National Exams December 2008

07-Mec-A6-2 Advanced Strength of Materials

3 Hours Duration

NOTES

1 If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made

2 Any non-communicating calculator is permitted This is an open book exam

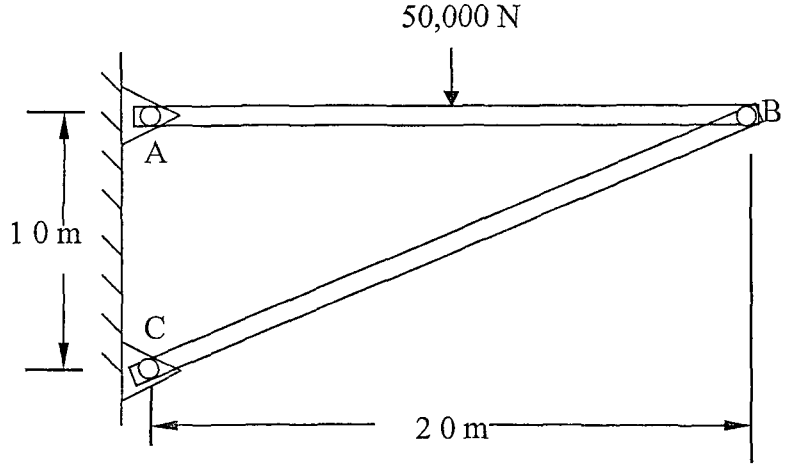
3 Any five of the eight problems constitute a complete paper If you choose to attempt more than five problems, only the first five problems as they appear in your answer book will be marked

4 All problems are of equal value

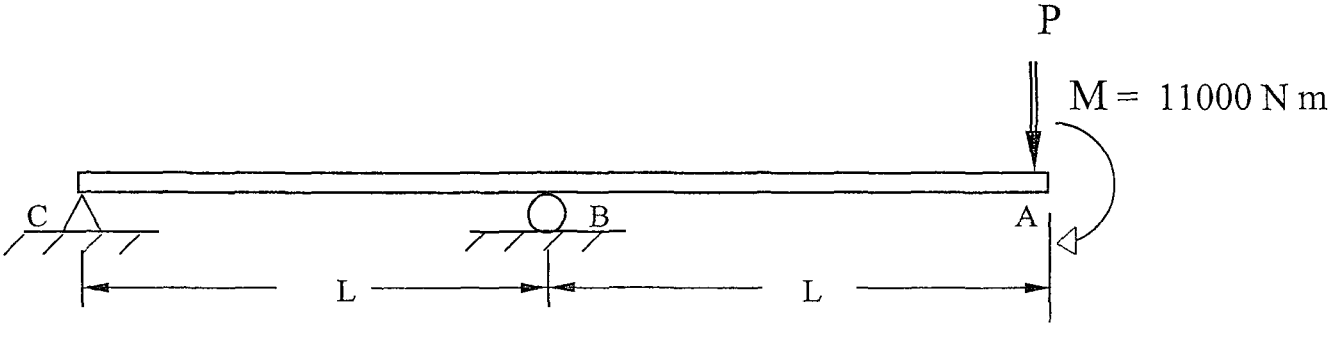
1- The steel compression strut BC of the frame ABC in the figure below is of tubular cross section with an outer diameter of 55 mm and a wall thickness of 7 mm

a- Determine the factor of safety against elastic buckling of BC if the 50,000 N load shown below is applied at the mid point between A and B Let E = 200 GPa and $\sigma_{yielding}$ = 320 MPa

b- What is the wall thickness that BC can have if the buckling safety factor was 1 5?



2- Determine the magnitude and direction (up or down) of the force P applied at point A of the beam below if the displacement at A was not to exceed 2 mm (down) Take E = 200 GPa, I = 750x10^6 mm^4, L = 4 m



3- A thick-walled cylinder with 0 12 m internal diameter and 0 20 m external diameter is fabricated of a material whose elastic limit is 350 MPa and Poisson's ratio ν = 0 28 The cylinder is subjected to an internal pressure five times greater than the external pressure Calculate the allowable internal pressure according to

a) the maximum shear stress theory, and

b) the energy of distortion theory

4- A two-dimensional strain field is given by

$$\varepsilon_x = c(-3x^2+7y^2) \qquad \varepsilon_y = c(x^2-5y^2) \quad \gamma_{xy} = bxy$$

where b and c are nonzero constants

a) What is the relationship between b and c for this field to satisfy the strain compatibility conditions?

b) Determine the displacements u(x,y) and v(x,y) corresponding to this field of strain

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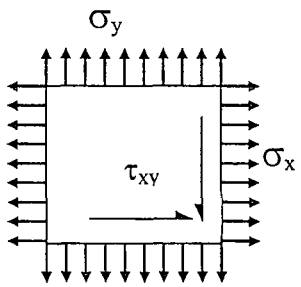
5- The state of plane stress shown below is defined by the following stresses

$$\sigma_x = 210 \text{ MPa} \qquad \sigma_y = 70 \text{ MPa} \qquad \text{and} \qquad \tau_{xy} = -120 \text{ MPa}$$

a- Show this state of stress on a properly constructed Mohr's circle

b- Will the above stress condition cause yielding according to the maximum shear stress theory? Assume $\sigma_{yielding} = 290$ MPa

c- Determine σ_x and τ_{xy} on an element rotated 60 degrees clockwise from the x-axis



6- A three element rosette is mounted on a thin steel specimen with a Young's modulus of 190 GPa and a Poisson's ratio of 0 3 The rosette provides the following readings along the 0, 60 and 120 degree directions respectively

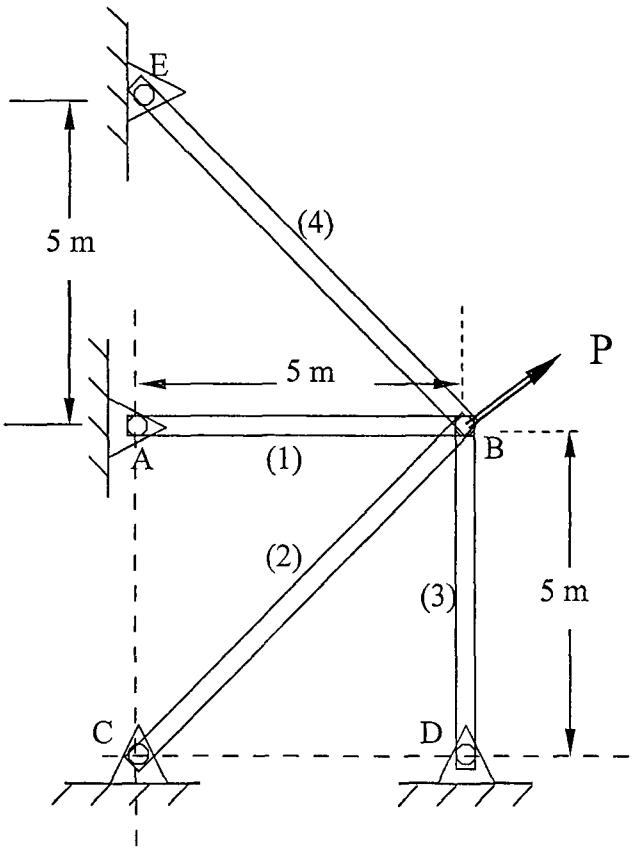
$$\varepsilon_0 = 300\ \mu \qquad \varepsilon_{60} = 1500\ \mu \qquad \varepsilon_{120} = 600\ \mu$$

a) From these readings, calculate the strains ε_x , ε_y and γ_{xy} along the +45 degree direction

b) Determine the principal strains ε_1 and ε_2 and the principal directions

c) Using the generalized Hooke's law, calculate σ_x , σ_y and τ_{xy}

7- A force P = 30 KN is applied at joint B of the four-member structure below, at a 45° angle from the horizontal line Each member has a cross section area A = 100 mm^2 and a modulus of elasticity E = 75 GPa Use an energy method of your choice to determine the member forces F_1 to F_4 and the corresponding stresses and strains Assume linear elastic behaviour of the members



8- Two uniform linearly elastic rods are welded together at B, and the resulting two-segment rod is attached to rigid supports at A and C Rod (1) has a modulus E_1 = 220 MPa, cross-sectional area A_1 = 5 cm^2, length L_1 = 150 cm , and coefficient of thermal expansion $\alpha_1 = 9 \times 10^{-6}$/°C Rod (2) has a modulus E_2 = 120 MPa, cross-sectional area A_2 = 8 cm^2, length L_2 = 110 cm, and coefficient of thermal expansion $\alpha_2 = 15 \times 10^{-6}$/°C

a) Determine the axial stresses in the rods if the temperature of both is raised by 40 °C
b) Determine whether joint B moves to the right or left and by how much?