 535.54 \times l_2$

$l_2 = 264.94 \approx 280$

Design strength due to rupture [Pg 30.33 Cl 6.3.3]

$$\beta = 1.4 - 0.076 \times \frac{w}{t} \times \frac{f_y}{f_u} \times \frac{b_s}{L_c} \leq \frac{f_u \times \gamma_{m0}}{f_y \times \gamma_{m1}} \geq 0.7$$

$$= 1.4 - 0.076 \times \frac{50}{8} \times \frac{250}{410} \times \frac{50}{280} \leq \frac{410 \times 1.1}{250 \times 1.25} \geq 0.7$$

$= 1.34 \leq 1.44 \geq 0.7$

$\beta = 1.34$

$A_{nc} = (80 - \frac{8}{2}) \times 8 = 608 mm^2$

$A_{go} = (50 - \frac{8}{2}) \times 8 = 368 mm^2$

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

$$= \frac{0.9 \times 608 \times 410}{1.25} + \frac{1.34 \times 368}{1.1} \times 250$$

$T_{dn} = 291.55 kN$

Design strength due to block shear [Pg 33 Cl 6.4]

$A_{vg} = A_{vn} = L_t \times t = ~~2~~ 80 \times 8 = 2240 mm^2$

$A_{tn} = A_{tg} = L_t \times t = 80 \times 8 = 640 mm^2$

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$$T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\,\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$$

$$= \frac{2240 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 640 \times 410}{1.25}$$

$$T_{db1} = 482.85 \text{ kN}$$

$$T_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\,\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$

$$= \frac{0.9 \times 2240 \times 410}{\sqrt{3} \times 1.25} + \frac{640 \times 250}{1.1}$$

$$T_{db2} = 527.22 \text{ kN}$$

$$T_{db} = \min(T_{db1}, T_{db2}) = 482.85 \text{ kN}$$

$$T_d = \min(T_{dg}, T_{db}, T_{dn})$$

$$T_d = 222.22 \text{ kN}$$

PART B

1 Find the size of the weld for two plates of size 100mm x 8mm and 100 mm x 12mm. The ultimate stress in weld is 410mpa assume field welding

Sol Both the plates elongate equally under the load and therefore the stress will be equal in both plates. But force carried by both the plates will be different since C/s area will be different

Hence the weld size proportional to thickness of plate is provided.

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$$\frac{D1}{D2} = \frac{8}{12}$$

$D_1 = 0.67 D2$

From Cls NO 6.2 , P-32

Force = stress x area

$T_{dg} = \frac{A_g f_y}{\lambda_{mo}} = \frac{100 \times 8 \times 250}{1.1} = 181.82$ — for plate 1

$T_{dg} = \frac{100 \times 12 \times 250}{1.1} = 272.73 kN$ ⟶ for plate 2

strength of joint = Full strength of thinner plate = 181.82 kN

since there are 2 size of weld

The total strength of weld /mm length

$= 0.707 D_1 \times b \times \frac{f_u}{\sqrt{3}\lambda_{mw}} + 0.707 D_2 \, b \frac{f_u}{\sqrt{3}\lambda_{mw}} = 182.82 \times 10^3 N$

$D2 = \frac{181.82 \times 10^3}{7475.26 \times 11157.70} = 9.76 < 12 - 1.5 = 11.5$ mm safe

$D_1 = 0.67 D2$

$= 0.67 \times 9.76$

$D_1 = 6.5$ mm $\leq 8 - 1.5 = 6.5$ mm safe

Overlap length = 4 x t = 4 x 8 = 32 mm

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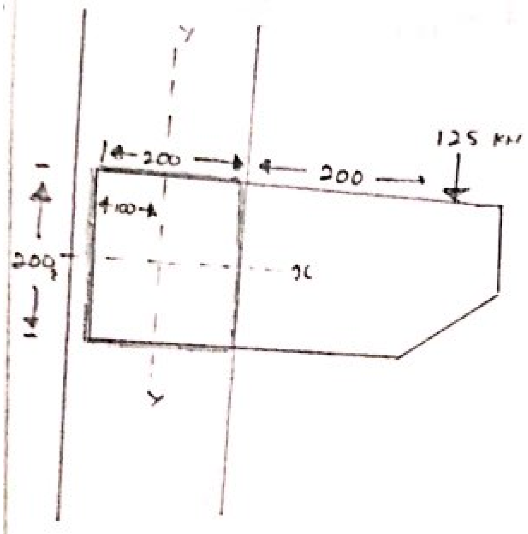
A welded bracket connection of a plate to column flange is having length of 200mm on all four sides and load of 125 kN is 125 kN is acting at distance of 200mm from the face of column. Determine size of the weld



$\bar{x} = \frac{a_1 x_1 + a_2 x_2}{a_1 + a_2} = 100\ mm$

$e = 200 + 100 = 300mm$

$l_w = 2 \times 200 + 2 \times 200 = 800mm$

Stress due to direct load

$f_p = \frac{P}{l_w \times t} = \frac{125 \times 1000}{800 \times t}$

$= \frac{156.25}{t}\ N/mm^2$

Stress due to torsional moment

$f_w = \frac{M \times r}{I_P}$

$I_{xx} = \frac{bd^3}{12} + ah^2$

$= 2 \times \left(\frac{200 \times t^3}{12} + 200 \times t \times 100^2\right) + 2 \times \left(\frac{t \times 200^3}{12} + t \times 200 \times 0\right)$

$I_{xx} = 5.33 \times 10^6\ t\ mm^4$

$I_{yy} = \frac{db^3}{12} + ah^2$

$2 \times \left(\frac{t \times 200^3}{12} + 200 \times t \times 0\right) + 2 \times \left(\frac{200 \times t^3}{12} + 200 \times t \times 100^2\right)$

$= 5.33 \times 10^6\ t\ mm^4$

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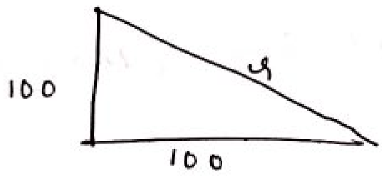
$I_p = I_{xx} + I_{yy} = 10.66 \times 10^6 t \ mm^4$

$M = P \times e = 125 \times 10^3 \times 300 = 37.5 \times 10^6 \ mm^4$

$r = \sqrt{100^2 + 100^2} = 141.72$



$f_w = \dfrac{37.5 \times 10^6 \times 141.72}{10.66 \times 10^6 \times t} = \dfrac{497.49}{t} \ N/mm^2$

$\cos\theta = \dfrac{100}{141.42} = 0.7$

$R = \sqrt{f_p^2 + f_w^2 + 2 \times f_p \times f_w \times \cos\theta}$

$R = \sqrt{\left(\dfrac{156.25}{t}\right)^2 + \left(\dfrac{497.49}{t}\right)^2 + 2 \times \dfrac{156.25}{t} \times \dfrac{497.49}{t} \times 0.7}$

$R = \dfrac{617}{t} \ N/mm^2$

Strength of weld = Resultant force

Assuming shop weld

$\dfrac{0.707 f_u}{\sqrt{3} \times \gamma_{mw}} = R$

$\dfrac{0.707 \times 410}{\sqrt{3} \times 1.25} = \dfrac{617}{t}$

$t = 4.6mm \approx 6mm$

∴ Provide 6mm size weld.

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