Q. Design a double angle tension member connected on each side of a 10 mm thick gusset plate, to carry an axial factored load of 375 kN, use 20 mm black bolts. Assume shop connection.

Ans. Area required from the consideration of yielding

$$= \frac{1.1 \times 375 \times 1000}{250} = 1650 \text{ mm}^2$$

Try 2 ISA 75 X 50, 8 mm thick which has gross area = 2X938 = 1876 mm²

Strength of 20 mm black bolts.

(a) In double shear $= \left[\frac{\pi}{4} \times 20^2 + .78 \times \frac{\pi}{4} \times 20^2\right] \times \frac{400}{\sqrt{3}} \times \frac{1}{1.25}$

$= 103314$ N

(b) Strength in bearing

Taking e = 40 mm, p = 60 mm.

$K_b = \frac{40}{3 \times 22}, \frac{60}{3 \times 22} - .25, \frac{400}{410}, 1.0$ is Smaller one

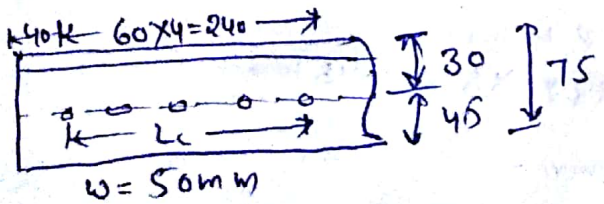
$K_b = .606$

$\therefore V_{dpb} = \frac{1}{1.25} \times 2.5 \times 0.606 \times 20 \times 8 \times 400 = 77568$ N

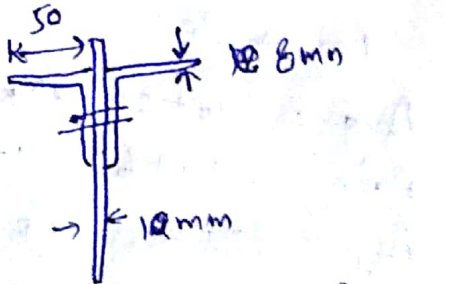
$\therefore$ Bolt Value = 77568 N

No. of bolts required $= \frac{375000}{77568} = 4.83$

Provide 5 bolts in a row.



$b_s = 50 + 35 - 8 = 75$ mm



$L_c = 60 \times 4 = 240$ mm

Checking the design. ①

(a) Strength against yielding $= \frac{A_g \cdot f_y}{\gamma_{mo}} = \frac{1876 \times 250}{1.1}$

$= 426364\,N > 375 \times 1000$

(b) Strength of plate in rupture.

Area of connected leg,

$A_{nc} = 2\left(75 - 22 - \frac{8}{2}\right) \times 8 = 784\,mm^2$

Area of outstanding leg,

$A_{go} = 2 \times \left(50 - \frac{8}{2}\right) \times 8$

$= 736\,mm^2$

$\beta = 1.4 - 0.076 \times \frac{w}{t} \times \frac{f_y}{f_u} \times \frac{b_s}{L_c}$

$= 1.4 - 0.076 \times \frac{50}{8} \times \frac{250}{410} \times \frac{77}{240}$

$= 1.307$

$\therefore T_{dn} = \frac{0.9 f_u A_{nc}}{\gamma_{n1}} + \frac{\beta A_{go} \cdot f_y}{\gamma_{mo}}$

$= \frac{0.9 \times 410 \times 784}{1.25} + 1.307 \times \frac{736 \times 250}{1.1} = 450062 > 375000\,N$

O.K.

(c) Strength against block shear failure!

Per angle!

$A_{vg} = (40 + 60 \times 4) \times 8 = 2240\,mm^2$

$A_{vn} = (40 + 60 \times 4 - 4.5 \times 22) \times 8 = 1448\,mm^2$

$A_{tg} = (75 - 35) \times 8 = 320\,mm^2$

$A_{tn} = (75 - 35 - 0.5 \times 22) \times 8 = 232\,mm^2$

Strength against block failure of each angle is the smaller of the following two values.

$$= \frac{A_{vg} \cdot f_y}{\sqrt{3}\,\gamma_{m0}} + \frac{0.9 \times A_{tn} f_y}{\gamma_{m1}}$$

$$= \frac{2240 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 232 \times 410}{1.25}$$

$$= 362410 \text{ N}$$

(ii) $$= \frac{0.9 \cdot A_{vn} f_u}{\sqrt{3}\,\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$

$$= \frac{0.9 \times 1448 \times 410}{\sqrt{3} \times 1.25} + \frac{320 \times 250}{1.1}$$

$$= 319515 \text{ N}$$

∴ Strength of two angles against block failure

$$= 2 \times 319515 > 375000$$

Hence use 2 ISA 75 50, 8 mm with 5 bolts of 20 mm dia.

Q.2. Design a single angle strut connected to the gusset plate to carry 180 KN factored load. the length of the strut b/w c/c connection is 3m.

Sol. Assuming $f_{cd} = 90 \text{ N/mm}^2$

$$A = \frac{180 \times 10^3}{90} = 2000 \text{ mm}^2$$

Try ISA 9090, 12mm, which has $A = 2019 \text{ mm}^2$

$$r_{min} = r_{vv} = 17.4 \text{ mm}$$

Assuming the struts will be connected to the gusset plate with atleast 2 bolts (Strength of 20 mm bolt in single shear is about 45 kN)

$$\frac{KL}{r} = \frac{2550}{17.4} = 146.55$$

from the table 6.1(c)

for $f_y = 250\ N/mm^2$

when $\frac{KL}{r} = 140$, $f_{cd} = 60.2$

$\frac{KL}{r} = 150$, $f_{cd} = 59.2$

$\therefore$ when $\frac{KL}{r} = 146.55$

$$f_{cd} = 58.4 - \frac{6.55}{10}(58.4 - 52.6) = 54.6\ N/mm^2$$

$\therefore P_d = A f_{cd} = 2019 \times 54.6 = 110239 < 1800\,00\,N$

Hence revise the section

Try ISA 130X130, 8 mm

$\therefore \frac{KL}{r} = \frac{2550}{25.5} = 100$

$\therefore f_{cd} = 107\ N/mm^2$

$\therefore P_{cd} = 2022 \times 107 = 216354 > 180{,}000N$

Provide ISA 130X130, 8mm.

(3)

Q. Explain any 5 important points on Lacing in Comp. Member.

Ans (1) The slenderness ratio $\frac{KL}{\gamma}$ for Lacing bars should not exceed 145

(2) Lacing bars shall be inclined at 40° to 70° to the axis of built up member.

(3) In bolted/riveted construction, the min. width of lacing bars shall be three times the nominal dia. of the bolts/rivets

(4) the thickness of the flat lacing bars shall not be less than $1/40^{th}$ of its effective length for single lacing and $1/60^{th}$ of the effective length for double lacing

(5) Laced compression members shall be provided with end tie plates.