Ex/PROD/PC/B/T/213/2023(S)

B.E. PRODUCTION ENGINEERING, SECOND YEAR, FIRST SEMESTER
SUPPLEMENTARY EXAM 2023

DEFORMATION OF SOLIDS

Time: 3 hours Full Marks: 100

Answer any FIVE questions, taking any THREE
from group-A and any TWO from group-B.

All parts of a question (a, b etc) should be answered at one place.

All the dimensions in the figures are in centimeters unless indicated otherwise.

GROUP—A

1 (a)A rigid steel plate is supported by three concrete posts each having a 10cm×10cm square cross-section as shown in Fig. 1(a). By accident, the middle post is 0.05cm shorter than the other two before load P is applied. Find the safe value of load P if the working stress for the concrete in compression is 200kg/cm^2 and the modulus of elasticity $E_c = 12\times10^4$ kg/cm^2.

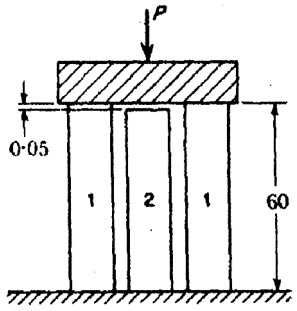

Fig.1 (a)

(b) A steel tube 1 in. external diameter and 3/4 in. internal diameter encloses a copper rod 5/8 in. diameter to which it is rigidly joined at

each end. If, at a temperature of 60 °F there is no longitudinal stress, calculate the stress in the rod and tube when the temperature is raised to 400 °F. For steel $E_s=30\times10^6$ lb/sq.in. and for copper $E_c=14\times10^6$ lb/sq.in, coefficient of linear expansion for steel and copper is $\alpha_s=6\times10^{-6}$/ °F and $\alpha_c=10\times10^{-6}$/ °F respectively.

10+10

2(a) A solid truncated conical bar of circular cross-section tapers uniformly from a diameter d_1 at its small end to d_2 at the large end. The length of the bar is ℓ. Determine the elongation due to an axial force P applied at each end.

(b) For the simple structure shown in Fig. 2(b), member BC is a steel wire having diameter d = 3 mm and member AB is a wood strut of 2.5cm-square cross-section. Calculate the horizontal and vertical components of the displacement of point B due to a vertical load P = 200 kg acting as shown. For steel, $E_s = 2\times10^6$ kg/cm^2 for wood, $E_w = 10\times10^4$ kg/cm^2.

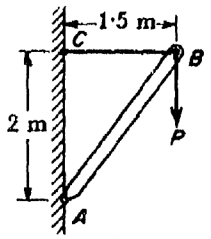

Fig.2 (b)

8+12

3(a) Consider a vertical bar of uniform cross-section with a flange at the lower end as shown in Fig. 3(a). Weight '*W*' is released from a height '*h*' and falls freely along the bar until it strikes the flange. Determine the maximum deflection 'δ' of the bar and also calculate the maximum stress

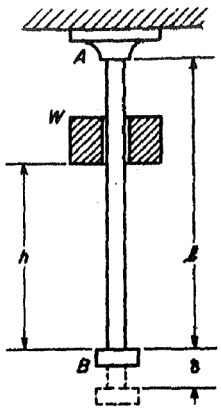

Fig. 3(a)

(*i*) when '*h*' is large compared to the elongation of the bar &

(*ii*) when '*h*' is zero.

(b) A prismatic steel rod of length *l*, modulus of elasticity E and cross-sectional area A hangs vertically under its own weight. How much strain energy is stored in the bar if its weight per unit volume is γ?

15+5

4(a) Show that bending stress can be expressed as

$$\sigma = My/I$$

Where each symbol holds its usual significance.

(b) A shaft of diameter *d*, bent in the form of a semicircle AB of radius *R*, is built-in at A and loaded at B by a force *P* acting perpendicular to the plane of the ring as shown in Fig.4 (b). Thus any cross-section C of the ring is subjected to both bending and torsion. Assuming that *d* is small compared with *R* so that the theory of bending of straight bars may be used, find the value of Φ for which the principal stress σ will be a maximum.

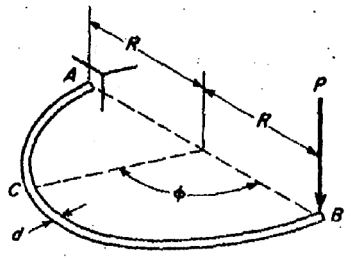

Fig.4 (b)

10+10

5(a) Construct the complete shear force and bending moment diagram for the beam shown in Fig.5 (a). Also determine the maximum bending moment and the point of contra-flexure.

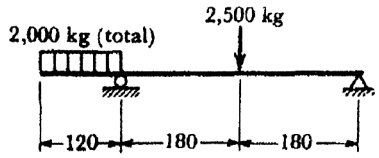

Fig.5 (a)

(b) For a rectangular element shown in Fig. 5(b), the following numerical data are given σ_x= 100 kg/cm^2, σ_y= 75 kg/cm^2 and τ_{xy}= 50 kg/cm^2. Determine

(i) The values of σ_x and τ on the plane whose normal is defined by φ = 30°.

(ii) The magnitude and direction of the principal stresses σ_1 and σ_2.

(iii) The stress component and planes on which shear stress is the maximum.

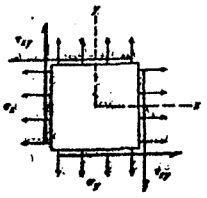

Fig.5 (b)

10+10

GROUP—B

6(a)A hollow steel pipe is to be used as a standard to support a highway road sign as shown in Fig. 6(a). The maximum wind pressure on the face of the board is assumed to be 250 kg/m^2. The standard is unsupported laterally and its outside-to-inside diameter ratio is 1.12. The allowable working stress in shear is given as τ_w = 600 kg/cm^2. Calculate the required outside diameter d of the pipe.

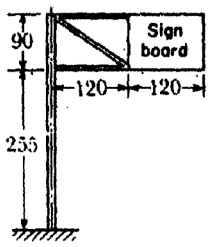

Fig. 6(a)

(b)Show that the Euler's column formula for the case of a slender column built in at one end and free at the top is

$$P_{cr} = \frac{\pi^2 EI}{l^2}$$

Where the symbols have the usual meaning.

12+8

7(a) A torsion pendulum consists of a solid right circular disk suspended by a thin steel shaft of circular cross-section as shown in Fig.7(a). The disk has weight W = 50 kg; the shaft has length l = 50 cm and diameter d = 3 mm. For the shaft, allowable stresses in tension and shear, respectively, are σ_w= 1,120kg/cm^2 and τ_w= 560 kg/cm^2. What is the maximum angle of twist Φ that the shaft may have during torsional oscillations of the disk without exceeding either given working stress?

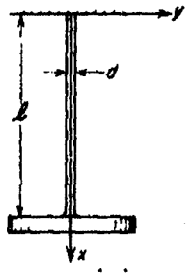

Fig. 7(a)

(b) A truncated conical tank having the dimensions shown in Fig. 7(b) is filled with water (w = 1 gm/cm3). Calculate the membrane stresses σ_1 and σ_2 for an element A of the wall situated as shown in the figure if t = 0.03 cm.

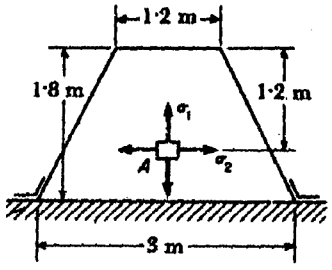

Fig. 7(b) 10+10

8(a) A simply supported beam is subjected to the loading as shown in Fig. 8(a). Determine the deflection at the point of application of the load

P=10t and also find out the maximum deflection. The following numerical data are given: $E = 2\times10^6$ Kg/cm^2, $I = 47\times10^3$ cm^4.

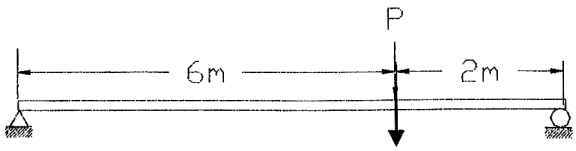

Fig. 8(a)

(b)A prismatic shaft of diameter d has built-in ends and is subjected to the action of externally applied twisting moments T1 and T2, as shown in Fig. 4(b). Find the internal torques Ta, Tb, Tc in the three portions a, b, c, of the shaft. The following numerical data are given: a = 75 cm, b = 125 cm, c = 100 cm, T1 = 12,000 kg-cm, and T2 = 24,000kg-cm.

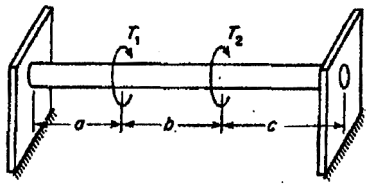

Fig. 8(b) 10+10