Q.

Design a suitable double-angle discontinuous strut in a steel truss to carry a working axial compressive load of 200 kN. The effective length of the strut is 2·12 m. Use a gusset plate of 20 mm thick. Assume column buckling class c. $f_y = 250$ MPa, $f_u = 400$ MPa, $\gamma_{mb} = 1{\cdot}25$.

Relevant portion of the code books is enclosed.

**Solution :-** Assuming $f_{cd} = 0.5 f_y$

$$f_{cd} = 0.5 \times 250$$

$$\boxed{f_{cd} = 125 \quad N/mm^2}$$

Effective sectional area required

$$A_e = \frac{P}{f_{cd}} = \frac{1.5 \times 200 \times 10^3}{125}$$

$$\boxed{A_e = 2400 \ mm^2}$$

cross sectional area of a single Angle = $\frac{2400}{2} = 1200\ mm^2$

- selecting ISA 80 x 80 x 8, $A = 1221\ mm^2 > 1200\ mm^2$

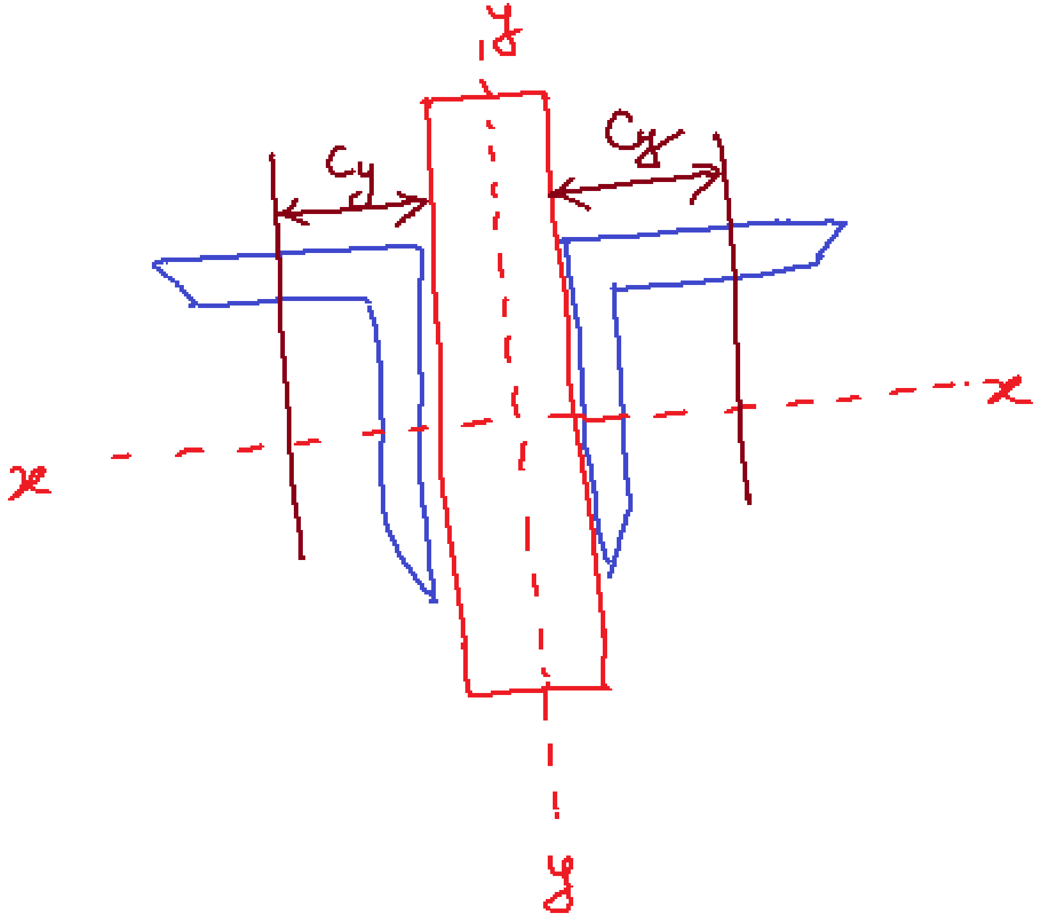
properties of ISA 80 x 80 x 8

$C_x = C_y = 22.7\ mm$

$I_{xx} = I_{yy} = 72.5 \times 10^4\ mm^4$

$r_x = r_y = 24.4\ mm$

- let Angles are placed opposite side of the gusset plate




$$A' = 2A$$

$$A' = 2 \times 1221$$

$$\boxed{A' = 2442\ mm^2}$$

$$I'_x = 2 I_x$$

$$A' = 2A$$

$$r'_x = \sqrt{\frac{I'_x}{A'}} = \sqrt{\frac{2 I_x}{2A}} = r_x$$

$$r_x' = r_x = 24.4\,mm$$

$$\boxed{r_x' = 24.4\,mm}$$

$$I_y' = 2\left[I_y + Ah^2\right]$$

$$I_y' = 2\left[I_y + A\left(C_y + \frac{t_g}{2}\right)^2\right]$$

$$I_y' = 2\left[72.5 \times 10^4 + 1221 \times \left(22.7 + \frac{20}{2}\right)^2\right]$$

$$\boxed{I_y' = 406.12 \times 10^4 \quad mm^4}$$

$$r'_y = \sqrt{\frac{I'_y}{A'}} = \sqrt{\frac{406.12 \times 10^4}{2442}}$$

$$\boxed{r'_y = 40.78 \text{ mm}}$$

$$r_{min} = (r'_x , r'_y)$$

$$r_{min} = (24.4 \text{ mm}, 40.78 \text{ mm})$$

$$\boxed{r_{min} = 24.4 \text{ mm}}$$

$$\lambda = \frac{l_e}{r_{min}} = \frac{2.12 \times 10^3}{24.4} = 86.88$$

$$\boxed{\lambda = 86.88} < 350 \quad \text{OK} \checkmark$$

From the buckling class 'c'

| $\lambda$ | $f_{cd}$ |
|---|---|
| 80 | 136 |
| 86.88 | $f_{cd}$ |
| 90 | 121 |

$$\frac{90-80}{121-136} = \frac{90-86.88}{121-f_{cd}}$$

$$\boxed{f_{cd} = 125.68 \ N/mm^2}$$

Design capacity, $P_d = f_{cd} \times A'$

$$P_d = (125.68 \times 2442) \times 10^{-3}$$

$$\boxed{P_d = 306.91 \ KN}$$

$\because \; (P_u = 300 \text{ kN}) < (P_d = 306.91 \text{ kN})$

$\therefore$ Safe

# Design of Bolted Connection

Assuming diameter of bolt = 20mm

$d = 20mm$

$d_0 = 22mm$

⊙ Design shearing strength of bolt

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

$$V_{dsb} = \frac{400}{\sqrt{3} \times 1.25}\left(1 \times 0.78 \times \frac{\pi}{4} 20^2 + 1 \times \frac{\pi}{4} 20^2\right) \times 10^{-3}$$

$$\boxed{V_{dsb} = 103.314 \text{ kN}}$$

⊙ Design bearing strength of bolt

$$V_{dpb} = \frac{2.5\, k_b\, (dt)\, f_u}{\gamma_{mb}}$$

$e_{min} = 1.5\, d_0 = 33\,mm$

$p_{min} = 2.5\, d = 50\,mm$

Assuming

| |
|---|
| $e = 35\,mm$ |
| $p = 50\,mm$ |

$$k_b = \min\left[\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1\right]$$

$$k_b = \min\left[\frac{35}{3 \times 22}, \frac{50}{3 \times 22} - 0.25, \frac{400}{410}, 1\right]$$

$$k_b = \min\left[0.53, 0.507, 0.97, 1\right]$$

$$\boxed{k_b = 0.507}$$

$$t = \min[2 \times 8 \text{ mm}, 20 \text{ mm}]$$

$$\boxed{t = 16 \text{ mm}}$$

$$V_{dpb} = \frac{2.5 \times 0.507 \times 20 \times 16 \times 410}{1.25} \times 10^{-3}$$

$$\boxed{V_{dpb} = 133.04 \text{ kN}}$$

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

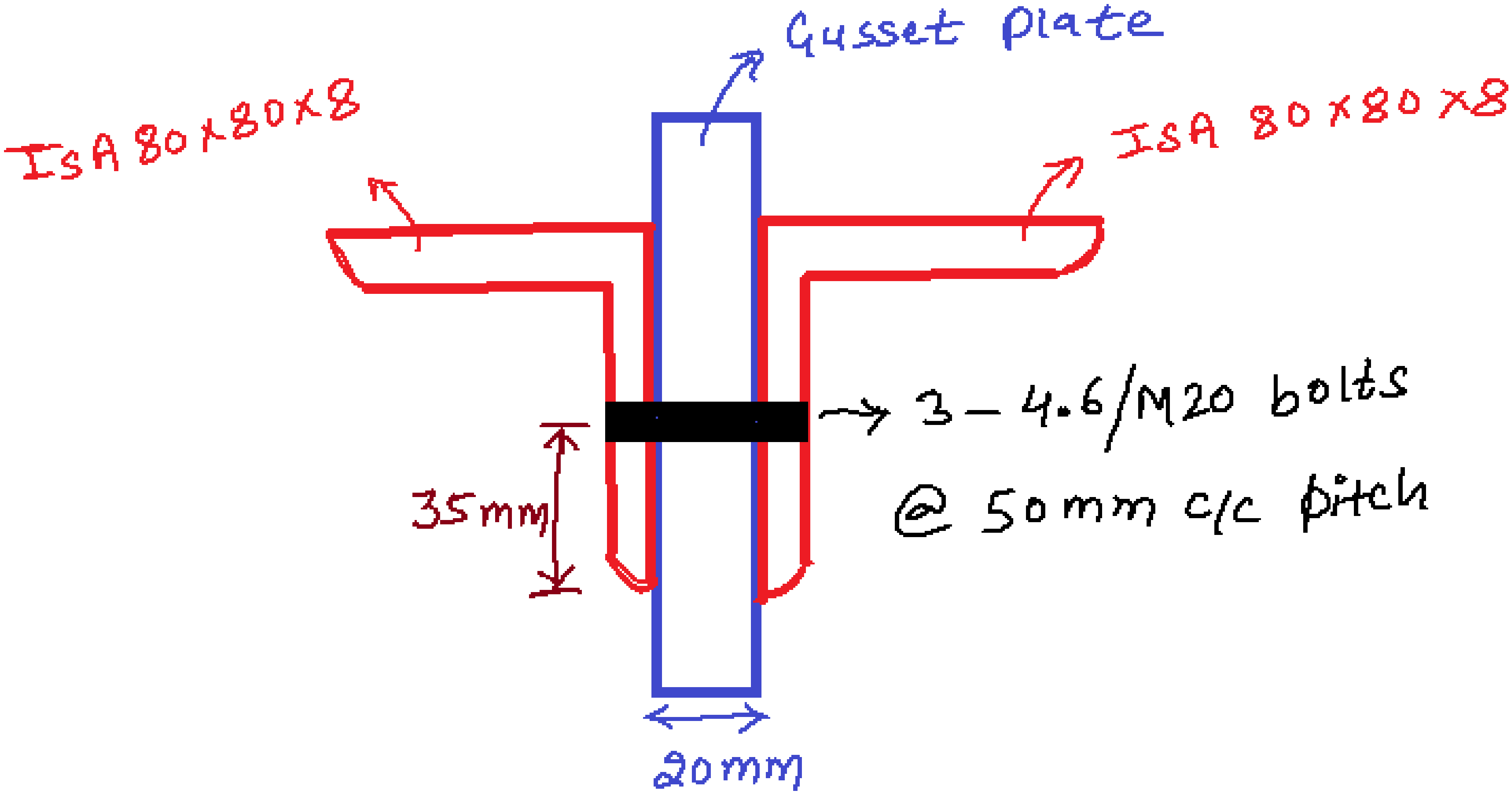
$$V_{db} = 103.314 \text{ kN}$$

No. of bolts required $= \dfrac{P_u}{V_{db}}$

$$N = \frac{300}{103.314} = 2.9$$

$$N = 3$$

Providing 3 bolts of 20 mm diameter @ 50 mm c/c pitch


Gusset plate
ISA 80x80x8
ISA 80x80x8
3 – 4.6/M20 bolts
@ 50mm c/c pitch
35mm
20mm