Design of Tension member

Design a tie member of roof truss subjected to working loads of DL 80kN and LL 120kN. Use double angle section connected back to back on either side of the gusset plate 8mm thick. Use bolted connection. Take fy=250 MPa and fu=410 MPa for both member and bolt material.

Solution :

Factored load = 1.5 (DL + LL)

= 1.5 (80 + 120)

= 300 kN

T = factored design tension

= 300 kN

$f_y = 250 \text{ N/mm}^2$

$$\therefore \quad A_g \text{ required} = \frac{T}{f_y} \cdot \gamma_{mo}$$

$$= \frac{300 \times 10^3}{250} \times 1.10 = 1320 \text{ mm}^2$$

Choose two ISA 75 × 50 × 6 mm from steel table

$A_g = 2 \times 716$

$= 1432 \text{ mm}^2$

(i) Strength governed by yielding of gross section :

$T_{dg} = A_g \cdot f_y/\gamma_{mo}$

$= 1432 \times 250/1.10$

$= 325454$ N

= 325.45 kN > 300 kN ...... ∴ OK

- **Design of bolts :**

d = 20 mm

$d_h = 20 + 2 = 22$ mm

Minimum pitch = 2.5 × d

= 2.5 × 20 = 50 mm

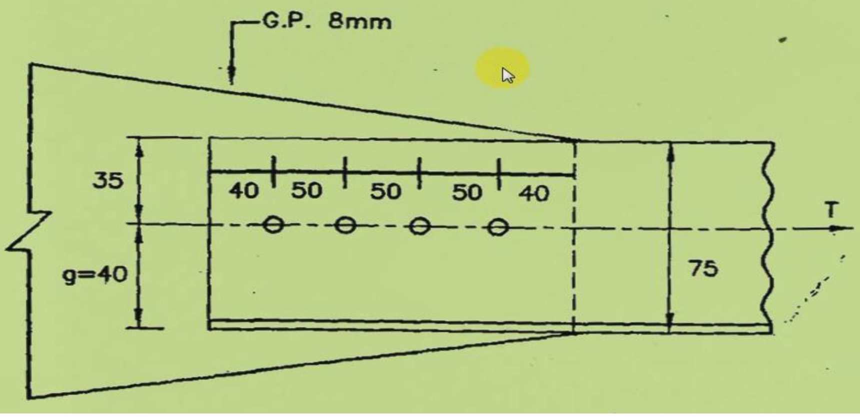
Minimum end distance = $1.7\ d_h$

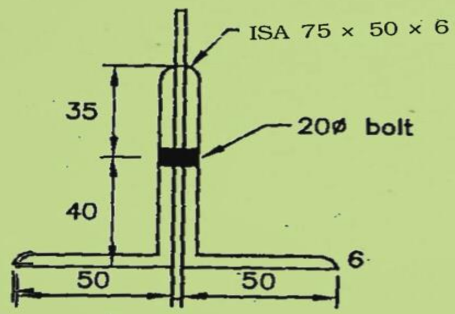
= 1.7 × 22

= 37.4 mm say 40 mm

Strength of 20 ϕ bolts in double shear = 90.6 kN

No. of bolts required $= \dfrac{300}{90.6} = 3.31$ say 4 nos.





(i) Strength governed by rupture of net section :

$T_{dn} = 2 \times [0.9\ A_{nc} \cdot f_u/\gamma_{m1} + \beta \cdot A_{go}\ f_y/\gamma_{mo}]$

g = 40 mm for ISA 75 × 50 × 6 mm (Form H.B. SP-1)

w = 50 mm

$b_s = 50 + 40 - 6 = 84$ mm

$L_c = 3 \times 50 = 150$ mm

$\therefore \quad \beta = 1.4 - 0.076 \left(\dfrac{w}{t}\right)\left(\dfrac{f_y}{f_u}\right)\left(\dfrac{b_s}{Lc}\right)$

$= 1.4 - 0.076 \left(\dfrac{50}{6}\right)\left(\dfrac{250}{410}\right)\left(\dfrac{84}{150}\right)$

$= 1.4 - 0.216$

$= 1.184 > 0.7$

$A_{nc} = \left(75 - \dfrac{6}{2} - 22\right) \times 6 = 300\ mm^2$

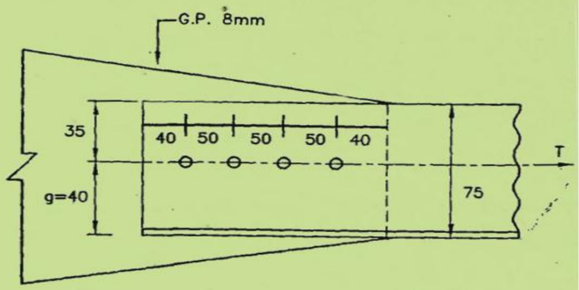
$A_{go} = \left(50 - \dfrac{6}{2}\right) \times 6 = 282\ mm^2$

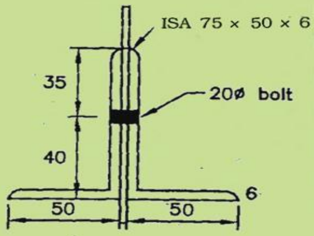
$\therefore \quad T_{dn} = 2 \times [0.9 \times 300 \times 410/1.25 + 1.184 \times 282 \times 250/1.10]$

$= 2 \times (88{,}560 + 75{,}883)$

$= 328{,}886$ N

= 328.88 kN > 300 kN .... OK





(iii) Strength governed by block shear : [For one angle]

$A_{vg} = (3 \times 50 + 40) \times 6 = 1140\ mm^2$

$A_{vn} = (3 \times 50 + 40) - 3.5 \times 22) \times 6 = 678\ mm^2$

$A_{tg} = 35 \times 6 = 210\ mm^2$

$A_{tn} = (35 - 0.5 \times 22) \times 6 = 144\ mm^2$

$\therefore \quad T_{db1} = A_{vg} \cdot f_y/(\sqrt{3} \cdot \gamma_{mo}) + 0.9\ A_{tn} \cdot f_u/\gamma_{m1}$

$= 1140 \times 250/(\sqrt{3} \times 1.10) + 0.9 \times 144 \times 410/1.25$

$= 149.586 + 42{,}508.8$

$= 192094.8$ N

$= 192.09$ kN

$T_{db2} = 0.9\ A_{vn} \cdot f_u/(\sqrt{3} \times \gamma_{m1}) + A_{tg} \cdot f_y/\gamma_{mo}$

$= 0.9 \times 678 \times 410/(\sqrt{3} \times 1.25) + 210 \times 250/1.10$

$= 115{,}554 + 47{,}727.27$

$= 163{,}281$ N

$= 163.28$ kN

Smaller of T_{db1} and T_{db2} is 163.28 kN

$\therefore$ Block shear strength for 2-ISA,

$T_{db} = 2 \times 163.28$

= 326.56 kN > 300 kN .... ∴ OK