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M.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2017

THEORY OF PLASTICITY

FULL MARKS 100 DURATION 3 HRS

Answer a total of four questions with atleast one from each group. If the breakup is not given for any question, assume uniform distribution of the marks among the parts (if any). Symbols have their usual meanings. Assume suitable values for any missing data.

GROUP-A

1. Assume the following properties of a thick tube-
   Inner radius $a = 25$ mm, Outer radius $b = 30$ mm, Young's modulus $E = 200E3$ MPa, Poisson's ratio $\nu = 0.3$, Yield stress $\sigma_y = 200$ MPa, Tangent modulus negligible. Then-
   a. Determine the external pressure required to initiate plastic deformation in the cross-section.
   b. Determine the maximum load bearing capacity.
   c. Determine the pressure required to create an elastic core with a boundary $c = \frac{a+b}{2}$.
   d. Plot the variation of σ_r, σ_θ with radius for the above pressure.
   e. Plot the variation of the residual stresses $(\sigma_r, \sigma_\theta)$ with radius once the pressure is released.
   Use maximum shear stress theory.

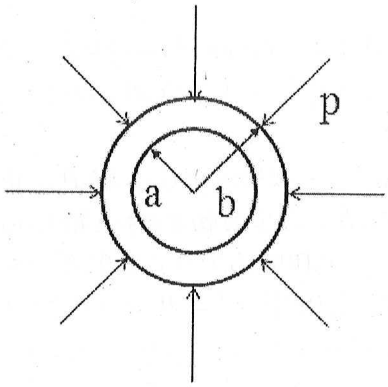

Figure (1)

2. For a shaft subjected to combined bending and torsion as shown in the Figure (2) with the variation of the torque related to the variation of the point load as-

$$T = 0.25\alpha\mu d_0 F$$

, where, d_0 is the outer radius of the shaft. Other shaft properties-

Length=L, Young's modulus=E, Poisson's ratio=ν, Yield stress=σ_y, tangent modulus negligible. Then-

a. Determine the value of F to initiate plastic deformation in the cross-section.
b. Determine the maximum load bearing capacity.
c. Determine the force required to create an elastic core with a boundary $c = 0.25d_0$.
d. Plot the variation of σ, τ with radius for the above pressure.
e. Plot the variation of the residual stresses (σ, τ) with radius once the load is released.

Use maximum shear stress theory. Ignore shear stress due to bending.

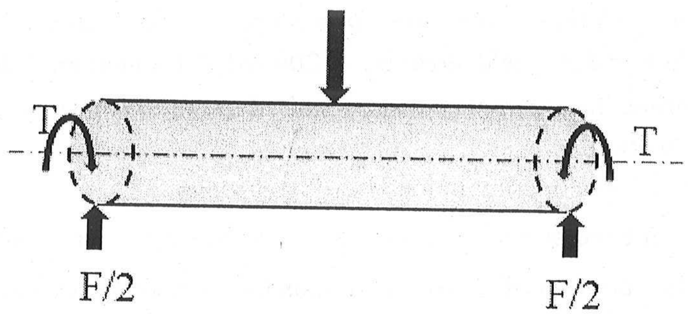

Figure (2)

GROUP-B

3. FE simulation is being performed for an elasto-plastic material with Young's modulus $E = 200\text{E}3$ MPa, Poisson's ratio $\nu = 0.3$, Yield stress $\sigma_y = 200$ MPa, and nonlinear isotropic hardening model-

$$dR = b(Q - R)d\|\epsilon_p\|$$

, where, $Q = 800$ MPa and $b = 3.5$. If in a given iteration the total strain increment is $\Delta\epsilon = [0.0005, -0.00015, \ -0.00015, 0.0, 0.0, 0.0]^T$ and $\boldsymbol{\sigma}^0 = [180.0, 0.0, 0.0, 0.0, 0.0, 0.0]^T, \epsilon_p^0 = [0.0, 0.0, 0.0, 0.0, 0.0, 0.0]^T, R^0 = 0.0$ be respectively the stress, the plastic strain and the isotropic hardening stress values from the previous step, then use a numerical scheme to-

a. Determine the stress $\boldsymbol{\sigma}$ and the plastic strain$\boldsymbol{\epsilon_p}$.
b. Determine the consistent tangent matrix, $\boldsymbol{C_t} = \frac{d\sigma}{d\Delta\epsilon}$.

Use von-Mises yield criteria.

4. FE simulation is being performed for an elasto-plastic material with Young's modulus E, Poisson's ratio v, Yield stress σ_y, and simplified Chaboche kinematic hardening model-

$$d\boldsymbol{\alpha} = \frac{2}{3} C d\boldsymbol{\epsilon}_p - \gamma \boldsymbol{\alpha} \| d\boldsymbol{\epsilon}_p \|$$

, where, boldface characters are vector quantities. If in a given iteration the total strain increment is $\Delta\boldsymbol{\epsilon}$ and $\boldsymbol{\sigma}^0, \boldsymbol{\epsilon}_p^0, \boldsymbol{\alpha}^0$be respectively the stress the plastic strain and the back stress values from the previous step, then write the numerical scheme to-

   c. Determine the stress $\boldsymbol{\sigma}$ and the plastic strain$\boldsymbol{\epsilon}_p$.

   d. Determine the consistent tangent matrix, $\boldsymbol{C}_t = \frac{d\boldsymbol{\sigma}}{d\Delta\boldsymbol{\epsilon}}$.

Use von-Mises yield criteria.

GROUP-C

5. Answer following questions-
   a. What do you mean by plastic instability in elastic- plastic process ? <05>
   b. Show that the condition of instability for uni-axial tension is given by-
   $$\frac{d\sigma_1}{d\varepsilon_1} = \sigma_1$$
   <10>
   c. For a thin cylinder of mean diameter 200 mm and wall thickness 3mm is subjected to internal pressure. Both the ends of the cylinder id closed. Find the instability pressure. The following data are given E= 200 GPa, $\upsilon = 0.3$ The material stress –strain relation is given by $\bar{\sigma} = 1120(\bar{\varepsilon})^{0.25}$ MPa < 10>
6. Answer the following questions-
   a. What do you mean by (i) Statically admissible stress field and ii) kinematically admissible displacement field ? <05>
   b. State and explain Hill's criteria for maximum dissipation. <10>
   c. Determine the pressure P required for a rigid punch indentation in semi infinite deformable material using Upper bound theorem . The material has a yield stress in shear equals to 'k'. State the assumptions clearly. Draw the deformation pattern and velocity diagram and explain. <10>