EX/PROD/T/213/2019

B.E. PRODUCTION ENGINEERING

SECOND YEAR FIRST SEMESTER EXAMINATION-2019

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 a one place.

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

GROUP–A

1(a) For the simple structure shown in Fig. 1(a), 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 .

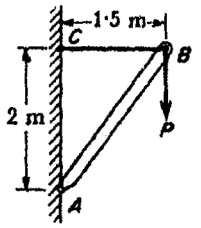

Fig.1 (a)

(b) A tapered shaft with circular cross-section has diameter 'd' at one end diameter 'd/2' at the other; the length of the shaft is 'ℓ'. Determine the total angle of twist Φ between the two ends of the shaft if it is subjected to uniform torque T.

10+10

2(a)The frame shown in Fig.2 (a) is made up of10 cm x 10 cm square wood posts for which the allowable stress in shear parallel to the grain is τ_w=7

kg/cm^2 while that in compression perpendicular to the grain is σ_w = 28 kg/cm^2. The vertical post is pinned to the sill at its lower end.

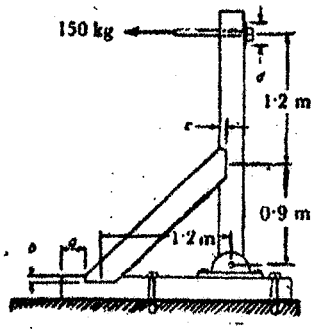

Fig.2 (a)

(i) Calculate the minimum safe values of the dimensions a, b and c.
(ii) What is the required diameter *d* of the pin, if the bearing pressure between the wood and pin at the bottom end of the vertical post is 14 kg/cm^2 ? Assume the width of the bearing area in this case is projected diameter of the pin.

(b) A simply supported prismatic beam AB carries a uniformly distributed load of intensity w over its span ℓ. Develop the equation of the elastic line and find the maximum deflection at the middle of the span.

15+5

3(a) A rigid steel plate is supported by three concrete posts each having a 10cm×10cm square cross-section as shown in Fig. 3(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 = 12×10^4 kg/cm^2.

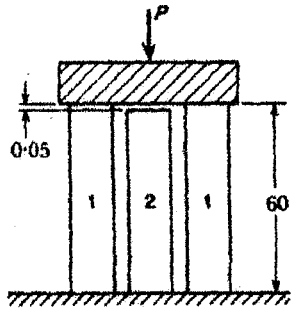

Fig.3 (a)

(b) A hollow steel pipe is to be used as a standard to support a highway road sign as shown in Fig. 3(b). 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.

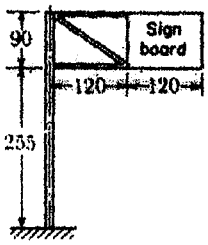

Fig. 3(b) 10+10

4 (a) Show that the angle of twist for a shaft subject to torsion, can be represented by the following relation

$$\Phi = TL/GJ$$

Where the symbols have the usual meaning.

(b) A solid shaft of diameter d=12 mm is built in at its ends A and B and carries a disk at C as shown in Fig.4 (b). If the working stress in shear for the shaft is 700 kg/cm^2, what is the maximum safe angle of rotation that can be given to the disk which is rigidly attached to the shaft? G = 84 x 10 kg/cm^2.

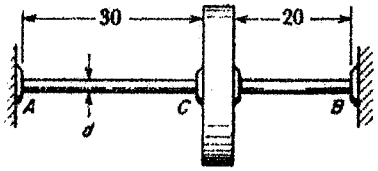

Fig.4 (b) 10+10

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.

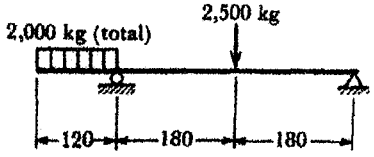

Fig.5 (a)

(b) 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

$$P_{cr} = \pi^2 EI/4\ell^2$$

Where I is the least moment of inertia of the constant cross- sectional area of the column and P_{cr} , E and I are the critical load, Modulus of elasticity and length of the column respectively.

10+10

GROUP–B

6(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.6(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?

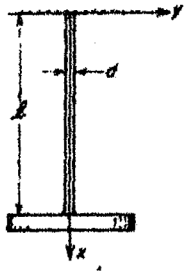

Fig. 6(a)

(b) A truncated conical tank having the dimensions shown in Fig. 6(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.

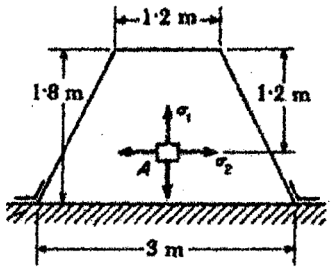

Fig. 6(b) 10+10

7(a) A 6-tonne tractor is to cross a bridge consisting of two parallel beams as shown in Fig. 7(a). What is the required section modulus Z for each beam if the allowable working stress in bending is σ_w = 1,120 kg/cm'.

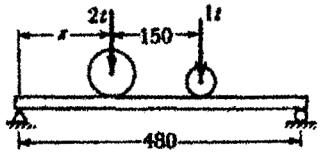

Fig.7 (a)

(b) Calculate the total elongation δ of a prismatic bar of length ℓ, cross-sectional area A and modulus of elasticity E which hangs vertically under its own weight W.

15+5

8(a) For a rectangular element shown in Fig. 8(a), 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.

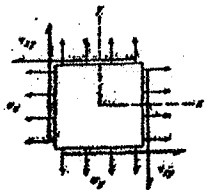

Fig.8 (a)

(b) A flywheel of weight W = 18 kg and radius of gyration i = 25 cm is mounted at the middle of a solid steel shaft of diameter d = 5 cm and length ℓ. The shaft rotates in bearings A and B at its ends with an angular speed n = 120 rpm. If both bearings suddenly freeze so that the ends of the shaft become locked, the shaft will have to absorb the kinetic energy of the flywheel. Calculate the shortest length ℓ of the shaft for which this can be done without exceeding a maximum shear stress τ_w = 840 kg/cm^2 in the shaft.

10+10