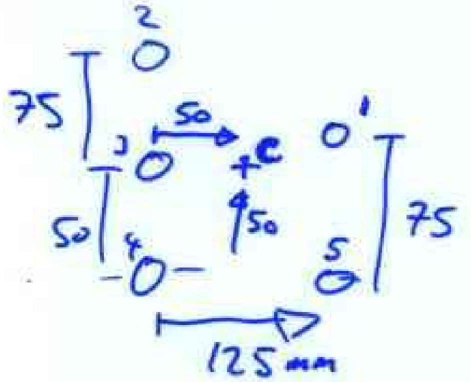
Area of a Rivet $12\,mm\,\phi \Rightarrow \pi 6^2 = 113\,mm^2$

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



$$\frac{0+0+0+125+125}{5}$$

$$= \underline{\underline{50\,mm}}$$

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

$\rho_1 = \sqrt{75^2 + 25^2} = 79.1$

$\rho_2 = \sqrt{75^2 + 50^2} = \underline{90.1} \leftarrow F_2$

$\rho_3 = 50 \qquad = 50.0$

$\rho_4 = \sqrt{50^2 + 50^2} = 70.7$

$\rho_5 = \sqrt{\cancel{25}^{\,\text{''}}_{\,50^2} + 75^2} = \underline{90.1} \leftarrow F_5$

$\sum M_o = \rho_1 F_1 + \rho_2 F_2 + \rho_3 F_3 + \rho_4 F_4 + \rho_5 F_5 \leftarrow$ sum of moments.

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

$$\frac{F_1}{\rho_1} = \frac{F_2}{\rho_2} = \frac{F_3}{\rho_3} = \frac{F_4}{\rho_4} = \frac{F_5}{\rho_5}$$

Can express F_1 F_2 F_3 F_4 in terms of F_5 + geometry

$$\underbrace{F_1 = \frac{\rho_1 F_5}{\rho_5} \qquad F_2 = \rho_2 \frac{F_5}{\rho_5} \text{ etc.}}_{}$$

$$F_5 = \frac{\rho_5 F_5}{\rho_5}$$

SUBSTITUTE into $\sum M_o$

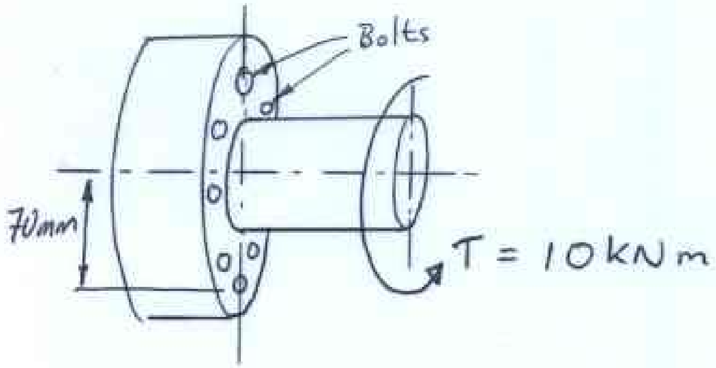
$$\Sigma M_0 = (\rho_1^{\,2} + \rho_2^{\,2} + \rho_3^{\,2} + \rho_4^{\,2} + \rho_5^{\,2}) \frac{F_5}{\rho_5}$$

$$\Sigma M_0 = T_{orque} = 2700 \text{ Nm}$$ BY EQUILIBRIUM

$$F_5 = \frac{\rho_5 (2700)}{\Sigma \rho_i^{\,2}} \times 10^3$$ (if ρ_i are in mm)

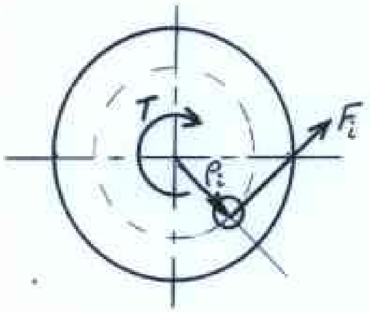
$$\frac{(90.1)(2700)}{[(2)(90.1)^2 + 50^2 + 70.7^2 + 79.1^2]} = 6.38 \text{ kN}$$

$$\sigma_5 = \frac{F_5}{A} = \frac{6.38 \times 10^3}{113 \times 10^{-6}} = 56.5 \text{ MPa}.$$



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

Centre of rotation & Centroid of Joint are @ circle centre



$$F_i = \tau_i A_i$$

$$\rho_i = 70mm$$

$$\Sigma M_o = \Sigma \rho_i F_i = 10\,000$$

$$\Sigma \rho_i F_i = \Sigma \rho_i \tau_i A_i$$

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

$$A_i = \frac{\pi}{4}(20 \times 10^{-3})^2 = 314 \cdot 16 \times 10^{-6} \ m^2$$

$$\therefore \quad n = \frac{1 \times 10^4}{(70 \times 10^{-3})(314 \cdot 16 \times 10^{-6})(70 \times 10^6)}$$

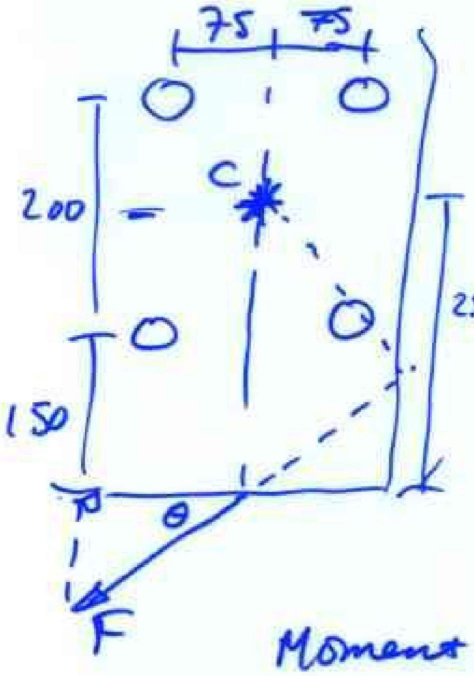
max shear stress allowed

$n = 6 \cdot 5$

$\Rightarrow$ 7 bolts.

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

Centroid is very easy to find



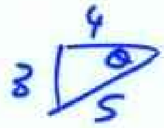
$$\frac{\sum x_i A_i}{\sum A_i} = \frac{0 + 0 + 150 + 150}{4}$$

$$= 75$$

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

$$= 250$$

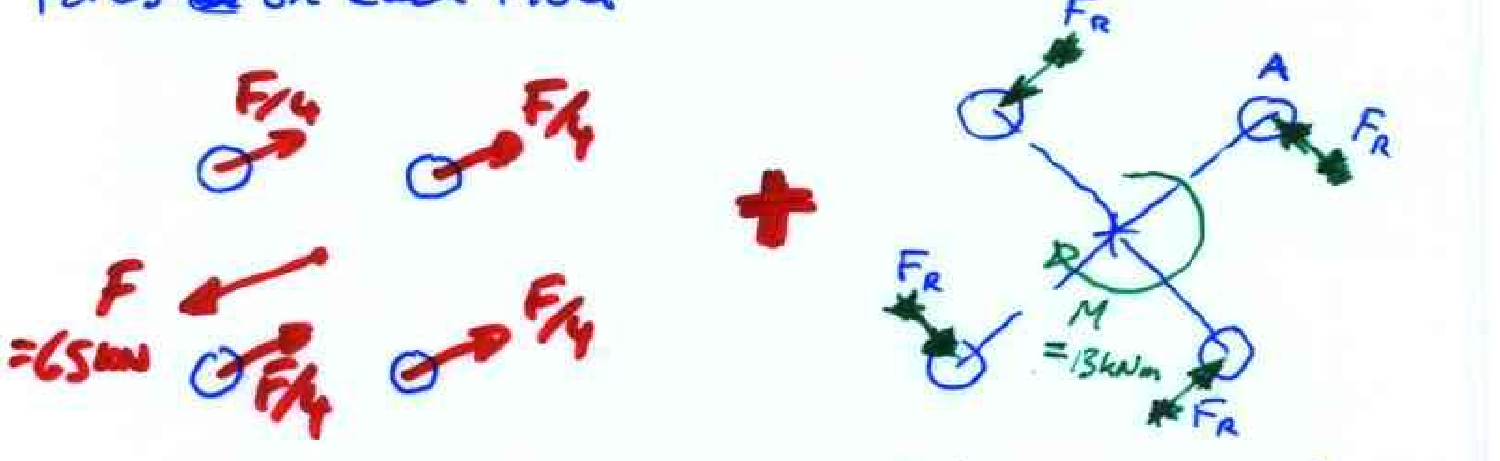
Moment of F about C



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

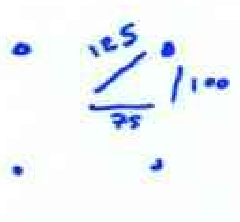
$$= F\,\frac{4}{5}\left(\frac{250}{1000}\right) = 0.2F = \underline{\underline{13\,\text{kNm}}}$$

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
$\Rightarrow$ F_r = same for all rivets

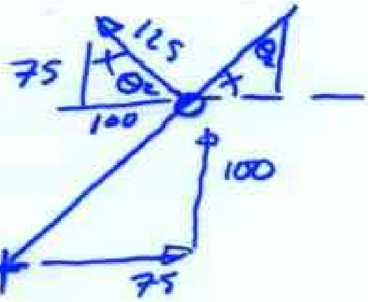


$$\Sigma M_c = 4 F_r \rho = M$$

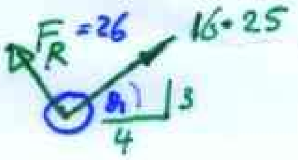
$$F_R = \frac{M}{4\rho} = \frac{13 \times 10^3}{(4)(125 \times 10^{-3})}$$

$F = 16.25\,kN.$ $F_R = 26\,kN$

look @ top left rivet 1st



A



Sum x components

$$16.25(\cos\theta_1) - 26(\cos\theta_2)$$
$$(16.25)\left(\frac{4}{5}\right) - 26\left(\frac{100}{125}\right) = -7.8\,kN$$

y components:

$$(16.25)\sin\theta_1 + 26(\sin\theta_2)$$
$$(16.25)\left(\frac{3}{5}\right) + (26)\left(\frac{75}{125}\right) = 25.35\,kN$$

$$\text{Magn} = \sqrt{x^2+y^2} = \sqrt{(7.8)^2+(25.35)^2}$$
$$= 26.52\,kN$$

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

to get $\sigma = \frac{F}{A} = \frac{26.52\times10^{+3}}{490.9\times10^{-6}} = 54\,MPa$

$\phi = 25\,mm$

& so on for other rivets