THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 5
FINAL EXAMINATION 2006/2007

028

MEX 5232 – STRENTH OF MATERIAL -II
DATE : 31st March 2007
TIME : 1330 HRS TO 1630 HRS
DURATION : 3 HOURS

Answer any **five** questions. All questions carry equal marks.

1. Obtain expressions for the bending moments and end reactions at the two supports of an unloaded built-in-beam of length L, when one support moves a distance δ relative to the other in a vertical direction.

   A horizontal built-in-beam with a span of 3m is designed to carry a concentrated load of 75MN at its center. Subsequent to initial loading, one of the supports is allowed to move down vertically with respect to the other until the resulting end moment of the movable support disappears. If EI for the beam is $15MNm^2$ calculate the value of required vertical movement. What would be the magnitude of end moment at the movable support if it is moved down by only 60% of this vertical movement?

2. Derive expressions for the radial and hoop stress distribution in a thick cylinder of internal radius R_1 and external radius R_2 when the cylinder is subjected to an internal pressure P.

   In order to determine the internal diameter of a pressurized thick cylinder experimentally, the hoop and longitudinal strains on the outer surface of the cylinder were measured using strain gauges. When the pressure inside the cylinder was increased by $100MN/m^2$ the strain gauges recorded strains of $250x10^{-6}$and $80x10^{-6}$ in the hoop and longitudinal directions respectively. If the external diameter of the cylinder is 120mm, determine the internal diameter by assuming values of $210GN/m^2$ for the elastic coefficient and 0.29 for the Poisson's ratio of the cylinder material.

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3. Show that the interference allowance δ of a compound cylinder of common radius r is given by

$$\delta = \frac{r}{E}(\sigma_{H_0} - \sigma_{H_i}).$$

Where σ_{H_0} and σ_{H_i} are the hoop stresses set up at the common surface on the outer and inner tubes respectively. The tubes are made of the same material of elastic modulus E.

A compound cylinder is made by shrink fitting of a tube of 60mm internal diameter and 100mm external diameter inside a larger tube of 100mm internal diameter and 140mm external diameter. If the interference allowance based on radius is 0.01, calculate the radial pressure set up at the common surface of the tubes due to shrink fitting. Both tubes are of same material having an elastic modulus of 240 GN/m^2.

4. State the criteria for failure in elastic materials subjected to 3-dimensional stresses, in terms of principal stresses and the elastic limit stress in simple tension, under each of the following theories of failure

   i. maximum shear stress
   ii. maximum strain energy
   iii. maximum shear strain energy

A steel tube of thickness 4 mm and mean diameter 90mm is designed to transmit a torque of magnitude 3kNm along with an axial force of 12kN. Which of the above theories provide the best factor of safety if the elastic limit of steel in tension is 225MN/m^2 and Poisson's ratio is 0.3?

5. Show that the partially plastic moment M_{PP} of a rectangular sectioned beam is given by

$M_{PP} = \frac{B\sigma_y}{12}(3D^2 - d^2)$ where B is the beam width, D is the beam height and d is the height of the yielded portion. Thus, calculate the 'shape factor' for a beam of rectangular cross section.

A rectangular sectioned beam of length 2.5m, width 50mm and depth 80mm is simply supported at its ends and loaded at its centre. If the yield strength of the beam material is 225MN/m^2 (in both tension and compression), determine the limiting value of the central concentrated load that would allow beam stresses, anywhere within the beam, to remain elastic. If the load is now increased further by 10% upto what depth the beam would yield from the top and bottom surfaces in the section at mid-span?

6. Briefly explain the use of Mohr's circle of second moment of area in the analysis of beam sections.

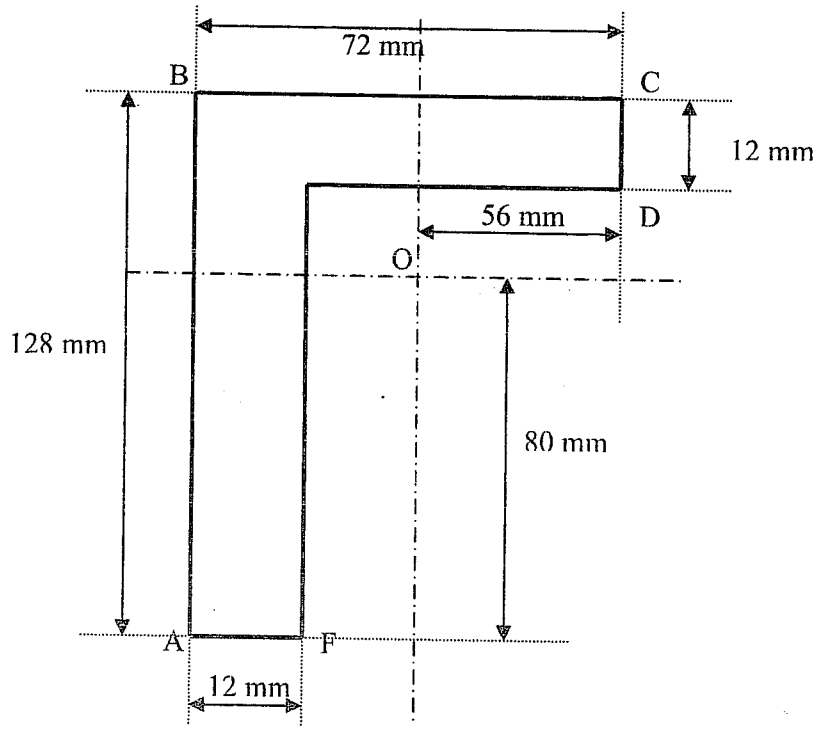


Fig.Q6

A cantilever of length 1.8m and of cross-section shown in Fig.Q.6 carries a vertical load of 15kN at its free end. If the direction of the applied load is parallel to the vertical edge AB of the section and the centroid of the section is located at O as shown in the figure, determine the stresses at points B, D and F.

Also determine the angle of inclination of the neutral axis.

7. The shear stress at a given position on the periphery of a thin walled enclosed tube of irregular cross-section and wall thickness is given by

$\tau = \frac{T}{2At}$ where, T is the torque applied, A is the area enclosed by the median line of the wall thickness, and t is the thickness of wall at the position considered.

Considering that the shear strain energy per unit volume of such a tube is given by $U = \int \frac{\tau^2}{2G}$ show that the angle of twist for tubes of constant thickness and length L is given by

$$\theta = \frac{TLs}{4A^2Gt}.$$

Where s is the perimeter of the median line.

A hollow circular tube of 40mm mean diameter and 2mm wall thickness is subjected to a torque of 200Nm. Calculate the maximum shear stress set up in the tube. In order to reduce the maximum shear stress the circular tube is replaced by a tube of square box section having the same torsional stiffness and wall thickness as that of the circular tube. Calculate the dimensions of the square tube and the percentage reduction in maximum shear stress.

8. The general equations for radial and hoop stresses developed in a rotating disk of uniform thickness are given by

$$\sigma_r = A - \frac{B}{r^2} - (3+\nu)\frac{\rho w^2 r^2}{8}$$

$$\sigma_H = A + \frac{B}{r^2} - (1+3\nu)\frac{\rho w^2 r^2}{8}.$$

Assuming the usual meanings for the notations used in the above equations, obtain expressions for the distribution of stresses in a rotating disc with a central hole of inner radius R_1 and outer radius R_2. Thus show that the maximum hoop stress occurs at the inside surface and is given by

$$\sigma_{H_{max}} = \frac{\rho w^2}{4}\left[(3+\nu)R_2^2 + (1-\nu)R_1^2\right].$$

By similar treatment of a rotating solid disk show that the drilling of even a very small hole at the center of a solid disk will double the maximum hoop stress set up in the disk due to rotation.