Mansoura University
Faculty of Engineering
Prod. Eng. & Mech. Design Dept.

Level 100 –BME & MTE Eng. Dept.
PDE181 - Strength of Materials
50 Marks - 2 Hours
Date: 28/12/2017

Question One: ***(10 Marks)***

The plastic block shown in Fig. 1 is bonded to a rigid support and to a vertical plate to which a 240 KN load P is applied. Knowing that for the plastic used G = 1050 MPa, determine the deflection of the plate.

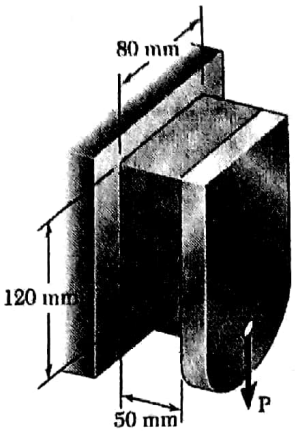


Fig. 1

Question Two: ***(15 Marks)***

A compound shaft consisting of a steel segment and an aluminum segment is acted upon by two torques as shown in Fig. 2. Determine the maximum permissible value of T subject to the following conditions: $\tau_{st} \leq 83$ MPa, $\tau_{al} \leq 55$ MPa, and the angle of rotation of the free end is limited to 6°. For steel, G = 83 GPa and for aluminum, G = 28 GPa.

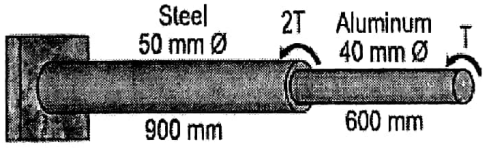


Fig. 2

Question Three: ***(15 Marks)***

A 400 lb vertical force is applied at D to a gear attached to the solid 1 in diameter shaft AB. Determine the principal stresses and the maximum shearing stress at point H located as shown in Fig. 3 on the top of the shaft.

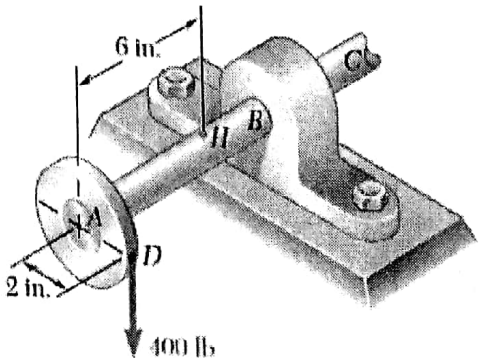


Fig. 3

Question Four: **(10 Marks)**

(2) *(1) For a beam, if fundamental equations of statics are not sufficient to determine all the reactive forces at the supports, the structure is said to be …*

(a) Determinate *(b) Statically Indeterminate*

(c) Statically Determinate *(d) None of these*

(2) *(2) Brittle materials generally fail in shear. Ductile materials are weaker in tension than shear.*

(a) True *(b) False*

(2) *(3) For a hollow shaft of do = 50mm & di = 35mm subjected to a torque of 65KNm, shear stress at the outer surface is …… that at the inner surface of shaft.*

(a) ≥ *(b) <* *(c) =* *(d) otherwise*

(2) *(4) Modulus of Elasticity is considered a measure of …*

(a) Stiffness *(b) Strength* *(c) Toughness* *(d) Resilience*

(2) *(5) A steel bar of 5mm is heated from 15° C to 40° C and it is free to expand. The bar will induce*

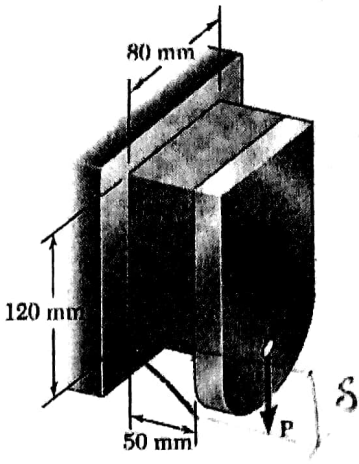
(a) Tensile Stress *(b)* Compressive Stress *(c)* No Stress *(d)* Shear Stress

Good Luck

Assoc. Prof. Dr. Noha Fouda

Question One (10 Marks)

The plastic block shown is bonded to a rigid support and to a vertical plate to which a 240-kN load **P** is applied. Knowing that for the plastic used $G = 1050$ MPa, determine the deflection of the plate.



- لأن القوة توازي مساحة التلامس بين السطحين يكون نوع الإجهاد (shear stress).

$$\tau = G\,\gamma$$

$$\frac{P}{A} = G\,\frac{\delta}{w} \qquad (3)$$

$$\frac{(240 * 10^{3})}{(120 * 80 * 10^{-6})} = (1{,}050 * 10^{6}) * \frac{\delta}{50 * 10^{-3}} \qquad (3)$$

$$\delta = 1.19 * 10^{-3}\ m$$

$$= 1.19\ mm \qquad (1)$$

Question Two (15 Marks)

A compound shaft consisting of a steel segment and an aluminum segment is acted upon by two torques as shown in Fig. P-316. Determine the maximum permissible value of T subject to the following conditions: $\tau_{st} \leq 83$ MPa, $\tau_{al} \leq 55$ MPa, and the angle of rotation of the free end is limited to 6°. For steel, G = 83 GPa and for aluminum, G = 28 GPa.

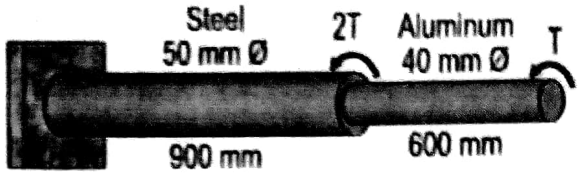


Figure P-316

Solution 316

Based on maximum shearing stress, $\tau_{max} = 16T / \pi d^3$:

Steel

$$\tau_{st} = \frac{16(3T)}{\pi(50^3)} = 83$$

$$T = 679\,042.16\ \text{N} \cdot \text{mm}$$

$$T = 679.04\ \text{N} \cdot \text{m} \quad \leftarrow \quad (5)$$

Aluminum

$$\tau_{al} = \frac{16T}{\pi(40^3)} = 55$$

$$T = 691\,150.38\ \text{N} \cdot \text{mm}$$

$$T = 691.15\ \text{N} \cdot \text{m} \quad \leftarrow \quad (5)$$

Based on maximum angle of twist, $\theta_{max} = 6°$:

$$\vartheta = \left(\frac{TL}{JG}\right)_{st} + \left(\frac{TL}{JG}\right)_{al}$$

$$6°\left(\frac{\pi}{180°}\right) = \frac{3T(900)}{\frac{1}{32}\pi(50^4)(83\,000)} + \frac{T(600)}{\frac{1}{32}\pi(40^4)(28\,000)}$$

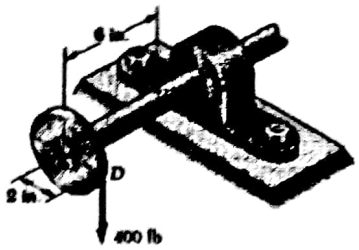
$$T = 757\,316.32\ \text{N} \cdot \text{mm}$$

$$T = 757.32\ \text{N} \cdot \text{m} \quad \leftarrow \quad (5)$$

Use the least value of T. Thus, T = 679.04 N·m *answer*

Question Three (15 Marks)

7.35 A 400-lb vertical force is applied at *D* to a gear attached to the solid one-inch diameter shaft *AB*. Determine the principal stresses and the maximum shearing stress at point *H* located as shown on top of the shaft.



SOLUTION

Equivalent force-couple system at center of shaft in section at point H.

$V = 400$ lb $\quad M = (400)(6) = 2400$ lb·in

$T = (400)(2) = 800$ lb·in.

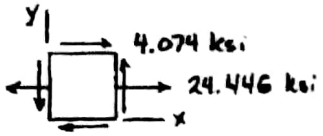
Shaft cross section. $d = 1$ in $\quad c = \frac{1}{2}d = 0.5$ in

$J = \frac{\pi}{2}c^4 = 0.098175$ in^4 $\quad I = \frac{1}{2}J = 0.049087$ in^4

Torsion: $\tau = \dfrac{Tc}{J} = \dfrac{(800)(0.5)}{0.098175} = 4.074 \times 10^3$ psi $= 4.074$ ksi (5)

Bending: $\sigma = \dfrac{Mc}{I} = \dfrac{(2400)(0.5)}{0.049087} = 24.446 \times 10^3$ psi $= 24.446$ ksi

Transverse shear: Stress at point H is zero. (5)



$\sigma_x = 24.446$ ksi $\quad \sigma_y = 0$ $\quad \tau_{xy} = 4.074$ ksi

$\sigma_{ave} = \frac{1}{2}(\sigma_x + \sigma_y) = 12.223$ ksi

$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \sqrt{(12.223)^2 + (4.074)^2}$

$= 12.884$ ksi

$\sigma_a = \sigma_{ave} + R = \boxed{25.107 \text{ ksi}}$

$\sigma_b = \sigma_{ave} - R = \boxed{-0.661 \text{ ksi}}$ (5)

$\tau_{max} = R = \boxed{12.884 \text{ ksi}}$

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