G 6505

M.E. DEGREE EXAMINATION, MAY/JUNE 2007.

First Semester

Structural Engineering

ST 1603 A — CONSTITUTIVE MODELS AND MODES OF FAILURE

(For candidates admitted from the year 2006 – 07 onwards)

(Regulation 2005)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate plane stress from plane strain problems.

2. Why do we call stress as a tensor quantity?

3. Write down the equilibrium equations is polar co-ordinates.

4. Determine the radial and shear stresses for the Airy's stress function $\phi = \dfrac{\cos^3 \theta}{r}$.

5. What are the different analogies available to solve torsion problem?

6. A hollow tube 50 mm mean diameter and 2 mm wall thickness with a 2 mm wide saw cut along its length is subjected to a twisting moment. If the maximum shear stress induced is 5 N/mm^2, find the value of the maximum twisting moment.

7. State the principle of virtual work.

8. The force versus displacement relation of an elastic body is given by $F = ax^n$. Compute complementary energy of the material.

9. State Griffith's theory of brittle fracture.

10. Draw stress strain curve for an elastic perfectly plastic material.

PART B — (5 × 16 = 80 marks)

11. (a) Show that

    (i) $\left(Ae^{\alpha y} + Be^{-\alpha y} + Cye^{\alpha y} + Dye^{-\alpha y}\right)\sin\alpha x$ is a stress function. (8)

    (ii) Derive the biharmonic equation in Cartesian co-ordinates system. (8)

Or

(b) Show that the line elements at the point x, y that have the maximum and minimum rotation are those in the two perpendicular directions θ determined by $\tan 2\theta = \dfrac{\partial v/\partial y - \partial u/\partial x}{\partial v/\partial x + \partial u/\partial y}$.

12. (a) Determine the value of the constant C in the stress function.

    $\phi = C r^2 (\cos 2\theta - \cos 2\alpha)$ required to satisfy the conditions

    $\sigma_\theta = 0$ and $\tau_{r\theta} = s$ on $\theta = \infty$

    $\sigma_\theta = 0$ and $\tau_{r\theta} = -s$ on $\theta = -\infty$

    corresponding to uniform shear loading on each edge of a wedge, directed away from the vertex. Verify that no concentrated force or couple acts on the vertex.

Or

(b) (i) At a point in a stressed material the Cartesian components of stresses $\left(\text{in N/mm}^2\right)$ are

    $\sigma_x = -40 \quad \sigma_y = 80 \quad \sigma_z = 120$

    $\tau_{xy} = 72 \quad \tau_{yz} = 46 \quad \tau_{xz} = 32.$

    Calculate the normal and shear stresses on a plane whose normal makes an angle of 48° with the x-axis and 61° with the y-axis. (8)

    (ii) The state of stress at a point is given by

    $\sigma_x = x^3 y - 2a\,xy + by$

    $\sigma_y = xy^3 - 2x^3 y$

    $\tau_{xy} = \frac{3}{2}x^2 y^2 + ay^2 + \frac{x^4}{2} + c.$

    Check whether the equilibrium exists or not. (8)

13. (a) (i) Describe membrane analogy. (8)

(ii) Find the torsional resistance of a triangular section by assuming suitable stress function. (8)

Or

(b) Derive the expressions for angle of twist, shear stress and hence maximum shear stress induced in a circular section due to a twisting moment.

14. (a) (i) With a simple example, explain the Rayleigh – Ritz technique. (8)

(ii) State and explain the principle of virtual force and principle of virtual displacement. (8)

Or

(b) Using Rayleigh – Ritz method, obtain an expression for deflection of a simply supported beam of span L subjected to a UDL of intensity 'w' and a concentrated load P at its mid span.

15. (a) Write briefly about : $(4 \times 4 = 16)$

(i) Kelvin and Maxwell models

(ii) Friction and Coulomb models

(iii) Flow rule

(iv) Stress intensity factor.

Or

(b) Write briefly about : $(4 \times 4 = 16)$

(i) St. Venant's theory of plastic flow

(ii) Fracture toughness testing

(iii) Von-Mises yield criteria

(iv) Factors affecting plastic deformation of a material.

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