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Question Paper Code : 11286

M.E./M.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

First Semester

Structural Engineering

ST 5103 — THEORY OF ELASTICITY AND PLASTICITY

(Regulation 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write down the equilibrium equations in Cartesian coordinates.

2. State the generalized Hooke's law.

3. Differentiate between plane stress and plane strain problems.

4. State Saint Venant's principle

5. What are the assumptions made in St. Venant's theory for deformation of twisted bars?

6. State the analogy between torsion and membrane problems.

7. What is meant by semi infinite beam?

8. Write the equation for calculating deflection of a finite beam subjected to single concentrated load.

9. Define the terms: yield surface and yield criteria.

10. Mention the important theories of failures adopted in practice.

PART B — (5 × 13 = 65 marks)

11. (a) The three stress components at a point are given by

$$\begin{bmatrix} 10 & 5 & 6 \\ 5 & 8 & 10 \\ 6 & 10 & 6 \end{bmatrix} MPa$$

Calculate the principal stresses and principal planes.

Or

(b) Derive the compatibility equations for plane stress problem and plane strain problem in cartesian coordinate considering the body forces. Also show that when the body forces are constant or zero, the compatibility equations for plane stress problem and plane strain problem reduces to the same.

12. (a) (i) Discuss the use of polynomials in the solution of structural problems.

(ii) Show that the Airy's stress function $\phi = A\left(xy^3 - (3/4)\,xyh^2\right)$ represents the stress distribution in a cantilever beam loaded at the free end with load P. Find the value of A, if $\tau_{xy} = 0$ at $y = \pm h/2$ where b and h are width and depth respectively of the cantilever beam cross section.

Or

(b) (i) The following stress function is proposed for a long cantilever carrying a point load at the free end. Determine the stress components and verify the same.

$\phi = Axy^3 + Bxy$

(ii) Determine the state of stress in polar coordinates for a stressed plate having stress concentration due to circular hole.

13. (a) (i) A 300mm steel I beam with flanges and web 12.5mm thick is subjected to a torque of 4kNm. Find the maximum shear stress and angle of twist per unit length. Assume G = 100GPa.

(ii) A shaft is of elliptical cross section having semi major axis 50mm and semi minor axis 25mm. It is subjected to a torque of 1000Nm. Determine the maximum shear stress developed in the shaft.

Or

(b) (i) Explain in detail membrane analogy used in solving torsion problems.

(ii) A thin walled closed tube of non-circular section is subjected to a torque T. Derive the expression for shear stress and angle of twist.

14. (a) (i) What are the two types of elastic foundations? Explain them briefly.

(ii) Derive the governing differential equation for the elastic line of a beam resting on an elastic foundation.

Or

(b) The foundation for a machine base comprises of standard I beams of overall depth 75mm and 8m long supported on coil springs spaced at 800mm centres. The spring constant for each of the coil spring is 120N/mm. The machine transmits a concentrated load of 10 kN acting at the mid - point of the beam. Estimate the maximum deflection and the bending stress in the beam, assuming the modulus of elasticity of the material of the beam is 70kN/mm^2 and second moment of area of the beam is 1×10^6mm^4.

15. (a) (i) Discuss the various yield criteria and its use to predict the onset of yielding in metals.

(ii) The state of stress in a material is given by $\sigma_x = 75\ MPa$, $\sigma_y = 95\ MPa$ and $\tau_{xy} = 55 MPa$. If the yield strength of the material is 120MPa, determine whether yielding will occur or not.

Or

(b) (i) Write a detailed notes on Plastic bending of beams.

(ii) Explain the sand heap analogy for solving plastic torsion problems. What are the limitations of this analogy?

PART C — (1 × 15 = 15 marks)

16. (a) Show that $\psi = C$ (constant) solves the torsion problem of a solid circular shaft using warping function approach. Evaluate the maximum shear stress and torsional moment, in terms of torsional rigidity, and verify the results are in agreement with those given by the strength of materials approach.

Or

(b) An I section with flanges 50mm × 5mm and web 140mm × 3mm is subjected to a twisting moment of 200Nm. Find the maximum shearing stress and twist per unit length. Assume G = 80GPa.

If the I section is stiffened by welding two steel plates of size 140mm × 5mm, find the stresses due to the same torque.