Problems of Practices
Of
Mechanics of Solids
6- Theory of Flexure for Initially Straight Beams

Prepared By

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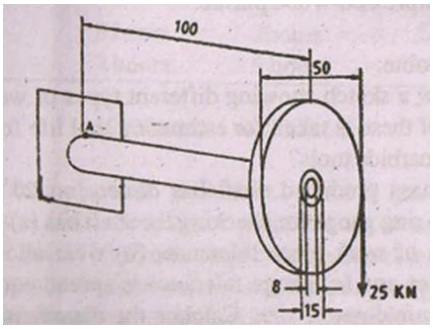
1. A hollow shaft of 40 mm outer diameter and 25 mm inner diameter is subjected to a twisting moment of 1200 kgf-cm, simultaneously; it is subjected to an axial thrust of 1000 kgf and a bending moment of 800 kgf-cm. Calculate the maximum compressive and shear stresses.

2. Figure 1 shows a hollow shaft of 15 cm external diameter and 8 cm internal diameter. At its free end a pulley of 50 cm diameter is rigidly fixed. A force of 25 kN is applied tangential to the pulley as shown in the figure. Determine the principal stresses and the absolute maximum shear stress at point A, located 100 cm from the free end and at the top of shaft surface.



3. A shaft 12 cm external diameter and 8 cm internal diameter is subjected to a bending moment of 300 kgf-m, twisting moment of 100 kgf-m and a direct thrust of 10000 kgf. Determine the maximum principal stress and direction in which it acts with reference to the axis of the shaft at the end points P and Q of diameter PQ as shown in Fig. 1.

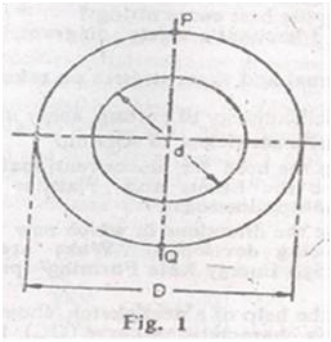


Fig. 1

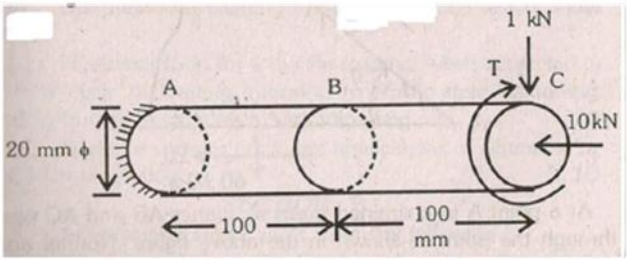
4. State the restrictions or assumptions made in deriving the formula for Theory of Bending'

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

5. A wire of diameter d is wound round a cylinder of diameter D. Determine the bending stress produced on the cross-section of the wire. Hence or otherwise find the minimum radius to which a 1 cm diameter circular rod of high tensile steel can be bent without undergoing permanent deformation. Take yield stress = 17000 kg/cm^2 and $E = 2 \times 10^6$ kg/cm^2. What is the magnitude of BM necessary for this?

6. A solid shaft of diameter 3 cm is fixed at one end. It is subjected to a tensile force of 10 kN and a torque of 60 Nm. At a point on the surface of the shaft, determine the principal stresses and the maximum shearing stress.

7. A cantilever ABC, 200 mm long and 20 mm diameter is fixed at end A as shown in the figure. A horizontal axial load 10 kN, a vertical load of 1 kN acts at end C. Torque T applied at a section C produces a maximum shear stress of intensity 50 MPa in cantilever. Determine principal stresses at point B of cantilever.



8. A steel tube of inner diameter 100 mm and wall thickness 5 mm is subjected to a torsional moment of 1000 Nm. Calculate the principal stresses and orientations of the principal planes on the outer surface of the tube.

9. A timber beam 15 cm wide and 20 cm deep carries a uniformly distributed load over a span of 4 m and is simply supported. If the permissible stresses are 30 N/mm^2 longitudinally and 3 N/mm^2 transverse shear, calculate the maximum load which can be carried by the timber beam.

10. The bracket shown in Figure 1 is subjected to a horizontal force P of 8 kN. Determine the stresses at points A and B.

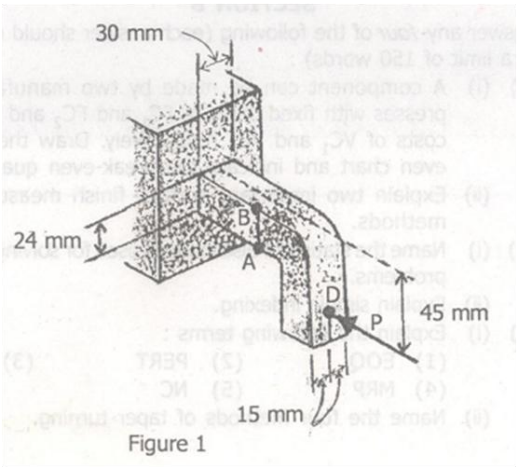


Figure 1

11. A simply supported beam made of rolled steel joist (I- section: 450 mm × 200 mm) has a span of 5 m and it carries a central concentrated load *W*. The flanges are strengthened by two 300 mm × 20 mm plates, one riveted to each flange over the entire length of the flanges. The second moment of area of the joist about the principal bending axis is 35,060 cm^4. Calculate:

(i) the greatest central load the beam will carry if the bending stress in the 300 mm/20 mm plates is not to exceed 125 MPa.

(ii) the minimum length of the 300 mm plates required to restrict the maximum bending stress in the flanges of the joist to 125 MPa.

12. A prismatic bar in compression has a cross-sectional area $A = 900\ mm^2$ and carries an axial load $P = 90$ kN. What are the stresses acting on –

(i) a plane transverse to the loading axis;

(ii) a plane at $\theta = 60°$ to the loading axis?

13. A simply supported beam AB of span length 4 m supports a uniformly distributed load of intensity $q = 4$ kN/m spread over the entire span and a concentrated load $P = 2$ kN placed at a distance of 1.5 m from left end *A*. The beam is constructed of a rectangular cross-section with width $b = 10$ cm and depth $d = 20$ cm. Determine the maximum tensile and compressive stresses developed in the beam due to bending.

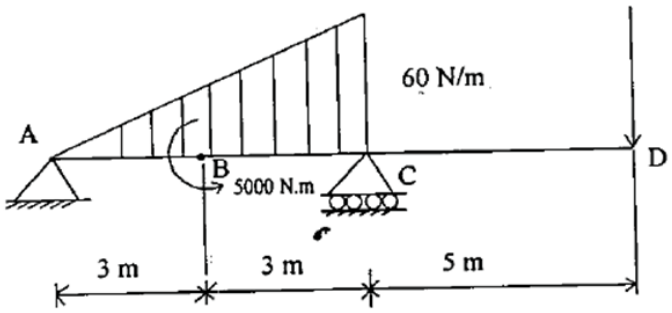
14. A cantilever of circular solid cross-section is fixed at one end and carries a concentrated load *P* at the free end. The diameter at the free end is 200 mm and increases uniformly to 400 mm at the fixed end over a length of 2 m. At what distance from the free end will the bending stresses in the cantilever be maximum?
Also calculate the value of the maximum bending stress if the concentrated load $P = 30$ kN.

15. A beam of I-section 300 mm depth with flanges 150 mm wide and 20 mm thick, and web 12 mm thick is simply supported over a span of 10 m. If the maximum permissible bending stress is 75 MPa, what concentrated load can be carried at a distance of 3 m from one of the supports?

16. A beam ABCD is loaded as shown in Fig. given below. The beam is of rectangular section 50 mm × 100 mm.

(i) Sketch the S.F. and B.M. diagram for the beam.

(ii) Determine the maximum bending stress at section *B* of the beam.

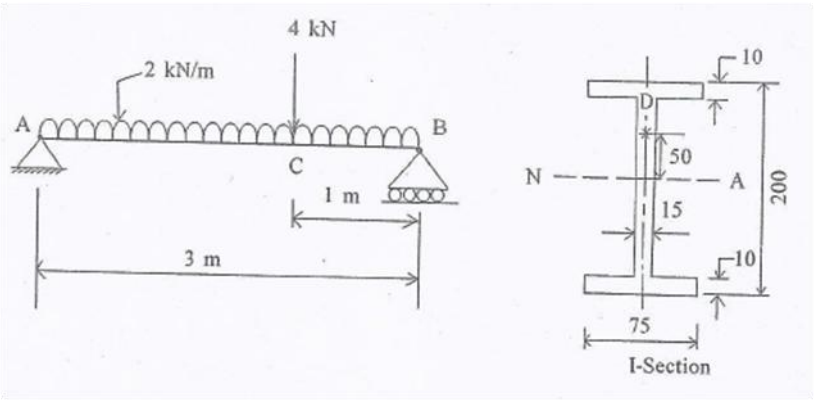


17. Compare the bending strengths of three beams of same material, same weight and same depth if one of them has solid rectangular area of 6 × 20 cm². The second beam is a hollow rectangular section having a wall thickness of 2 cm. The third beam has I-section of equal flanges having web and flange thickness equal to 2 cm.

18. Three steel tubes of outer diameter 20 mm and inner diameter 16 mm each are welded together so that their centres form an equilateral triangle of side 20 mm. Three meter length of this composite tube is used as a simply supported beam at ends with a central point load. How much point load can be applied if the maximum stress in beam sections is not to exceed 100 MPa?

19. At a section in a beam the tensile stress due to bending is 50 N/mm² and there is a shear stress of 20 N/mm².
Determine from first principles the magnitude and direction of the principal stresses and calculate the maximum shear stress.

20. A simply supported beam of 3 m span is subjected to loads as shown below. The beam is of I-section and all its dimensions are shown in mm. Determine the principal stresses at point *D* in the web. This section is located at a distance of 1 m from the right hand support of the beam.



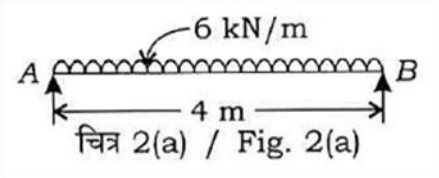
21. A simply supported circular beam of diameter *D* is subjected to a load of *W*. It is desired to replace this beam by a hollow beam having 80% flexural strength, but with outside diameter D_1 and inside diameter $0.5D_1$. Compare the weight of both beams for flexural strength, if they are supported over same span.

22. Compare the flexural strengths of the following three beams of equal weight and same material:
- (i) I-section 300 × 160 mm with flanges 20 mm thick and web 16 mm thick.
- (ii) Rectangular section having depth twice the width.
- (iii) Circular solid section.

23. Consider a hollow circular shaft whose outside diameter is 0.0762 m and whose inside diameter is equal to one-half the outside diameter. The shaft is subjected to

twisting moment of 2259.584 N-m as well as bending moment of 3389.376 N-m. Determine the principal stresses. Also determine the maximum shear stress.

24. A simply supported beam of rectangular section is 200 mm wide and 300 mm deep. It supports a uniformly distributed load of 6 kN/m over an effective span of 4 m as shown in Fig. 2(a). Calculate the magnitude and direction of the principal stresses at a point located at 0.50 m from the left support and 50 mm above the neutral axis.



चित्र 2(a) / Fig. 2(a)

25. Find the maximum flexural stress developed in a steel wire 2.00 mm in diameter, if it is coiled over a drum 0.5 m in radius (it is assumed that the limit of proportionality is not exceeded due to coiling). What is the bending moment to which the wire is subjected? Take E = 200 GPa.