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Final Assessment Test – November/December 2023

Course: BMEE202L - Mechanics of Solids

Class NBR(s): 1687/ 1689/ 1690/ 1691/ 1693/ 1694

Slot: C1+TC1

Time: Three Hours

Max. Marks: 100

KEEPING MOBILE PHONE/SMART WATCH, EVEN IN 'OFF' POSITION, IS TREATED AS EXAM MALPRACTICE

PART – A (1 X 20 = 20 Marks)

Answer the Questions

1. a) Two prismatic bars are rigidly fastened together and support a vertical load of 45 kN, as shown in Fig. 1. The upper bar is steel having length 10 m and cross-sectional area 60 cm^2. The lower bar is brass having length 6 m and cross-sectional area 50 cm^2. For steel E = 200 GPa, for brass E = 100 GPa. Density of brass = 8400 kg/m^3 and density of steel = 7700 kg/m^3. Determine the maximum stress in each material. **[10]**

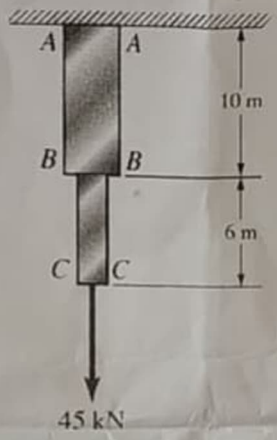

Fig. 1 Prismatic bar loaded vertically

b) A steel rail is 12 m long and is laid at a temperature of 18°C. The maximum temperature expected is 40°C. **[10]**

i) Estimate the minimum gap between two rails to be left so that the temperature stresses do not develop.

ii) Calculate the temperature stresses developed in the rails, if:
(a) No expansion joint is provided. (b) If a 1.5 mm gap is provided for expansion.

iii) If the stress developed is 20 N/mm^2, what is the gap provided between the rails?

Take E = 2 × 105 N/mm^2 and $\alpha = 12 \times 10^{-6}/°C$.

PART – B (5 X 16 = 80 Marks)

Answer any FIVE Questions

2. A plane element in a body is subjected to a normal stress in the x-direction of 80 MPa, as well as a shearing stress of 30 MPa, as shown in Fig. 2. (a) Determine the normal and shearing stress intensities on a plane inclined at an angle of 30° to *x* axis. (b) Determine the maximum and minimum values of the principal stresses that may exist on inclined planes and the directions of these stresses. **[16]**
(c) Determine the magnitude of the maximum shearing stress that may exist on an inclined plane.

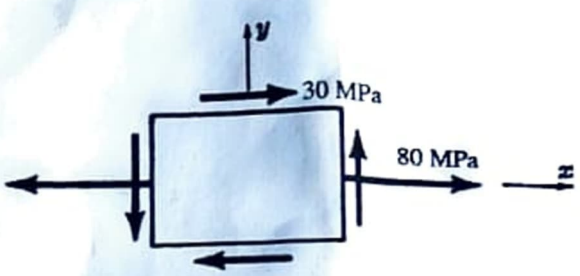

Fig. 2. Element subjected to plane stress

3. A beam of span 8 m has roller support at A and hinge support at B as shown in Fig. 3. Draw Shear Force and Bending Moment diagrams when the beam is subjected to uniformly distributed load for the length AC, a concentrated load at a point C and an externally applied moment at a point D as shown in the Figure. **[16]**

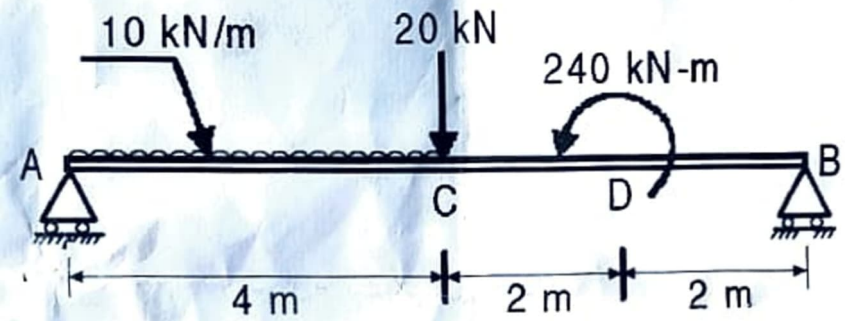

Fig. 3. A Simply supported beam with various loadings

4. The cross-section of a cast iron beam is as shown in Fig.4. The top flange is in compression and bottom flange is in tension. Permissible stress in tension is 30 N/mm^2 and its value in compression is 90 N/mm^2. What is the maximum uniformly distributed load the beam can carry over a simply supported span of 5 m? **[16]**

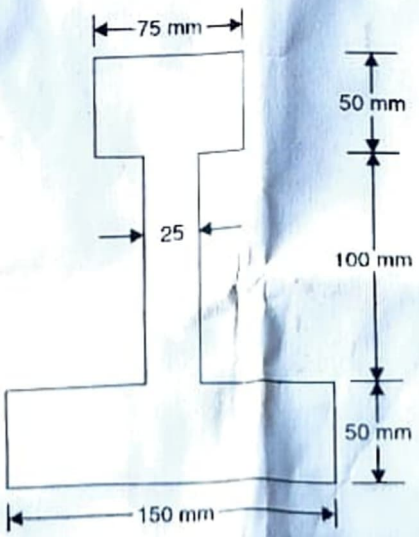

Fig. 4. Cross section of a simply supported beam

5. A timber beam of rectangular section 10 cm wide and 25 cm deep is simply supported over a span of 4m. What uniformly distributed load in kN/m should the beam carry to produce a central deflection of 0.6 cm? Also, Calculate the slope Take : $E = 11\ GN/m^2$. **[16]**

6. A hollow cylindrical steel shaft is 1.5 m long has the inner and outer diameters respectively equal to 40 and 60 mm (Fig. 5). (a) What is the largest torque that can be applied to the shaft if the shearing stress is not to exceed 120 MPa? (b) What torque should be applied to the end of the shaft to produce a twist of 2°? Use the value G = 77 GPa for the modulus of rigidity of steel. (c) What angle of twist will create a shearing stress of 70 MPa on the inner surface of the hollow steel shaft. **[16]**

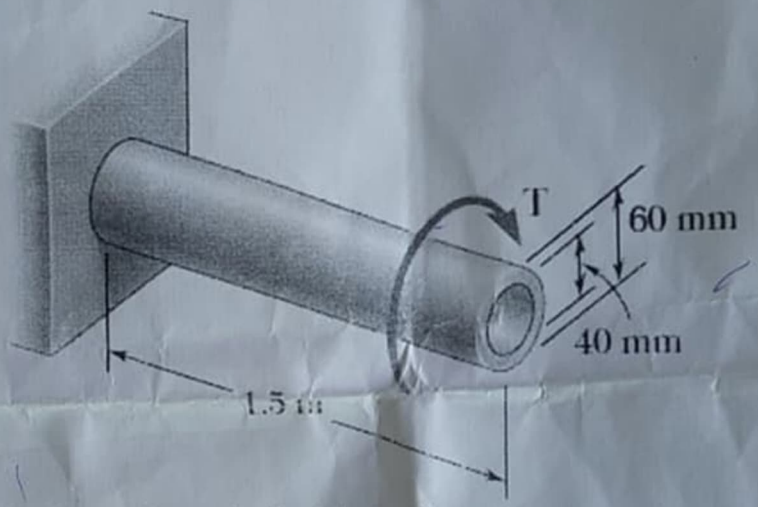

Fig. 5. A hollow cylindrical shaft subjected to a torque

7. An experimental determination of the buckling load for 1.2 cm diameter mild steel pin-ended struts of various lengths, two of the values obtained were: (i) When length is = 50 cm, the load is = 10 kN, and (ii) When the length is = 20 cm, the load = 30 kN. Make the necessary calculations and then state whether either of the above values of loads conforms with the Euler's formula for the critical load. Take $E = 200\ GN/m^2$. **[16]**

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