National Exams Dec 2016

07-Mec-B9 ADVANCED ENGINEERING STRUCTURES

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.

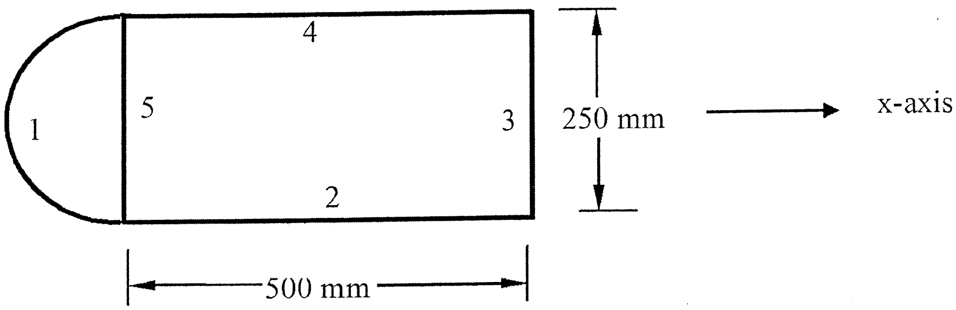
3. Any FIVE (5) questions constitute a complete exam paper. If more than five questions are attempted, only the first five as they appear in the answer book will be marked.

4. All problems are of equal total value. Marks for individual questions are indicated within each problem.

1. The torsion box shown below is symmetric with respect to the horizontal and is subjected to a constant torque T = 33000 N.m. acting clockwise.

a) Calculate the shear flow q in walls 1, 2, 3, 4 and 5. The thickness of each wall is as follows: t_1 = 1.5 mm, t_2 = 2.5 mm, t_3 = 2 mm, t_4 = 3.5 mm and t_5 = 2 mm. <u>Wall 1 is semi-circular</u>. (15 marks)

b) What is the maximum shear stress and in which wall does it occur? (5 marks)



2. An orthotropic composite material system has the following lamina properties:

$$E_{11} = 190 \text{ GPa}$$
$$E_{22} = 19 \text{ GPa}$$
$$G_{12} = 12 \text{ GPa}$$
$$\nu_{12} = 0.3$$

a) Determine the various entries in the 0° lamina stiffness matrix [C]. Recall ([σ] = [C][ε])

b) Evaluate the transform stiffness matrix [Q] for a 90° ply.

c) Evaluate the transform stiffness matrix [Q] for a 45° ply.

d) Determine σ_x , σ_y , and τ_{xy} for a 90° ply if ε_x , ε_y , γ_{xy} are given by 0.0007, 0.004 and -0.0015 respectively

3. The following data points have been obtained from a series of mechanical strain cycling tests on an aircraft component:

Range of plastic strain Δε	Number of cycles to failure N
0.0370	260
0.0211	970
0.0140	2800
0.0080	12000

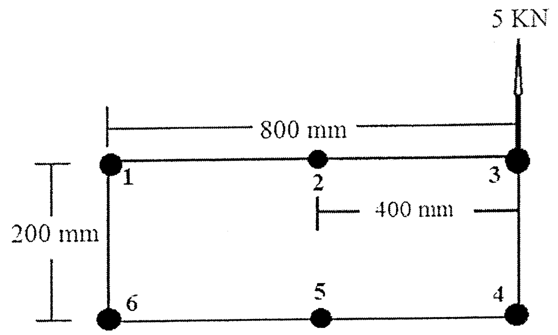
a) Determine the coefficient C and exponent α that would best represent these results through an equation of the type: $\Delta\varepsilon = CN^{\alpha}$. (10 marks)

b) A component made from this material is subjected to a range of plastic strain of 0.017 for the first 200 cycles and then to a range of plastic strain of 0.01 for the rest of its service life. Calculate the total number of cycles before failure, assuming the material obeys Miner's cumulative damage law. (10 marks)

4. A stiffened thin walled wing box has been idealized into normal stress carrying booms 1 to 6 and shear only resisting thin wall panels. The box is subjected to a vertical force of 5,000 N acting upward as shown below. The boom areas are: $B_1 = B_6 = 600\ mm^2$, $B_2 = B_5 = 400\ mm^2$ and $B_3 = B_4 = 850\ mm^2$.

a) Determine the location of the shear center with respect to boom 6 (10 marks)

b) Determine the shear flow in the panels of the idealized box. (10 marks)

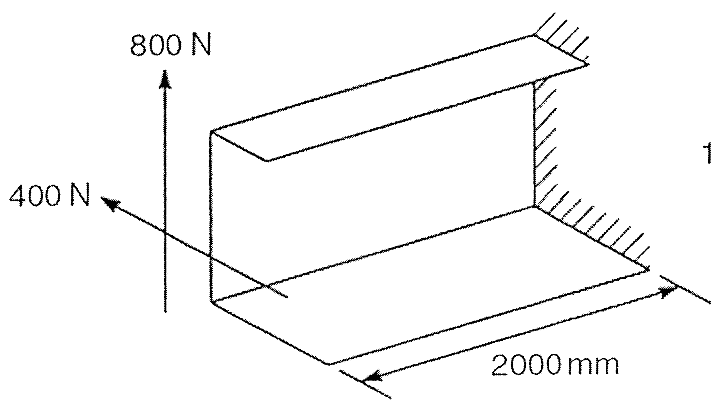


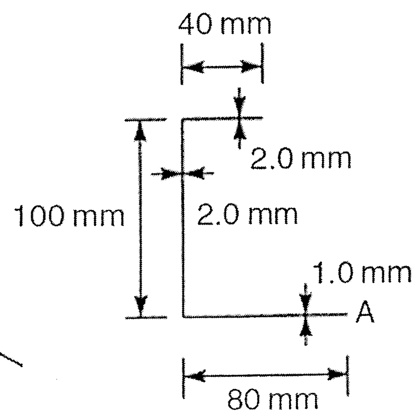
5. A cantilevered structural beam of solid square cross-section (**w** by **w**) is subjected at its free end to a compressive axial force of magnitude $P = 225 \times 10^3$ N and a torque $T = 22 \times 10^3$ N.m. This bar is to be designed in accordance with the maximum-shear-stress criterion of failure, with a safety factor of 3.

a) What is the minimum allowable dimension **w** if $\sigma_{yielding} = 330$ MPa? (10 marks)

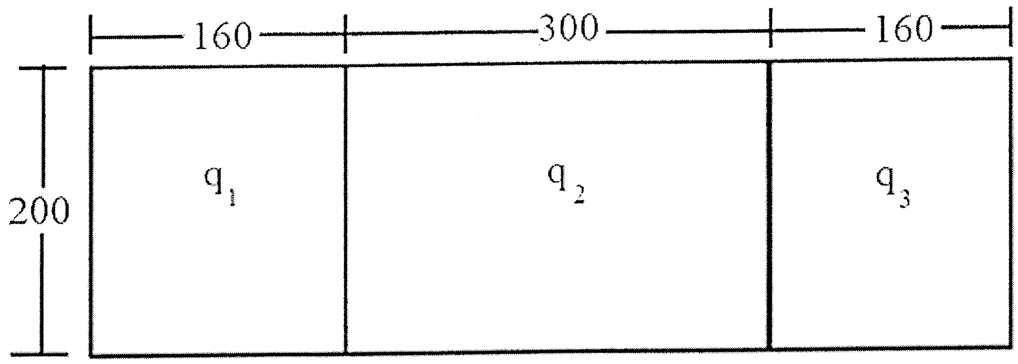
b) What would your answer be if the Von-Mises stress criterion is used? (10 marks)

6. A thin-walled, cantilever beam supports two loads at its free end as shown below. Calculate the bending stress at the extremity of the lower flange (point A) at a section 1200 mm away from where the loads are applied. Assume the applied loads are acting at the shear center of the section. (20 marks)





7. The figure below shows a three cell thin wall wing box made from a material whose shear modulus G is 70 GPa. The wing box is subjected to a constant clockwise torque of 28,000 N.m. The upper panels of the box have a constant thickness of 3.0 mm, while the lower panels have a thickness of 2.5 mm. All vertical panels are 1.5 mm in thickness.
a) Determine the shear flows q_1, q_2 and q_3 in the three cells (15 marks)
b) Determine the magnitude and location of the maximum shear stress. (5 marks)



All dimensions shown are in mm.

8. The thin-walled open structural element shown below (symmetric about the z-axis), is subjected to an upward vertical force of 23 KN acting through the shear center.

a) Find the shear flow distribution in the thin walls of the section. All of the walls have the same thickness of 2.5 mm. All the dimensions are in mm and are to the mid-planes of the walls. (12 marks)
b) Calculate the maximum shear stress in the section if the shear force acts through the vertical web instead of through the shear center. (8 marks)