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B020313(020)

B. Tech. (Third Semester) Examination, Nov.-Dec. 2020

(Civil Engg. Branch)

INTRODUCTION to SOLID MECHANICS

(ESE)

Time Allowed : Three hours

Maximum Marks : 100

Note : *Attempt all questions. Part (a) of each question is compulsory and carries 04 marks. Attempt any two parts from (b), (c) and (d) carry 08 marks.*

1. (a) Prove that :- *"Linear strain (e) of diagonal due to shear = Half the shear strain (ϕ)"* 4

(b) A member $ABCD$ is subjected to point loads of P_1, P_2, P_3 and P_4 as shown in figure 1 below. Calculate the force P_2 necessary for equilibrium if $P_1 = 10\text{ kN}$, $P_3 = 40\text{ kN}$ and $P_4 = 16\text{ kN}$. Taking modulus of elasticity as $2{\cdot}05 \times 10^5\ \text{N/mm}^2$, determine the total elongation of the member. 8

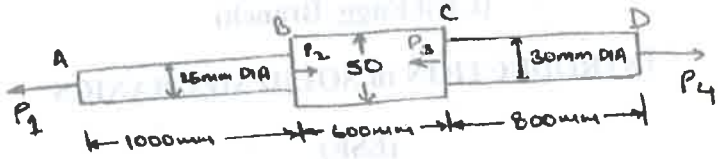

Fig.-1

(c) Derive an equation relating three elastic constant from first principal. 8

(d) A compound bar is made by fastening one flat bar of steel between two similar bars of aluminium alloy. The dimensions of each bar are 40 mm wide × 8 mm. So that the cross-section of the composite bar measures 40 mm × 24 mm. If E for steel $= 2{\cdot}04 \times 10^5\ \text{N/mm}^2$ and E for alloy $= 0{\cdot}612 \times 10^5\ \text{N/mm}^2$, find the apparent value of

E loaded in tension. If the respective elastic limits are 230 N/mm² and 50 N/mm², find the elastic of the compound bar. 8

2. (a) Explain : 4

(i) Principal stresses

(ii) Principal planes

(b) Derive an equation for p_n, p_t and p_r induced on an inclined plane due to state of biaxial stress. 8

(c) A piece of material is subjected to tensile of p_1 and p_2 at right angles to each other $(p_1 > p_2)$. Find the plane across which the resultant stress is most inclined to the normal. Find the value of this inclination and the resultant stress when $p_1 = 60\ \text{N/mm}^2$ and $p_2 = 40\ \text{N/mm}^2$ (both tensile). 8

(d) At a point in a material, the stresses on two mutually perpendicular planes are 50 N/mm² (tensile) and 30 N/mm² (tensile). The shear stress across these planes is 12 N/mm². Using Mohr circle, find the magnitude and direction of the resultant stress on a

plane making an angle of 35° with the plane of the first stress. Find also, the normal and tangential stresses on this plane. 8

3. (a) Define : 4

(i) Shear Force

(ii) Bending Moment

(b) Derive the expression for pure bending theory. 8

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

(c) The beam is loaded as shown in figure 2. Draw the shear force and bending moment diagram, indicating the values at important locations. 8

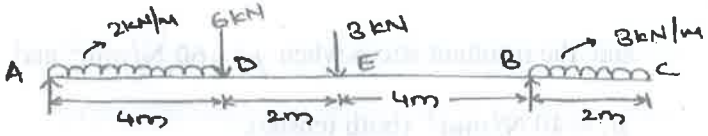

Fig.-2

(d) A 500 mm × 500 mm timber is strengthened by the addition of 500 mm × 8 mm steel plates secured to its top and bottom surfaces. The composite beam is simply supported at its ends and

carries a uniformly distributed load of 100 kN/m run over an effective span of 6 m. Find the maximum bending stresses in steel and timber at the mid-span. Take E for steel $= 2 \times 10^5$ N/mm^2 and E for timber $= 0{\cdot}1 \times 10^5$ N/mm^2. 8

4. (a) What are the modes of failure of a column? 4

(b) Derive the equation for Euler load when both the ends of a column are hinged. 8

(c) A masonry pier of 2 m × 3 m supports a vertical load of 50 kN as shown in figure 3. Find (a) Stresses developed at each corner of the pier (b) What additional load should be placed at the center of the pier, so that there is no tesnion anywhere in the pier section? (c) What are the stresses at the corner with the additional load in the centre? 8

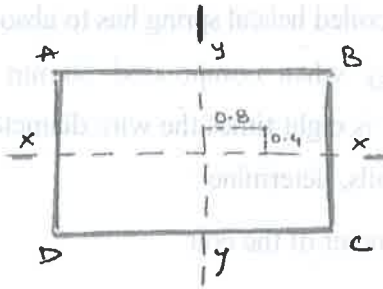

Fig.-3

(d) A dam 6 m high and 1·5 m wide at the top has vertical water face. Find the base width of the dam if no tension is to develop. Take unit weight of masonry as 20 kN/m^3 and $c = 1$. Investigate the stability of the dam if coefficient of friction is 0·6 and maximum allowable compressive stress is 1800 kN/m^2. 8

5. (a) Explain : 4

(i) Resilience of spring

(ii) Torsional Rigidity

(b) Prove that : *"The intensity of shear stress at any point in the cross section of a shaf subjected to pure torsion is proportional to its distance from the centre"*. 8

(c) A close-coiled helical spring has to absorb 60 N-m of energy when compressed 60 mm. The coil diameter is eight times the wire diameter. If there are 10 coils, determine :

(i) Diameter of the coil

(ii) Diameter of the wire

(iii) Maximum shear stress

Take $N = 0{\cdot}86 \times$ N/mm^2 8

(d) As shaft transmits 300 kW power at 120 r.p.m. Determine (a) the necessary diameter of solid circular shaft (b) the necessary diameter of hollow circular section, the inside diameter being 2/3 of the external diameter. The allowable shear stress is 70 N/mm^2. Taking the density of material is 77 kN/m^2 ; calculate the % saving in the material if hollow shaft is used. 8