KUMARAGURU
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M.E DEGREE EXAMINATIONS: NOV/ DEC 2024

(Regulation 2024)

First Semester

STRUCTURAL ENGINEERING

24STT502: Theory of Elasticity and Plasticity

COURSE OUTCOMES

CO1: Mathematical formulation of elasticity problems in equilibrium and compatibility equations for 3D problems.

CO2: Formulating Boundary Value Problems in Linearized Elasticity and Solving 2D Problems with Airy's Stress Functions.

CO3: Solution to boundary value problems corresponding to end torsion of prismatic beams

CO4: Analyze with Plasticity Theories.

CO5: Analyze with fracture mechanics.

Time: Three Hours   **Maximum Marks: 100**

PART A (4*20 = 80 Marks)

1.	a)	A cylindrical bar is subjected to a uniaxial tensile load of 50 kN. The bar has a diameter of 20 mm and a length of 300 mm. Using the generalized Hooke's law, calculate the axial stress, strain, and the change in length if the modulus of elasticity is E =200 GPa and Poisson's ratio is ν =0.3.	10	CO1	[K$_3$]
	b)	A thick-walled cylinder is subjected to internal pressure pi=100 MPa and external pressure po=50 MPa. Derive the expressions for radial and tangential stresses in cylindrical coordinates. Calculate these stresses at r=75mm.	10	CO1	[K$_3$]
2.	a)	A plate is subjected to plane stress conditions with a stress distribution given by: $\sigma_x=ax^2+by$, $\sigma_y=cy^2+dx$, $\tau_{xy}=exy$. Verify whether this stress distribution satisfies the equilibrium equations. Derive the corresponding Airy's stress function.	10	CO2	[K$_2$]
	b)	A thick cylinder with inner radius ri=50 mm and outer radius ro=150 mm is subjected to an internal pressure pi=20 MPa.Determine the radial and hoop	10	CO2	[K$_2$]

stresses at any radius r using Lame's equations. Plot the stress distribution across the cylinder thickness.

3.	a)	A solid rectangular beam with dimensions $b \times h$ is subjected to pure torsion. Using the Prandtl stress function method. Derive the expression for shear stress distribution in the cross-section.	10	CO3	[K$_3$]
	b)	Explain the membrane analogy for torsion and apply it to find the torsional constant J for a thin-walled hollow rectangular section with dimensions a = 100 mm, $b = 100$ mm, and thickness $t = 2$ mm. Calculate the torsional rigidity GJ and shear stress for a given torque $T = 500$ Nm.	10	CO3	[K$_3$]
4.	a)	A material follows a linear stress-strain relationship up to the yield stress σy =250 MPa and undergoes strain hardening thereafter, with the stress-strain curve given as $\sigma = \sigma y + k\epsilon p$, where k=1000 MPa. Explain the significance of strain hardening in materials	10	CO4	[K$_3$]
	b)	A pipeline is subjected to internal pressure and bending loads, causing localized plastic deformation. The pipeline material follows von Mises yield criterion with $\sigma y = 300$ MPa. Calculate the equivalent stress under combined axial σx=150 MPa and hoop stresses σh=200 MPa.	10	CO4	[K$_3$]

Answer any ONE Question
PART B (1*20 = 20 Marks)

5.	a)	Analyze a real-life engineering failure due to fracture, apply fracture mechanics to identify the cause, and propose design modifications to prevent future failures, considering stress intensity and crack propagation.	12	CO5	[K$_4$]
	b)	Evaluate the importance of fracture mechanics in modern engineering design.	8	CO5	[K$_3$]

OR

6.	a)	Given a plate with a thickness t=10 mm with a crack length a=25 mm, under an applied load of P=5 kN. Calculate the energy release rate and analyze the likelihood of crack propagation, comparing it with the materials fracture toughness.	12	CO5	[K$_4$]
	b)	Discuss the role of the stress intensity factor in characterizing fracture.	8	CO5	[K$_3$]

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