15

College of Engineering & Technology

Department: Mechanical Engineering
Lecturer: Dr. Rola Afify
Course Code: ME356

Marks: 15
Time: 11.00 - 12.00
Date: 25/11/2015

Name: Model Answer

R.N.:

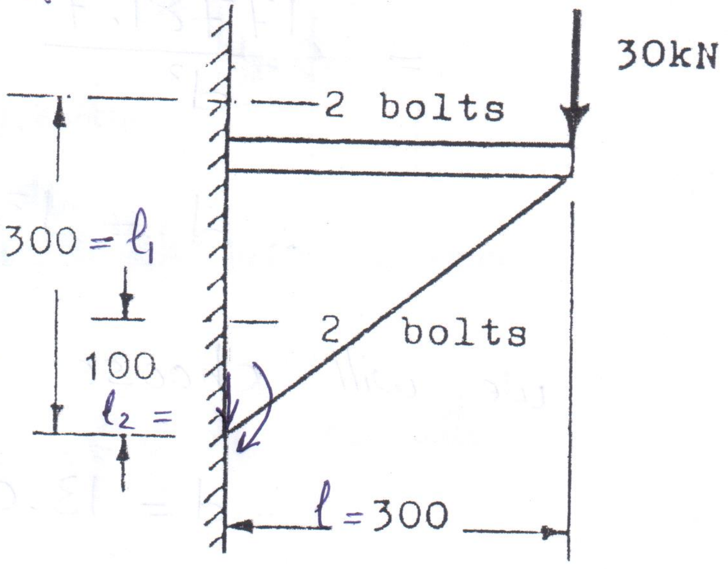
Answer the following questions: (*one mark for good drawings*)

Question one (7 marks)

Four 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 2.

4 bolts $S_y = 420\ MPa$ $d = ??$

$f.s. = 2$



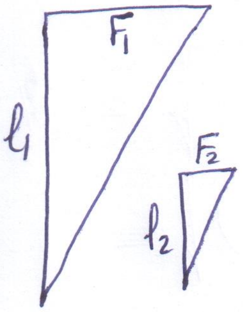
Dim. in mm.

soln

$$F\,l = 2F_1 l_1 + 2F_2 l_2$$

$$30*10^3*300 = 2F_1*300 + 2F_2*100$$

$$4.5*10^4 = 3F_1 + F_2 \longrightarrow (1)$$



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

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

sub. in (1)

$$4.5*10^4 = 3F_1 + \frac{F_1}{3} = 3.33F_1 \qquad \therefore F_1 = 13500 \text{ Newton}$$

$$\sigma_t = \frac{F_1}{A} = \frac{13500}{\frac{\pi}{4}(0.85d)^2} = \frac{23790.7}{d^2} \longrightarrow$$

$$\tau = \frac{F}{nA} = \frac{30*10^3}{4*\frac{\pi}{4}(0.85d)^2} = \frac{13217.02}{d^2} \longrightarrow$$

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

$$= \frac{23790.7}{2d^2} + \sqrt{\left(\frac{23790.7}{2d^2}\right)^2 + \left(\frac{13217.02}{d^2}\right)^2}$$

$$\sigma_{max} = \frac{29677.05}{d^2} = \frac{420}{2}$$

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

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

$$= \sqrt{\left(\frac{23790.64}{2d^2}\right)^2 + \left(\frac{13217.02}{d^2}\right)^2} = \frac{0.5 S_y}{f.s.}$$

$$= \frac{17781.7}{d^2} = \frac{0.5 * 420}{2}$$

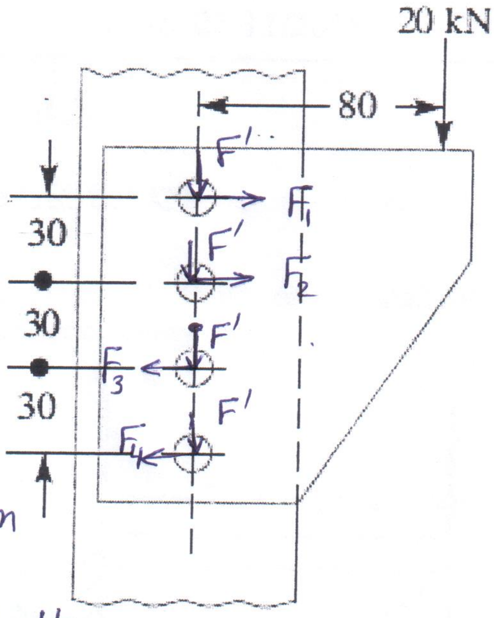
$$\therefore d = 13.013 \text{ mm}$$

we will choose the higher diameter

$$\therefore d = 13.013$$

Question two (7 marks)

A bracket is supported by means of 4 bolts of the same size. Determine the diameter of the bolts if the maximum shear stress is 140 MPa.



bolt (1) is the max. stress bolt

All dimensions in mm.

4 bolts $\quad d = ??$

$\tau_{max} = 140$ MPa

Soln

$r_1 = 45 \text{ mm} = r_4$

$r_2 = 15 \text{ mm} = r_3$

$\theta_1 = \theta_2 = \theta_3 = \theta_4 = 90^\circ$

$$F' = \frac{F}{n} = \frac{20*10^3}{4} = 5*10^3 \text{ Newton}$$

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

$$= \frac{20*10^3*80*45}{2(45)^2 + 2(15)^2} = 16000 \text{ Newton}$$

$$F_s = \sqrt{F'^2 + F_1^2 - 2F_1F'\cos\theta_1}$$

$$= \sqrt{(5000)^2 + (16000)^2 - 2*16000*5000*\cos 90} \quad (\to 0)$$

$$= 16763.055 \text{ Newton}$$

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

$$140 = \frac{16763.055}{\frac{\pi}{4}(0.85\,d)^2}$$

$d = 14.526$ mm

Dr. Rola Afify