ESO 202A
ASSIGNMENT # 8
(Due July 1, 2019)

Note: Problems # 1 and # 3 are not to be submitted.

1. A beam having a solid rectangular cross-section with the dimensions shown in Fig. 1 is subjected to a positive bending moment of 20 kN-m acting around the horizontal axis. Find (a) the compressive force acting on the shaded area of the cross-section developed by the bending stresses, and (b) the tensile force acting on the cross-hatched area of the cross-section. *[Ans. (a) 177.8 kN, (b) 11.1 kN]*

2. A small T-beam is used in an inverted position to span 400 mm (see Fig. 2). If, due to the application of the three forces shown in the figure, the longitudinal gage at A registers a compressive strain of 50×10^{-3}, how large are the applied forces? Take E = 200 GPa. *[Ans. P = 10.36 kN]*

3. Determine the ratios of the weights of three beams that have the same length, are made of the same material, are subjected to the same maximum bending moment, and have the same maximum normal stress if their cross-sections are (i) a rectangle with height equal to twice the width, (ii) a square, and (iii) a circle (see Fig. 3). *[Ans. 1:1.260:1.408]*

4. In an attempt to make a beam which combines light weight with large stiffness, 6.25 mm steel plates are riveted to the top and bottom of an aluminium-alloy beam I-beam for which $A = 3200$ mm^2 and $I_{zz} = 23.70 \times 10^6$ mm^4 (see Fig. 4). (a) By what ratio is the bending stiffness M_{zz}/κ of the I-beam increased by the addition of the plates? (b) In the composite beam, what is the ratio of the maximum bending stress in the aluminium to that in the steel? (c) What will your answer in (a) be if both the steel plates are added at the top? *[Ans. (a) 2.47, (b) 0.36, (c) 1.77]*

5. A beam is loaded so that the moment diagram varies, as shown in Fig. 5. For the cross-section shown, determine the bolt spacing for the critical region of the span. The bolts are arranged in pairs and the allowable shear force per high-strength bolt is 120 N. If the bolts connecting the top plate with the I-section are skipped by mistake, what will be the shear force in each bolt at the bottom flange for this spacing. *[Ans. s = 77.5 mm]*

6. A steel cantilever beam is fabricated from two structural tees welded together as shown in Fig. 6. Determine the allowable force P that the beam can carry if the allowable stress in bending is 150 MPa, in shear 100 MPa, and along the weld 2 MN/m. Neglect the weight of the beam. *[Ans. $P_{\max}$ = 140 kN]*

7. A beam having a cross-section with the dimensions (in mm) shown in Fig. 7 is in a region where there is a constant, positive vertical shear of 100 kN. (a) Calculate the shear flow q acting at each of the four sections indicated in the figure. (b) Assuming a positive bending moment of 27 kN-m at one section and a larger moment at the adjoining section 10 mm away, draw the isometric sketches of each segment of the beam isolated by the sections 10 mm apart and the four sections shown in the figure, and on the sketches, indicate all forces acting on the segments. Neglect the vertical shear stresses in the flanges. *[Ans. (a) q_{aa} = 83 kN/m; q_{dd} = 415 kN/m]*

8. In Fig. 8, find the total normal stress σ_{xx} and the total shear stress at point A of the base cross-section. *[Ans. σ_{xx} = 200.34 MPa (compressive)]*

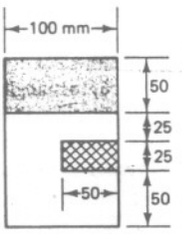


Fig.1

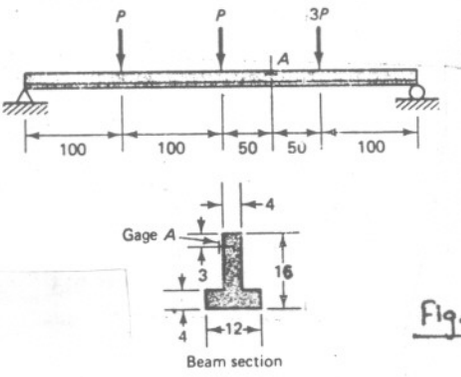


Fig.2

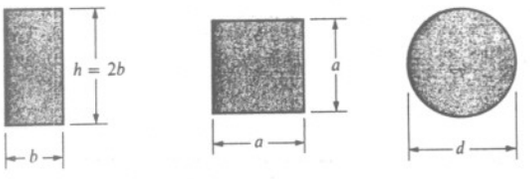


Fig.3

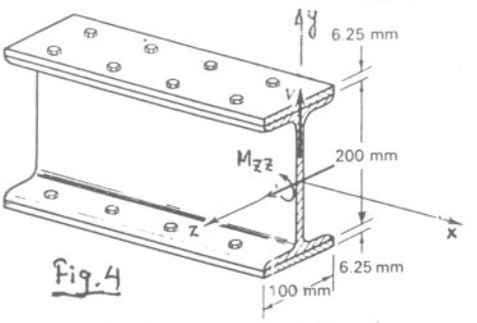


Fig.4

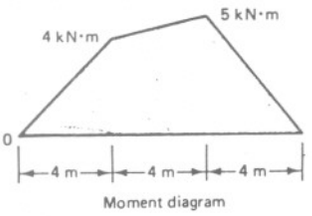
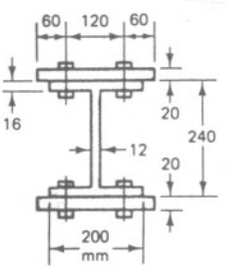


Fig.5



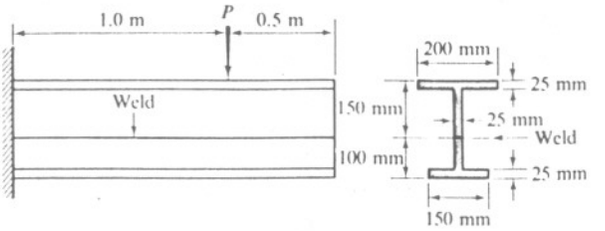


Fig.6

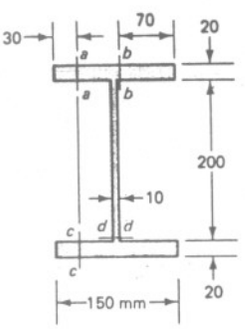


Fig.7

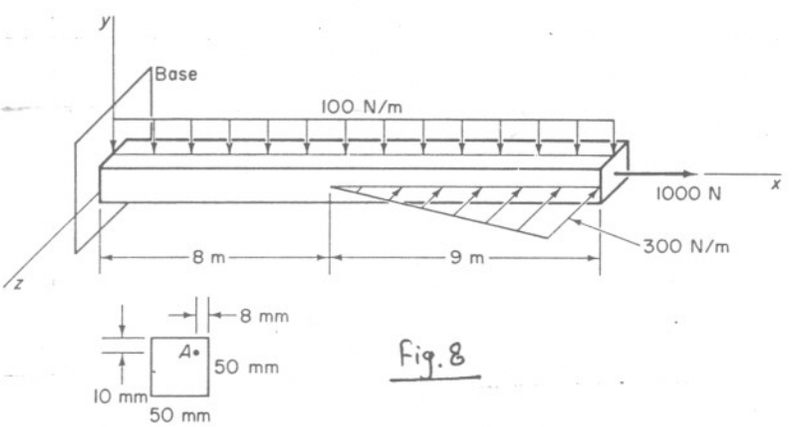


Fig.8