

CONCORDIA UNIVERSITY
 Building, Civil and Environmental Engineering Department
 ENGR 244/4 V: Mechanics of Materials

Friday, Feb 08, 2008

Test # 1

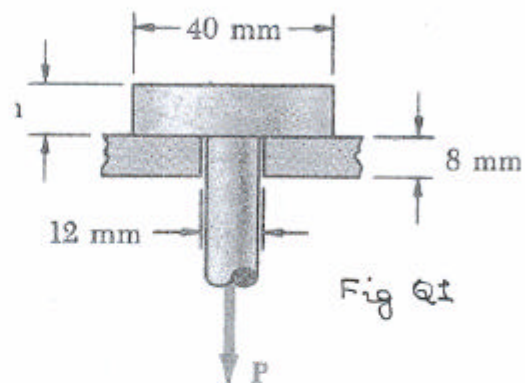
Time: 8:45 – 10:00

Answer all questions. Credit will be given to clear unambiguous answers. Sharp EL 531 or Casio FX-300 MS calculators are permitted. Cell phones are prohibited.

Question 1: (20 marks)

A force $P = 1.0 \text{ kN}$ is applied to the 10 mm diameter rod shown in Figure Q1. The other dimensions are shown, Determine,

- (a) the normal stress in rod
- (b) the shearing stress in the disc
- (c) the bearing stress on the support
- (d) the shearing stress in the support

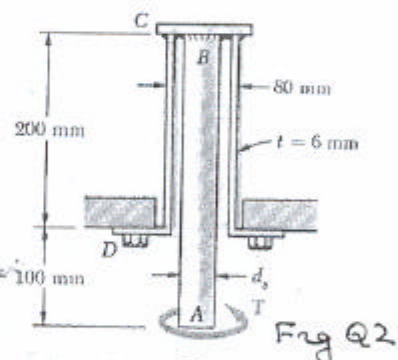


Question 2 (40 marks)

A torque of 1000 Nm is applied to the end A of the solid steel spindle of 40 mm diameter as shown in Figure Q2. The length of AB is 300 mm. The other end of this spindle is attached to an annular brass-sleeve CD of 80 mm outer diameter and 6 mm thick. The length of CD is 200 mm. The modulus of rigidity of steel and brass are 77 GPa and 39 GPa respectively.

Determine,

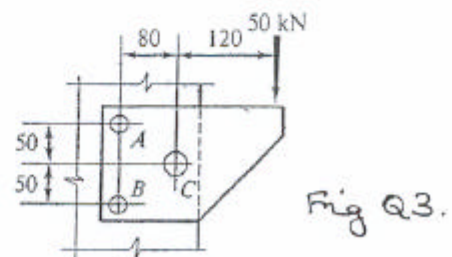
- (a) The maximum shear stress in sleeve CD
- (b) the rotation of end C of the sleeve in the sense of applied torque
- (c) the rotation of end A of the spindle in the sense of the applied torque



Question 3: (40 marks)

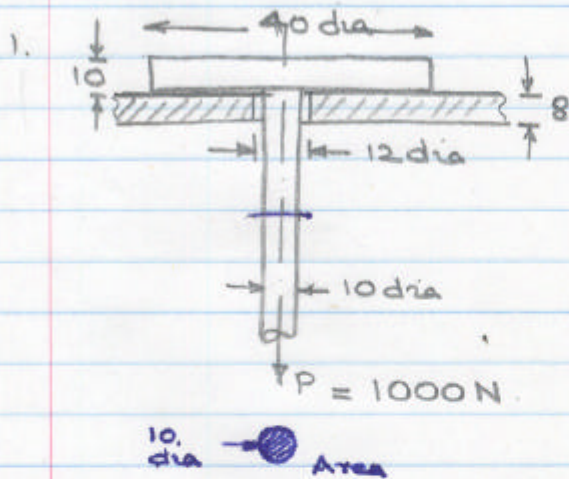
Three 35 mm diameter rivets are used in the joint shown in Figure 3. For each rivet, determine,

- (a) the direct stress
- (b) the torsional stress
- (c) the resultant stress



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SOLUTION TO TEST ① :



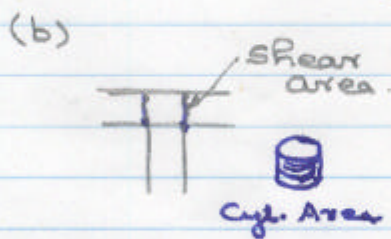
(a)

Axial force = 1000 N

Area = $\frac{\pi}{4} \times 0.010^2 \text{ m}^2$

\therefore Normal stress = $\frac{1000}{\frac{\pi}{4} \times 0.010^2}$

= 12.732 MPa.



Shear force = 1000 N.

Area = $(\pi \times 0.010) \times 0.010 \text{ m}^2$

\therefore Shear stress in disc = $\frac{1000}{\pi (0.010)(0.010)}$

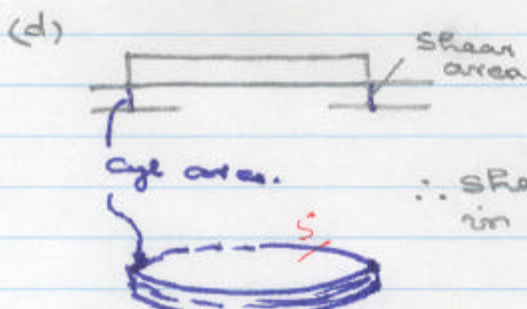
= 3.1831 MPa.



Bearing force = 1000 N

Area = $\frac{\pi}{4} \times 0.04^2 - \frac{\pi}{4} \times 0.012^2 \text{ m}^2$

\therefore Bearing stress = 0.87448 MPa.



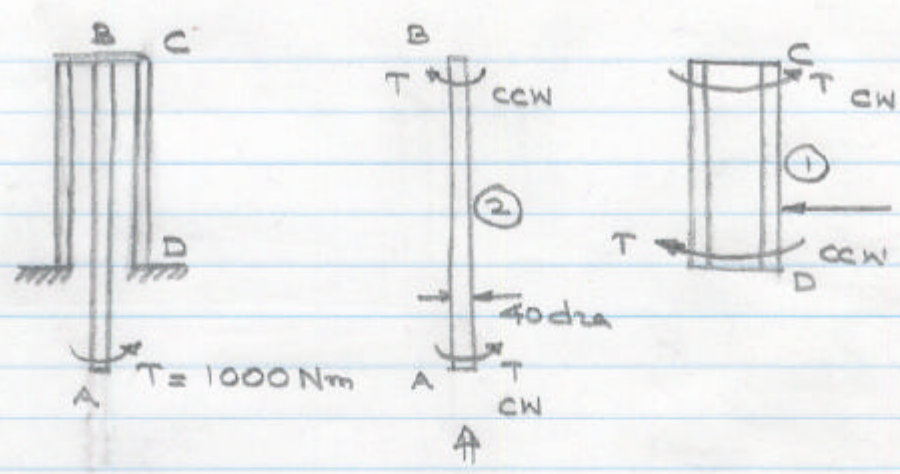
Force = 1000 N.

Area = $(\pi \times 0.040) \times 0.008 \text{ m}^2$

\therefore Shear stress in support = $\frac{1000}{\pi \times 0.040 \times 0.008}$

= 0.99472 MPa.

2.



80 OD
68 ID
Note: 80-2(6)
*

(a) Torque in sleeve = 1000 Nm *Note from figure.*

$$J_1 = \frac{\pi}{2} (0.040^4 - 0.034^4) \text{ m}^4$$

Use radius in formula

$$\tau_{max} = \frac{1000}{0.040 \cdot \frac{\pi}{2} (0.040^4 - 0.034^4)}$$

$$\tau_{max} = 20.810 \text{ MPa}$$

(b) Twist in sleeve.

$$\frac{T}{J} = \frac{G\phi}{L}$$

$$\therefore \phi_1 = \frac{1000}{\frac{\pi}{2} (0.040^4 - 0.034^4)} \times \frac{0.200}{39 \times 10^9}$$

$$= 2.6680 \times 10^{-3} \text{ rad} = 0.15286 \text{ rad}$$

$$\phi_c - \phi_D = \phi_1$$

$$\phi_D = 0$$

This explanation is needed

$$\therefore \phi_c = \phi_1$$

\therefore C rotates through 0.153° in the sense of applied torque.

(c) Spindle:

$$\approx \frac{T}{J} = \frac{G_s \phi}{L}$$

$$\phi_2 = \frac{1000 \approx}{\frac{\pi}{2} \times 0.020^4 \approx} \times \frac{0.300 \approx}{77 \times 10^9 \approx} = 0.015502 \text{ rad} = 0.88921 \text{ rad.}$$

$$\phi_A - \phi_B = \phi_2$$

$$\therefore \phi_B = \phi_C$$

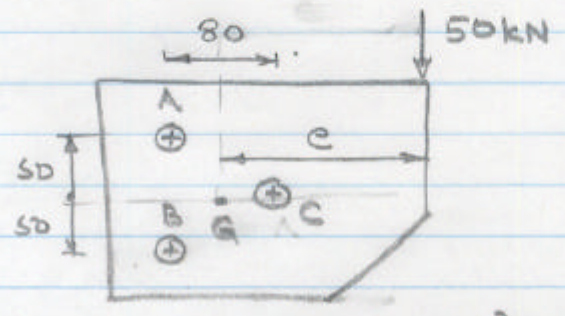
This explanation is needed

$$\therefore \phi_A = \phi_2 + \phi_1$$

$$= 0.01817 \text{ rad} = 1.041^\circ$$

\therefore A rotates through 1.041° in the sense of applied torque.

3



$$P = 50 \text{ kN}$$

$$e = 120 + \frac{2}{3} \times 80 \text{ mm} \quad \text{* Note}$$

$$T = P e$$

$$= 8.6667 \text{ kNm.}$$

$$A = \frac{\pi}{4} \times 0.035^2 = 0.96211 \times 10^{-3} \text{ m}^2.$$

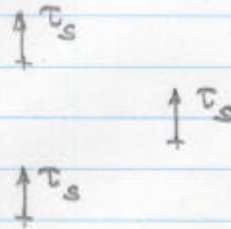
$$r_A = r_B = \sqrt{50^2 + (\frac{1}{3} \times 80)^2} = 56.667 \text{ mm.}$$

$$r_C = \frac{2}{3} \times 80 = 53.333 \text{ mm.}$$

$$J = A (r_A^2 + r_B^2 + r_C^2) = 8.9156 \times 10^{-6} \text{ m}^4.$$

Note: $J = \sum A_i r_i^2$
*

Direct Stress:



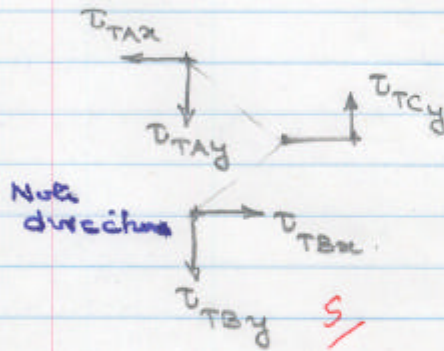
$$\tau_s = \frac{50 \times 10^3}{3 \times 0.96211 \times 10^{-3}}$$

$$= 17.323 \text{ MPa.}$$

S

Torsional Stress:

$$k = \frac{T}{J} = 0.97208 \times 10^9 \text{ N/m}^3.$$



$$\tau_{TAx} = \tau_{TBx} = 0.97208 \times 10^9 \times 0.050$$

$$= 48.604 \text{ MPa.}$$

$$\tau_{TAy} = \tau_{TBy} = 0.97208 \times 10^9 \times \frac{0.080}{3}$$

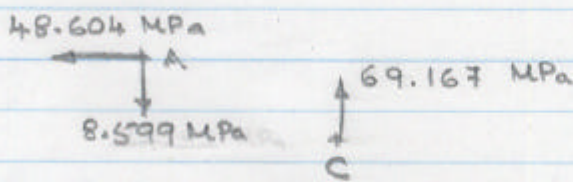
$$= 25.922 \text{ MPa.}$$

$$\tau_{TCy} = 0.97208 \times 10^9 \times \frac{2}{3} \times 0.080$$

$$= 51.844 \text{ MPa.}$$

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Resultant stress:

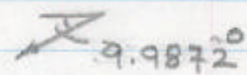


You must do it carefully Avoid numerical errors.

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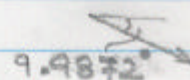
Stress on A

$$= 49.359 \text{ MPa}$$



Stress on B

$$= 49.359 \text{ MPa.}$$



Stress on C

$$= 69.167 \text{ MPa}$$

