Code : 011513

B.Tech 5th Semester Exam., 2014

MECHANICS OF SOLIDS—II

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Give short and complete answer (any *seven*) : 2×7=14

(a) A rectangular section is width b and depth h. What is the shape factor of the section?

(b) State which criterion of failure of materials is based on distortion energy.

(c) In an elliptical section the major axis is $2a$ and minor axis is $2b$. The section is subjected to a torque T. Write the expression for maximum shear stress due to torsion in the elliptical section.

(d) The following state of strain exists at a point :

$$\varepsilon_{xx} = 0{\cdot}02,\ \varepsilon_{yy} = 0{\cdot}06,\ \varepsilon_{zz} = 0,$$

$$\varepsilon_{xy} = -0{\cdot}04,\ \varepsilon_{xz} = 0,\ \varepsilon_{yz} = 0{\cdot}02$$

Determine the cubical dilatation and the first strain invariant.

(e) The following state of strain exists at a point :

$$\varepsilon_{xx} = 0{\cdot}02,\ \varepsilon_{yy} = 0{\cdot}06,\ \varepsilon_{zz} = 0,$$

$$\varepsilon_{xy} = -0{\cdot}04,\ \varepsilon_{xz} = 0,\ \varepsilon_{yz} = 0{\cdot}02$$

What is the green strain in the direction of line having direction components $n_x = 0{\cdot}6$, $n_y = 0{\cdot}0$ and $n_x = 0{\cdot}8$?

(f) The principal stresses at point are given by $\sigma_1 = 100$ MPa, $\sigma_2 = 80$ MPa, $\sigma_3 = -40$ MPa. Determine the magnitude of maximum shear stress and the associated normal stress.

(g) A single-wheel load of 170 kN is acting on an elastic beam which is supported on an elastic foundation of spring constant $k = 14\ \text{N/mm}^2$. The moment of inertia of the beam is $36{\cdot}9 \times 10^6\ \text{mm}^4$ and $E = 200 \times 10^3\ \text{N/mm}^2$. Determine the deflection at the load point.

(h) For a both end pinned column the Euler's buckling load is P_{cr}. If the column is restrained at two locations against sideway buckling, what is the critical load?

(i) An elastic material ($E = 200$ GPa) is yielding at 240 MPa. What is the strain energy density?

(j) Write the conditions of a plane stress case and a pure shear case.

2. Why are compatibility relations needed? Derive the compatibility relations in terms of strain components. 2+12=14

3. The displacement field for a body is given by

$$u = [(x^2 + y^2 + 2)i + (3x + 4y^2)j + (2x^3 + 4z)k]10^{-9}$$

(a) What is the displaced position of a point originally at (1, 2, 3)?

(b) What are the strain components at point (1, 2, 3) taking linear terms? 7+7=14

4. What do you mean by deviatoric and spherical stress tensor? What are their implications? Give geometrical interpretations of shear strain. 4+2+8=14

5. For steel, the following data is applicable :

$E = 207 \times 10^6$ kPa and $G = 80 \times 10^6$ kPa

For the given strain components,

$$\varepsilon_{xx} = 0{\cdot}001,\ \varepsilon_{yy} = -0{\cdot}003,\ \varepsilon_{zz} = 0,$$
$$\varepsilon_{xy} = 0,\ \varepsilon_{xz} = -0{\cdot}002,\ \varepsilon_{yz} = 0{\cdot}003$$

determine the components of stress matrix. 14

6. A machine part of T-section is acted upon by a 3 kN-m couple. The flange width and thickness of the T-section are 90 mm and 20 mm respectively. The web depth and thickness are 40 mm and 30 mm respectively, $E = 165$ GPa. Determine *(a)* the maximum tensile and compressive stresses in the section, *(b)* radius of curvature of the beam and *(c)* if for the material yield stress is 275 MPa and ultimate stress is 414 MPa, determine the bending moment M for which the factor of safety is 3·00 and the corresponding radius of curvature. 4+4+4+2=14

7. An aluminium column of length L and rectangular cross-section $a \times b$ has a fixed end B and supports a centric load P at A. Two plates restrain end A from moving in one of the vertical planes of symmetry of the column, but allow it to move in the other plane. *(a)* Determine the ratio a/b of the two

sides of the cross-section corresponding to the most efficient design against buckling. *(b)* Design the most efficient cross-section for the column knowing that $L = 500$ mm, $E = 70$ GPa, $P = 22$ kN and that a factor of safety of 2·5 is required. 7+7=14

8. *(a)* Derive the Euler's formula for critical load for a pin-ended column.

(b) A 2-m long pin-ended column of square cross-section is to be made of wood. Assuming $E = 13$ GPa and allowable stress is 12 MPa and using a factor of safety of 2·5 in computing the Euler's critical load for buckling, determine the size of the cross-section if the column is to safely support 200 kN load. 7+7=14

9. A thin circular ring of radius r is subjected to two diametrically opposite loads P in its own plane in the vertical direction. *(a)* Determine an expression for bending moment at any section. *(b)* Determine the change in the vertical diameter. 8+6=14

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