Sub:- Structural Design -II

Sem - 5th Sem

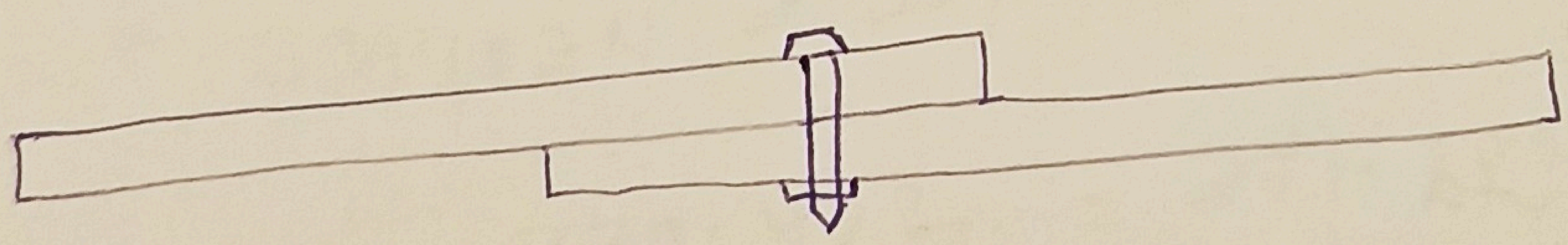
Q1.

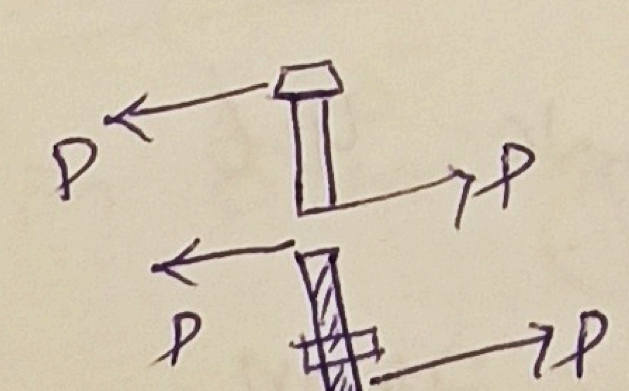
a) A riveted steel connection is made betn two plates overlapping at edges, making holes through thickness of both the members, passing the stem of the rivet through holes, and creating the head at the end of the stem on the other side.

b) There are two types of bolt connection

1) Lap joint
2) Butt joint

c) The location of maximum shear in the bolt is commonly referred to as a shear plane.





Shear plane on thread

2a) Design strength of the bolt V_{dsb} is given by

$$V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}}$$

V_{nsb} - nominal shear capacity of bolt and

γ_{mb} = partial safety factor of material of bolt

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

$A_{nb} = \frac{\pi}{4} d^2, 0.78$

f_{ub} = ultimate tensile strength of the bolt

A_{sb} = nominal shank area of the bolt

b) The following principals are observed in the design of connection:-

1) The centre of gravity of bolts should coincide with the centre of gravity of the connected members.

2) The length of connection should be kept as small as possible.

c) It is defined as the ratio of strength of joint and strength of solid plate in tension.

$$\text{efficiency } \eta = \frac{\text{Strength of joint}}{\text{Strength of solid plate}} \times 100$$

3a)

Given data

For M20 bolts of grade 4.6

diameter of bolt $d = 20\,mm$

diameter of bolt hole $d_0 = 22\,mm$

Ultimate strength $f_{ub} = 400\,Mpa$

partial safety factor $\gamma_{mb} = 1.25$

For Fe410 (E 250) plates

$f_u = 410\,Mpa$ $\quad \gamma_{m1} = 1.25$

Strength of plates in the joint:—

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}} =$$

$A_n = (b - n d_0) t$

$= (180 - 3 \times 22) 20 = 2280 \text{ mm}^2$

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}} = \frac{0.9 \times 410 \times 2280}{1.25} = 673056 \text{ N} = 673.056 \text{ kN}$$

Strength of bolts in shear

$$V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}}$$

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

$A_{nb} = 0.78 \times \frac{\pi}{4} d^2$

$= 0.78 \times \frac{\pi}{4} \times 20^2$

$= 245 \text{ mm}^2$

$n_n = 1 \times 6 = 6$

$n_s = 0$

$$= \frac{400}{\sqrt{3}} (6 \times 245 + 0)$$

$= 339482 \text{ N} = 339.482 \text{ kN}$

$$V_{dsb} = \frac{339.482}{1.25} = 271.586 \text{ kN}$$

Design strength in bearing

$$V_{dpb} = \frac{V_{npb}}{\gamma_{mb}}$$

$V_{npb} = 2.5 k_b d \cdot t \cdot f_u$

$$k_b = \frac{e}{3 d_0} = \frac{30}{3 \times 22} = 0.4545$$

$$k_b = \frac{p}{3 d_0} - 0.25 = \frac{60}{3 \times 22} - 0.25 = 0.6591$$

$$k_b = \frac{f_{ub}}{f_u} = \frac{400}{410} = 0.9756$$

$k_b = 1$

$k_b = 0.4545$

$V_{npb} = 2.5 \times 0.4545 \times 20 \times 20 \times 410 = 186345\ N$ per bolt

Design Strength $= \frac{V_{npb}}{\gamma_{mb}} = \frac{186345}{1.25} = 149076\ N$

Design strength of joint $= 6 \times 149076 = 894456.8\ N$

$= 894.456\ kN$

Design strength of bolts in joint $= 271.586\ kN < T_{dg}$

efficency of joint

Area of solid plate $= 180 \times 20 = 3600\ mm^2$

Design strength of solid plate

$\frac{f_y}{\gamma_{mo}} \times A_g = \frac{250}{1.1} \times 3600 = 818181.8\ N$

$= 818.182$

$\eta = \frac{\text{strength of joint}}{\text{strength of plate}} \times 100\ \%$

$= \frac{271.586}{818.182} \times 100 = 33.19\ \%$

3 b)

For rolled steel section:—

$f_y = 250\ N/mm^2$, $f_u = 410\ N/mm^2$ $E = 2\times10^5\ N/mm^2$

For both end pinned columns

$KL = L = 3$

For ISHB 300 @ 577 N/m

$h = 300\ mm$ $b_f = 250\ mm$ $t_f = 10.6\ mm$ $A_e = A = 7484\ mm^2$

$\frac{h}{b_f} = 1.2$ and $t_f < 40\ mm$

It falls under buckling class b for buckling about Z-Z axis and under class 'c' for buckling about y-y axis

From steel table $r_{min} = r_{yy}$ 54.1 mm

$$f_{cc} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{\pi^2 \times 2\times10^5}{\left(\frac{3000}{54.1}\right)^2} = 641.92\ N/mm^2$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{250}{641.92}} = 0.624$$

For buckling class b $\alpha = 0.34$

$$\phi = 0.5[1+\alpha(\lambda-0.2)+\lambda^2)$$

$$= 0.5[1+0.34(0.624-0.2)+0.624^2)$$

$$= 0.767$$

$$f_{cd} = \frac{f_y/\gamma_{m0}}{\phi+(\phi^2-\lambda^2)^{0.5}} = \frac{250/1.1}{0.767+(0.767^2-0.624^2)^{0.5}}$$

$$= 187.36\ N/mm^2$$

Strength of column $= P_d = A_c f_{cd} = 7484 \times 187.38$

$= 1402237\ N$

$= 1402.237\ KN$

Working Load $= \frac{1402.237}{1.5} = 934.823\ KN$