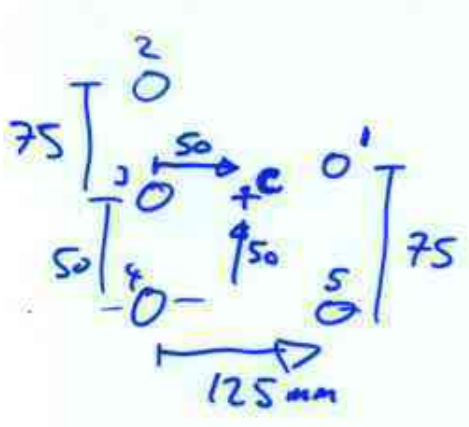


Area of a rivet $12\text{mm } \phi \Rightarrow \pi 6^2 = 113\text{mm}^2$

$\frac{\sum A_i x_i}{\sum A_i}$ A_i same for every rivet $\Rightarrow \frac{A_i \sum x_i}{\sum A_i} = \frac{113 \sum x_i}{(5)(113)}$



$$\frac{0 + 0 + 0 + 125 + 125}{5} = \underline{\underline{50\text{mm}}}$$

$\frac{\sum A_i y_i}{\sum A_i} = \frac{\sum y_i}{5} = \frac{0 + 0 + 50 + 125 + 75}{5} = \underline{\underline{50\text{mm}}}$

- $P_1 = \sqrt{75^2 + 25^2} = 79.1$
- $P_2 = \sqrt{75^2 + 50^2} = \underline{90.1} \leftarrow F_2$
- $P_3 = 50 = 50.0$
- $P_4 = \sqrt{50^2 + 50^2} = 70.7$
- $P_5 = \sqrt{\cancel{25^2} + 75^2} = \underline{90.1} \leftarrow F_5$

$\Sigma M_o = P_1 F_1 + P_2 F_2 + P_3 F_3 + P_4 F_4 + P_5 F_5$ ← sum of moments.

Force $\propto \delta$; we assume $\delta_i \propto P_i$ Because areas are all the same.

$$\frac{F_1}{P_1} = \frac{F_2}{P_2} = \frac{F_3}{P_3} = \frac{F_4}{P_4} = \frac{F_5}{P_5}$$

can express F_1, F_2, F_3, F_4 in terms of F_5 + geometry

$F_1 = \frac{P_1 F_5}{P_5}$ $F_2 = \frac{P_2 F_5}{P_5}$ etc.

$F_5 = \frac{P_5 F_5}{P_5}$

Substitute into ΣM_o

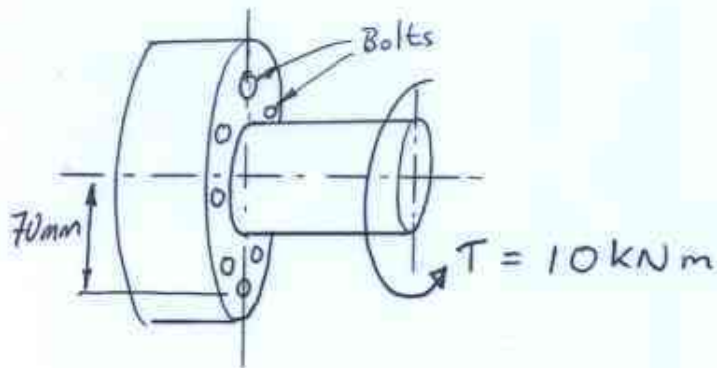
$$\sum M_0 = (P_1^2 + P_2^2 + P_3^2 + P_4^2 + P_5^2) \frac{F_s}{P_5}$$

$$\sum M_0 = T_{\text{torque}} = 2700 \text{ Nm} \quad \text{By EQUILIBRIUM}$$

$$F_s = \frac{P_5 (2700)}{\sum P_i^2} \times 10^3 \quad (\text{if } P_i \text{ are in mm})$$

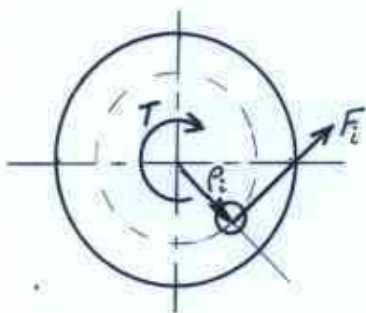
$$\frac{(90.1)(2700)}{[(2)(90.1)^2 + 50^2 + 70.7^2 + 79.1^2]} = 6.38 \text{ kN}$$

$$\delta_s = \frac{F_s}{A} = \frac{6.38 \times 10^3}{113 \times 10^{-8}} = 56.5 \text{ MPa.}$$



How many 20mm Bolts
are required to transmit
the torque of 10kNm
Shear not to exceed 70MPa

Centre of rotation & Centroid of Joint ~~is~~ ^{are} @ circle centre



$$F_i = \tau_i A_i$$

$$p_i = 70\text{mm}$$

$$\sum M_o = \sum p_i F_i = 10000$$

$$\sum p_i F_i = \sum p_i \tau_i A_i$$

$$= n(p_i \tau_i A_i) = 1 \times 10^4$$

$$A_i = \frac{\pi}{4} (20 \times 10^{-3})^2 = 314.16 \times 10^{-6} \text{ m}^2$$

$$\therefore n = \frac{1 \times 10^4}{(70 \times 10^{-3}) (314.16 \times 10^{-6}) (70 \times 10^6)}$$

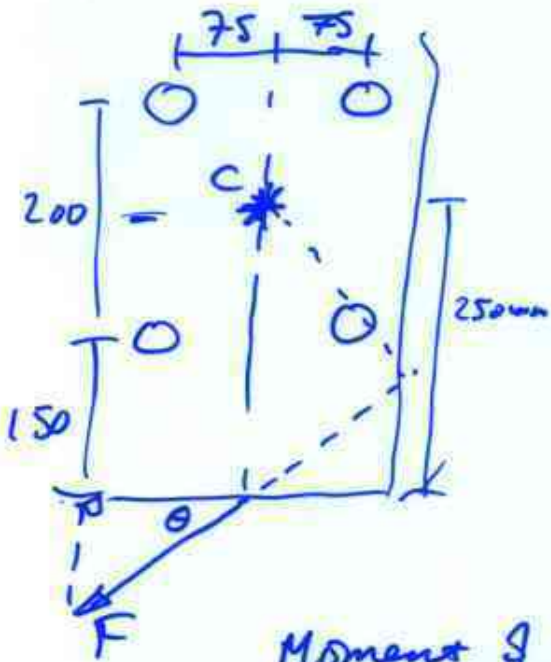
↙ max shear stress allowed

$$n = 6.5$$

⇒ 7 bolts.

cannot have a half bolt
& 6 bolts leads to stresses
greater than allowable

Centroid is very easy to find



$$\frac{\sum x_i A_i}{\sum A_i} = \frac{0 + 0 + 150 + 150}{4}$$

$$= 75$$

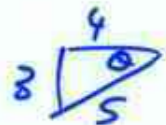
$$\frac{\sum y_i A_i}{A_i} = \frac{(150)(2) + (350)(2)}{4}$$

$$= 250$$

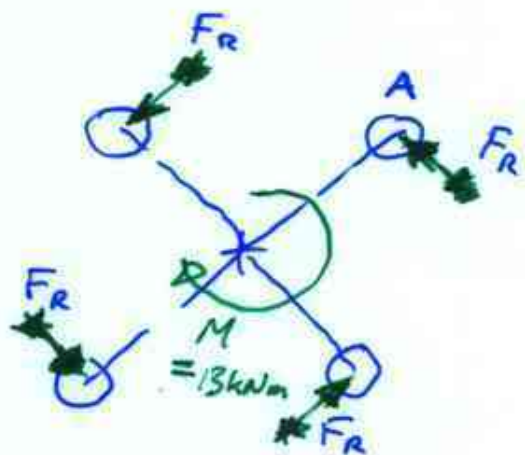
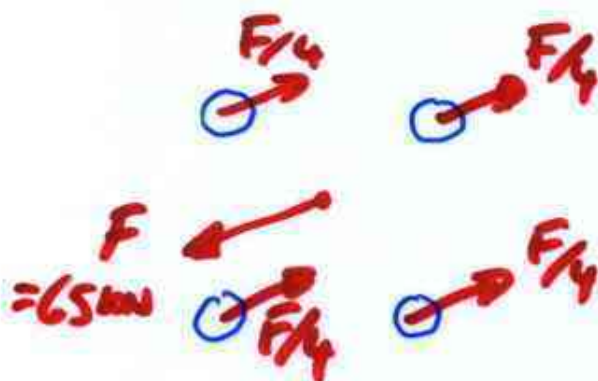
Moment of F about C

$$= (F \cos \theta)(250)$$

$$= F \frac{4}{5} \left(\frac{250}{1000} \right) = 0.2F = \underline{\underline{13 \text{ kNm}}}$$



Forces on each rivet



$$\frac{F}{4} = \frac{65 \text{ kN}}{4} = \underline{\underline{16.25 \text{ kN}}}$$

In this case, radius for each rivet rel. to centroid is same.

+ Areas same

⇒ Fr = same for all rivets

$$\sum M_c = 4 F_r r = M$$

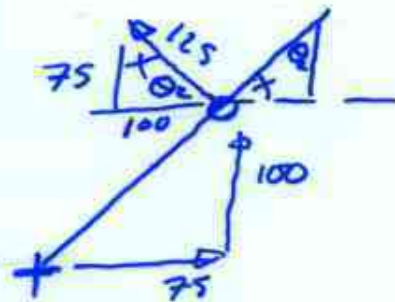
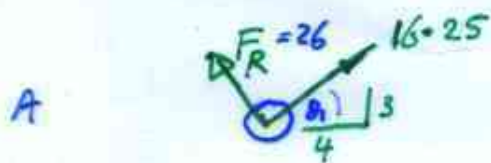
$$F_r = \frac{M}{4r} = \frac{13 \times 10^3}{(4)(125 \times 10^{-3})}$$

$$\frac{125}{75} = \frac{1000}{75}$$

$$F = 16.25 \text{ kN}$$

$$F_R = 26 \text{ kN}$$

look @ top left rivet 1st



Sum x components

$$16.25 (\cos \theta_1) - 26 (\cos \theta_2)$$

$$(16.25) \left(\frac{4}{5} \right) - 26 \left(\frac{100}{125} \right) = -7.8 \text{ kN}$$

y components:

$$(16.25) \sin \theta_1 + 26 (\sin \theta_2)$$

$$(16.25) \left(\frac{3}{5} \right) + (26) \left(\frac{7.5}{125} \right) = 25.35 \text{ kN}$$

$$\text{Magn} = \sqrt{x^2 + y^2} = \sqrt{(7.8)^2 + (25.35)^2}$$

$$= 26.52 \text{ kN}$$

$$\theta = \tan^{-1} \left(\frac{25.35}{7.8} \right) = 72^\circ$$

$$\text{to get } \sigma = \frac{F}{A} = \frac{26.52 \times 10^3}{490.9 \times 10^{-6}} = 54 \text{ MPa}$$

$\phi = 25 \text{ mm}$

250 on for other rivets