	15

College of Engineering & Technology

Department: Mechanical Engineering — Marks: 15
Lecturer: Dr. Rola Afify — Time: 1.00 - 2.00
Course Code: ME356 — Date: 25/11/2015

Name: Model Answer R.N.:

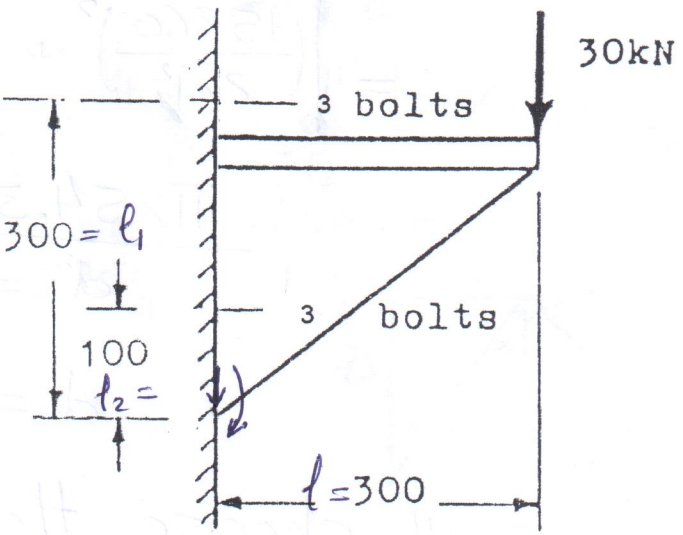
Answer the following questions: *(one mark for good drawings)*

Question one (7 marks)

Six bolts are used to secure the bracket, shown in figure, to the wall. If the bolts are made of steel having Sy = 420 MPa, determine their size using a factor of safety of 3.

6 bolts $S_y = 420$ MPa

$d = ??$ F.S. = 3



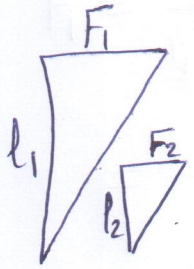
Dim. in mm.

Soln

$$F l = 3 F_1 l_1 + 3 F_2 l_2$$

$$30 * 10^3 * 300 = 3 F_1 * 300 + 3 F_2 * 100$$

$$3 * 10^4 = 3 F_1 + F_2 \longrightarrow (1)$$



$$\frac{F_1}{l_1} = \frac{F_2}{l_2}$$

$$F_2 = F_1 * \frac{l_2}{l_1} = \frac{100}{300} F_1 = \frac{F_1}{3} \longrightarrow (2)$$

sub. in (1)

$$3 * 10^4 = 3 F_1 + \frac{F_1}{3} = 3.33 F_1 \quad \therefore F_1 = 9000 \text{ Newton}$$

$$\sigma_t = \frac{F_1}{A} = \frac{9000}{\frac{\pi}{4}(0.85\,d)^2} = \frac{15860}{d^2} \text{ MPa} \longrightarrow$$

$$\tau = \frac{F}{n A} = \frac{30 * 10^3}{6 * \frac{\pi}{4}(0.85\,d)^2} = \frac{8811.346}{d^2} \longrightarrow$$

$$\sigma_{max} = \frac{\sigma_t}{2} + \sqrt{\left(\frac{\sigma_t}{2}\right)^2 + \tau^2} \leq \frac{S_y}{f.s}$$

$$\sigma_{max} = \frac{15860}{2d^2} + \sqrt{\left(\frac{15860}{2d^2}\right)^2 + \left(\frac{8811.346}{d^2}\right)^2}$$

$$= \frac{19784.312}{d^2} = \frac{420}{3}$$

$$\therefore d = 11.888 \text{ mm}$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_t}{2}\right)^2 + \tau^2} \leq \frac{0.5\, S_y}{f.s.}$$

$$= \sqrt{\left(\frac{15860}{2d^2}\right)^2 + \left(\frac{8811.346}{d^2}\right)^2} = \frac{0.5 * 420}{3}$$

$$\frac{11854.312}{d^2} = 70$$

$$d = 13 \text{ mm}$$

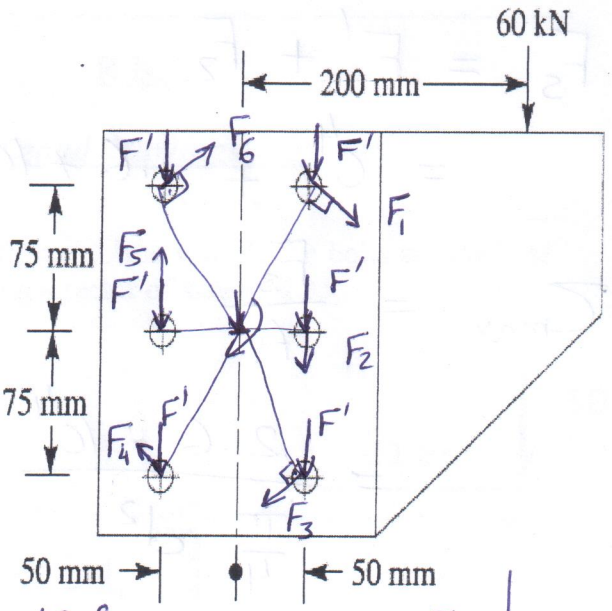
we'll choose the higher diameter

$$d = 13 \text{ mm}$$

Question two (7 marks)

A bracket is riveted to a column by 6 rivets of equal size. It carries a load of 60 KN at a distance of 200 mm from the center of the column. If the maximum shear stress in the rivet is limited to 150 MPa, determine the diameter of the rivet.

$\tau_{max} = 150$ MPa $d = ??$



Soln

$$F' = \frac{60 * 10^3}{6} = 10^4 \text{ Newton}$$

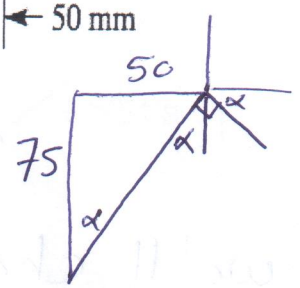
$r_1 = r_3 = r_4 = r_6$

$$= \sqrt{75^2 + 50^2} = 90.14 \text{ mm}$$

$$\alpha = \tan^{-1}\frac{50}{75} = 33.7^\circ$$

$$\theta_1 = 90 + \alpha = 123.7^\circ$$

$r_2 = r_5 = 50$ mm & $\theta_2 = 180^\circ$



bolt ① has max. r

$$F_1 = \frac{T r_1}{r_1^2 + r_2^2 + r_3^2 + r_4^2 + r_5^2 + r_6^2}$$

$$= \frac{60 * 10^3 * 200 * 90.14}{4 * (90.14)^2 + 2 * (50)^2} = 28844.12 \text{ Newton}$$

$$F_s = \sqrt{F'^2 + F_1^2 - 2F'F_1 \cos\theta}$$

$$= \sqrt{(10^4)^2 + (28844.12)^2 - 2(10^4) * 28844.12 \cos 123.7^\circ}$$

$$= 35384.51 \text{ Newton}$$

$$\tau_{max} = \frac{F_s}{A} = \frac{35384.51}{\frac{\pi}{4} d^2} = 150$$

$$\therefore d = 17.33 \text{ mm}$$

Good Luck 2/2

Dr. Rola Afify

Bolt ② has max. θ

$$F_2 = \frac{60 * 10^3 * 200 * 50}{4 * (90.14)^2 + 2 * (50)^2} = 16000 \text{ Newton}$$

$$F_s = F' + F_2$$

$$= 10^4 + 1.6 * 10^4 = 2.6 * 10^4 \text{ Newton}$$

$$\tau_{max} = \frac{F_s}{A}$$

$$= \frac{2.6 * 10^4}{\frac{\pi}{4} d^2} = 150$$

$$d = 14.86 \text{ mm}$$

we'll choose the biggest value of d

$$\therefore d = 17.33 \text{ mm}$$