PROBLEMS ON ECCENTRIC BOLTED CONNECTIONS

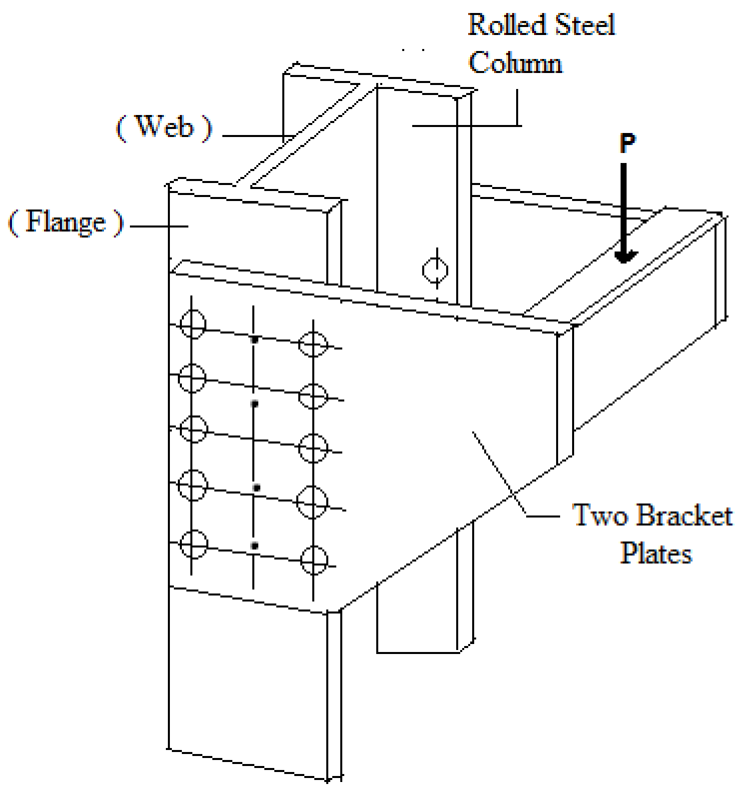


Fig. : Eccentric Bolted connection for Bracket

Problem 7) : A line shaft transmit a load of 25 KN at an eccentricity of 500 mm across a bracket plate bolted to a stanchion. Two rows of bolts 100 mm apart are provided with five bolts per row. The pitch of bolts in each row is 60 mm. find the greatest force induced in any bolt ?

Answer : Given a) P = 25 KN

b) n = Total no. of Bolts = 10

e) eccentricity (e) = 500 mm

Resistance against translation per bolt :

$$\left(\frac{p}{n} \right) = \left(\frac{25000}{10} \right) = 2500 \text{ N}$$

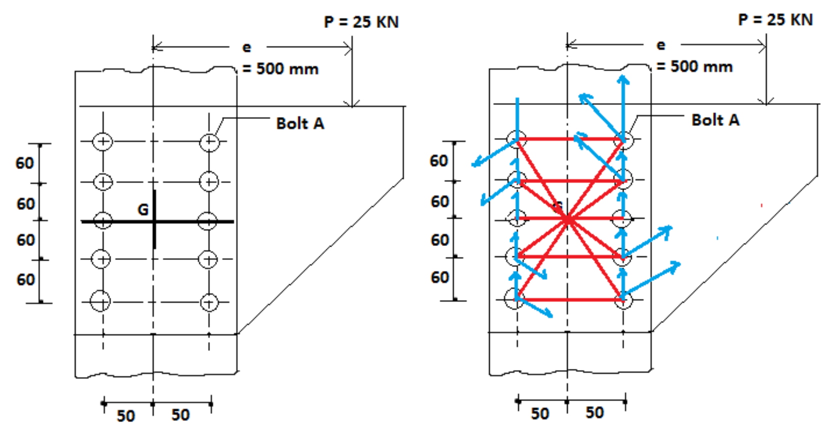


Fig. : Torsional Shear in Bolts

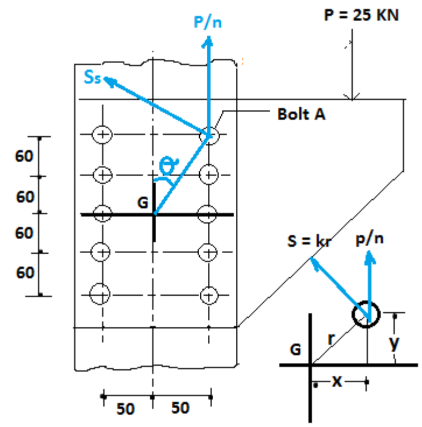


Fig : Torsional Shear in Bolt A

Torsional shear in the bolt = Resistance offered by bolts against the rotation of bracket plate

With respect to centroid G Of Bolt Group ;

$$\sum x^2 + \sum y^2 = 10\,(50^2) + 4\,(120^2) + 10\,(60^2)$$

$$= 97000\ mm^2$$

Now Consider Bolt A ;

Resistance force against Rotation = S = $k_a r_a$

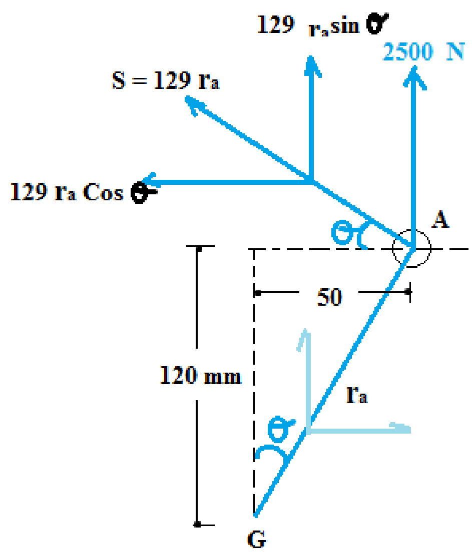
Where Ka = $\left(\frac{p \times e}{\sum x^2 + \sum y^2} \right) = \left(\frac{25000 \times 500}{97000} \right)$

= 129 $N/_{mm^2}$

We have ; $\sin\theta = \left(\frac{opp.}{hypo} \right) = \left(\frac{50}{r_a} \right)$

∴ $r_a \times \sin\theta = 50$

∴ $r_a \times \cos\theta = 120$



Total Vertical component on Bolt A (V) =

2500 + 129 $r_a \sin\theta$ = 2500 + (129 × 50)

V= 8950 N

Total Horizontal component on Bolt A (H) = 129 $r_a \times \cos\theta$ = 129 × 120

H = 15480 N

Resultant Resistance offered by Bolt A = $\sqrt{V^2 + H^2}$

A = $\sqrt{8950^2 + 15480^2}$ = 17881 N

Problem 8) : A Working Load of 150 KN is applied to a bracket plate at an eccentricity of 300 mm. 16 no. Bolts of 20 mm Ø are arranged in two rows with 8 bolts per row. The rows are 200 mm apart. The pitch of Bolt in each vertical row is 80 mm. The thickness of bracket plate is 12.5 mm. Investigate safety of Design ?

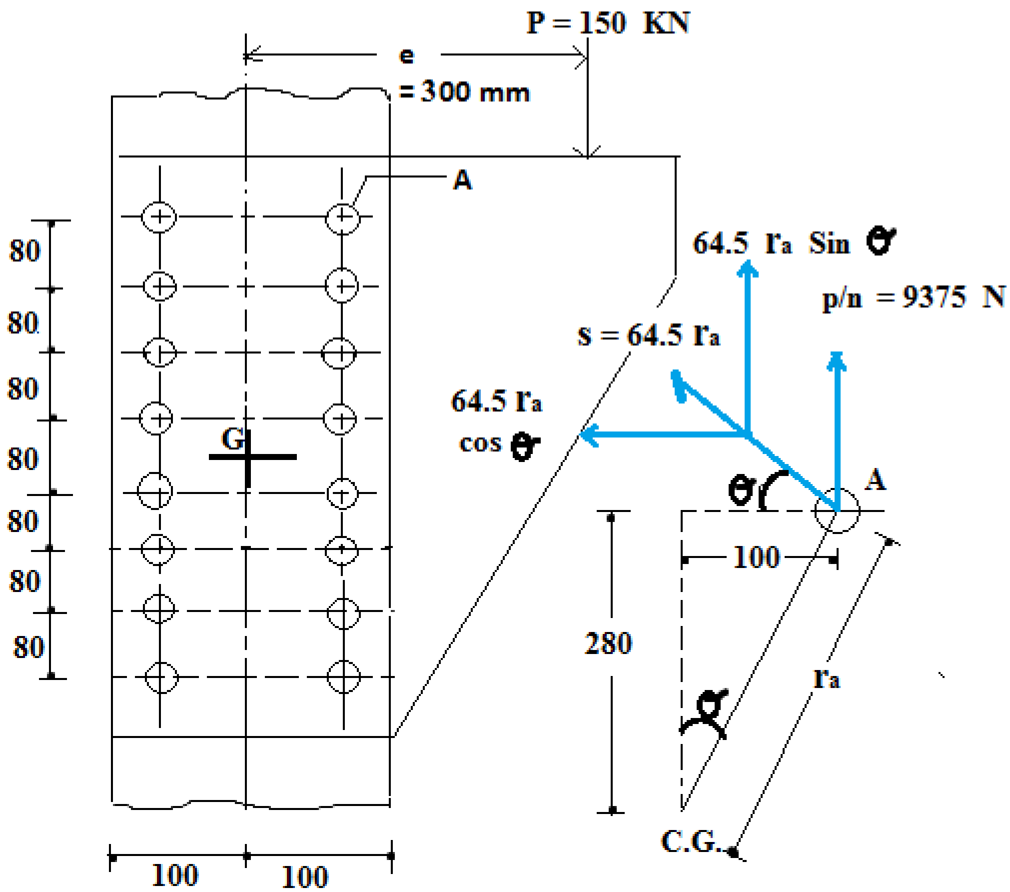
Answer : Given a) P = 150 KN

b) n = Total no. of Bolts = 16

c) eccentricity (e) = 300 mm

d) Bolt Diameter (d) = 20 mm

e) Bolt hole Diameter (d_O) = 20 +2 = 22 mm



Resistance against translation per bolt :

$$\left(\frac{p}{n}\right) = \left(\frac{150000}{16}\right) = 9375 \text{ N}$$

Torsional shear in the bolt = Resistance offered by bolts against the rotation of bracket plate

With respect to centroid G Of Bolt Group ;

$$\sum x^2 + \sum y^2 = 16\,(100^2) + 4\,(280^2) + 4\,(200^2) + 4\,(120^2) + 4\,(40^2)$$

$$= 697600 \;\; mm^2$$

Now Consider Bolt A ;

Resistance force against Rotation = S = $k_a r_a$

Where Ka = $\left(\frac{p \times \mathrm{e}}{\sum x^2 + \sum y^2} \right) = \left(\frac{150000 \times 300}{697600} \right)$

= 64.5 $N/_{mm^2}$

S = 64.5 r_a

We have ; $\sin\theta = \left(\frac{opp.}{hypo} \right) = \left(\frac{100}{r_a} \right)$

∴ $r_a \times \sin\theta = 100$

∴ $r_a \times \cos\theta = 280$

Total Vertical component on Bolt A (V) = 9375 + 64.5 $r_a \sin\theta$ = 9375 + (64.5 × 100)

V = 15825 N

Total Horizontal component on Bolt A (H) = 64.5 $r_a \times \cos\theta$ = 64.5 × 280

H = 18060 N

Resultant Resistance offered by Bolt A = $\sqrt{V^2 + H^2}$

$= \sqrt{15825 + 18060^2}$ = 24010 N

Bolts are in single shear ;

Step 1) i) Design Strength of Bolt in Shear ($single\ shear$) (V_{ds})

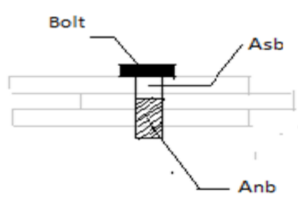
V_{ds} = { 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ ($n_n\, A_{nb}$)] }……………………………………………….cl 10.3.3, pg 75

Where $F_u = F_{ub}$ = 400 $N/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 1

ɣ = Partial safety factor for Bolt Material = 1.25 ……………. IS 800-2007 ;Table 5 ; pg. 30

Anb = 0.78 to 0.80 (π d²/4)
= **160.8491 mm²**



$$V_{ds} = 1 \times \left[\frac{1}{1.25} \times \frac{400}{\sqrt{3}} \left(1 \times 0.80 \times \frac{\pi\,(16)^2}{4}\right) \right] = \mathbf{45274\ N}$$

ii) : Design Strength of Bolt in Bearing (V_{bs})

V_{bs} = 1/ ɣ (2.5 $K_b\, d\, t\, F_u$) ....IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub}$ = 400 N/mm^2

d = 20 mm ;

t = Thickness of plate = 12.5 mm

ɣ = Partial safety factor for Bolt Material = 1.25 .... IS 800-2007 ;Table 5 ; pg. 3

K_b= Least of the following

i) $\frac{e}{3 \times d_0} = \frac{40}{3 \times 22} = 0.606$

ii) $\frac{p}{3 \times d_0} - 0.25 = \frac{80}{3 \times 22} - 0.25 = 0.962$

iii) $\frac{F_{ub}}{F_{uP}} = \frac{400}{410} = 0.975$

iv) 1.00

$\therefore\ K_b = 0.606$

$\boldsymbol{V_{bs}}$ = { 1/ 1.25 (2.5 × 0.606 × 20 × 12.5 × 400)}

= **121.200 KN**

$Since$; $\boldsymbol{V_{ds}} < \boldsymbol{V_{bs}}$

$\therefore$ Bolt value = $\boldsymbol{V_{ds}}$ = **45274 N**

Factored value of Bolt = 24010 × 1.5 = 36015 N

$Since$; $\boldsymbol{45274\ N > 36015\ N}$

$\therefore$ $\boldsymbol{Design\ is\ Safe}$

Problem 9) : Figure shows an eccentric bolted connection. Four bolts of 16 mm Ø are provided to connect 10 mm thick bracket plate to the flange of column. Determine safe load P that can be applied at an eccentricity of 250 mm ?

Answer : Given

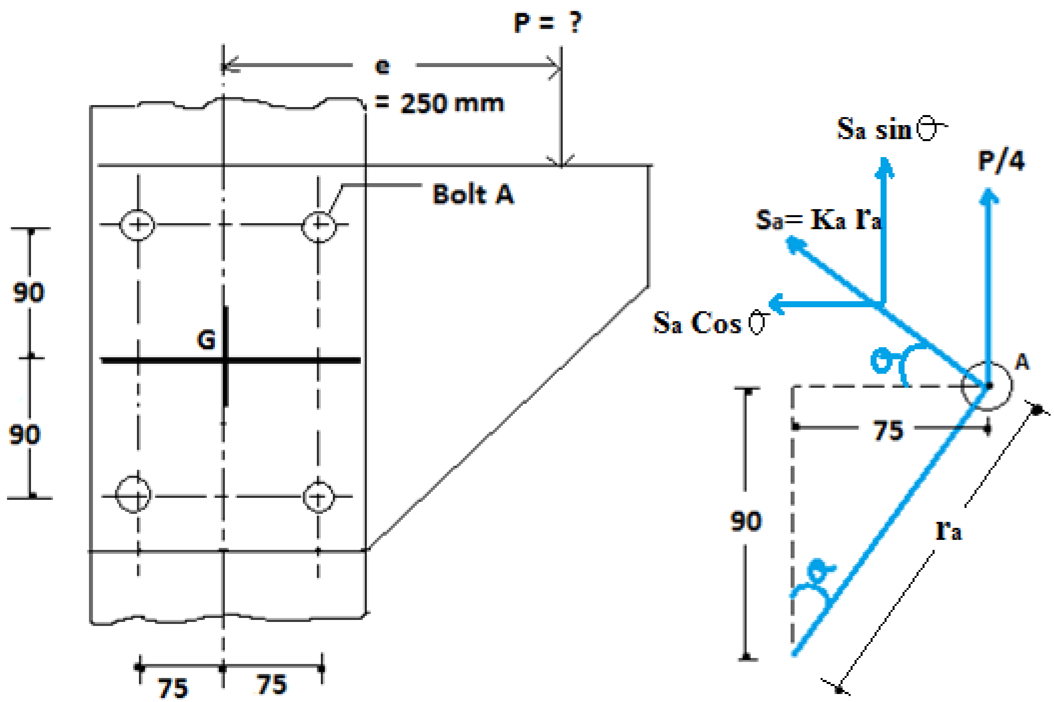
a) P = ?

b) n = Total no. of Bolts = 4

c) eccentricity (e) = 250 mm

d) Bolt Diameter (d) = 16 mm

e) Bolt hole Diameter (d_o) = 16 +2 = 18 mm



Resistance against translation per bolt :

$$\left(\frac{p}{n}\right) = \left(\frac{p}{4}\right)$$

Torsional shear in the bolt = Resistance offered by bolts against the rotation of bracket plate With respect to centroid G Of Bolt Group ;

$$\sum x^2 + \sum y^2 = 4\,(75^2) + 4\,(90^2)$$

$$= 54900\ mm^2$$

Now Consider Bolt A ;

Resistance force against Rotation = S = $k_a r_a$

Where Ka = $\left(\frac{p \times \text{e}}{\sum x^2 + \sum y^2} \right) = \left(\frac{P \times 250}{54900} \right)$

= 0.00455 × P N/mm

Sa = Ka r_a = (0.00455 × P) × ra

We have ; $\sin\theta = \left(\frac{opp.}{hypo} \right) = \left(\frac{75}{r_a} \right)$

∴ ra × sin θ = 75

∴ ra × cos θ = 90

Total Vertical component on Bolt A (V) = (p/4) + sa sin θ

= {(0.00455 × P) × ra × sin θ} + (p/4)

V = 0.5915 P

Total Horizontal component on Bolt A (H) = Sa × cos θ

= {(0.00455 × P) × ra } × cos θ

H = 0.4098 P

Resultant Resistance offered by Bolt A = $\sqrt{V^2 + H^2}$

= $\sqrt{(0.5915\ p)^2 + (0.4098\ \text{P})^2}$

= 0.7196 P

∴ Factored shear on the bolt = 1.5 × 0.7196 P = 1.0794 P

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Where $F_u = F_{ub}$ = 400 $N/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 1

ɣ = Partial safety factor for Bolt Material = 1.25 ……………. IS 800-2007 ;Table 5 ; pg. 30

$V_{ds} = 1 \times \left[\frac{1}{1.25} \times \frac{400}{\sqrt{3}} \left(1 \times 0.80 \times \frac{\pi\,(16)^2}{4} \right) \right]$ = 28975 N

Equating, 1.0794 P = 28975

∴ $P = 40265\ N$