National Exams May 2010

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.

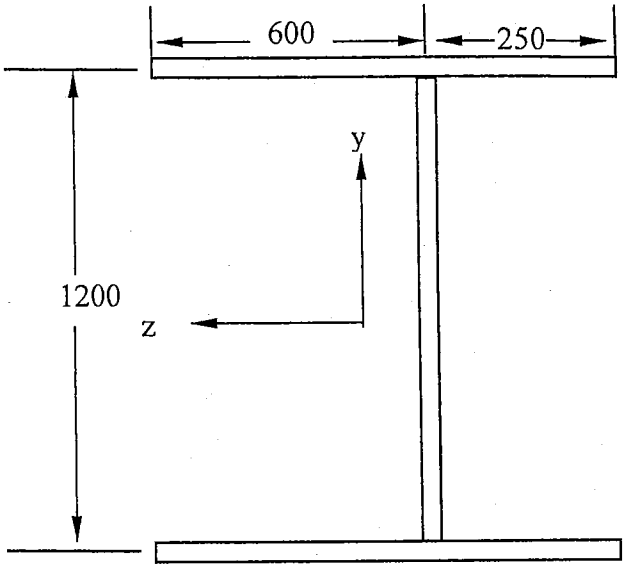
2. Any non-communicating calculator is permitted. This is an open book exam.

3. FIVE (5) questions constitute a complete exam paper. The first five questions 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 thin-walled open structural element shown below (symmetric about the z-axis), is subjected to an upward vertical force of 65 KN acting through the shear center.

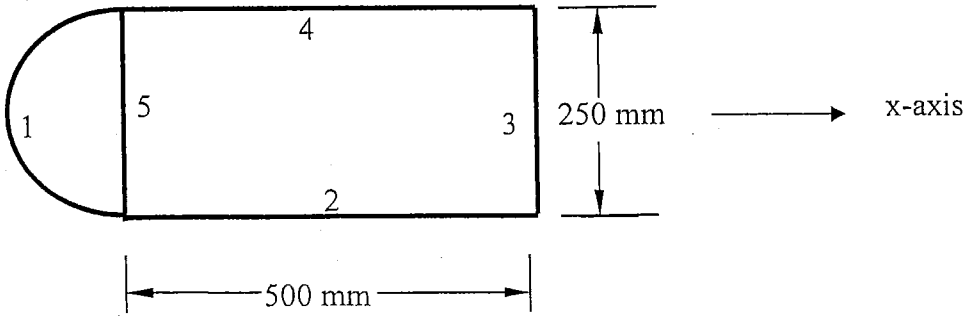
   a. Find the shear flow distribution in the thin walls of the section. All of the walls have the same thickness of 4 mm. All the dimensions are to the mid-planes of the walls. (10 marks)
   b. Locate the shear center relative to the vertical web. (5 marks)
   c. Calculate the maximum shear stress in the section if the shear force acts through the vertical web instead of through the shear center. (5 marks)



All dimensions are in mm

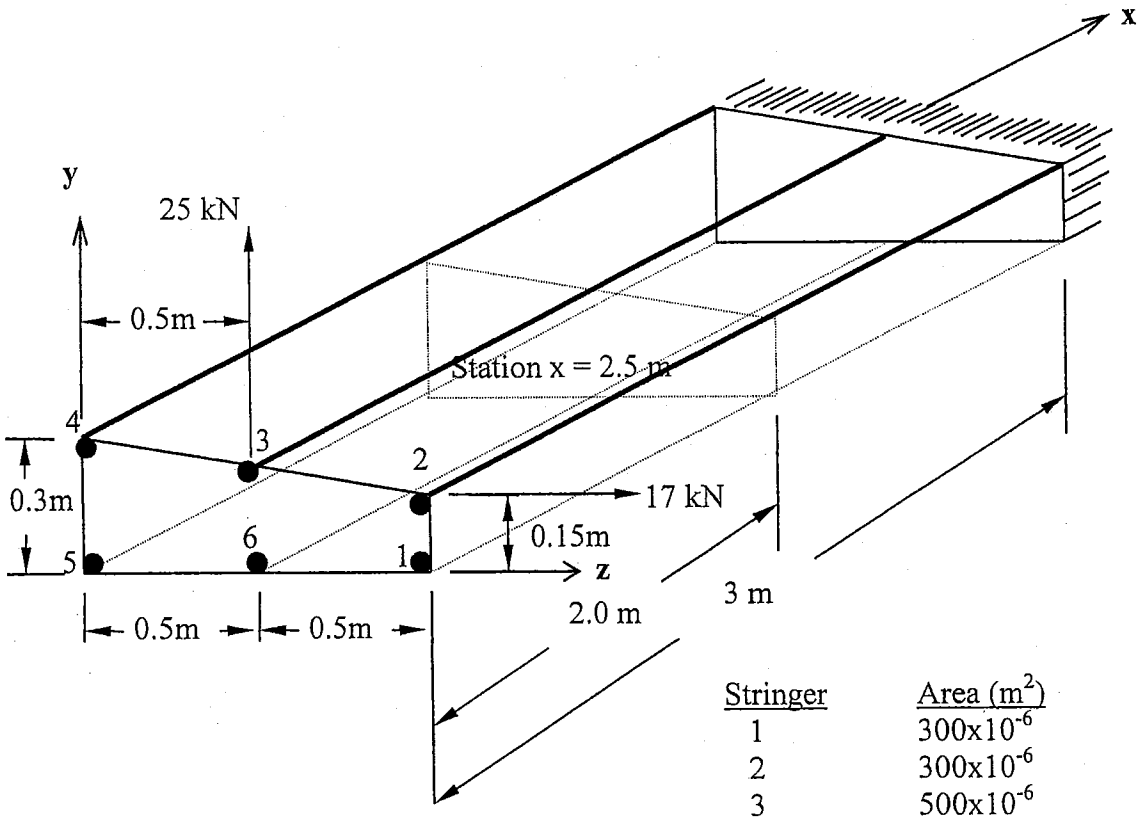
2. The horizontally symmetric torsion box shown below (all dimensions are median) is subjected to a constant torque T = 55000 N.m. acting clockwise.

   a. Calculate the shear flow q in walls 1, 2 ,3, 4 and 5. The thickness of each wall is as follows: $t_1 = 2$ mm, $t_2 = 4$ mm, $t_3 = 3$ mm, $t_4 = 4$ mm and $t_5 = 3$ mm. Wall 1 is semi-circular. (15 marks)
   b. What is the maximum shear stress and in which wall does it occur? (5 marks)



3. The figure below shows a cantilevered, idealized thin wall box with shear loads applied at the free end as shown. The cross-sectional areas of the stiffeners are listed. Assuming the thin wall panels are only effective in resisting shear:

a. find the shear flows in the walls at station x = 2.5 m, and (15 marks)
b. determine the stringer loads at the same station. (5 marks)



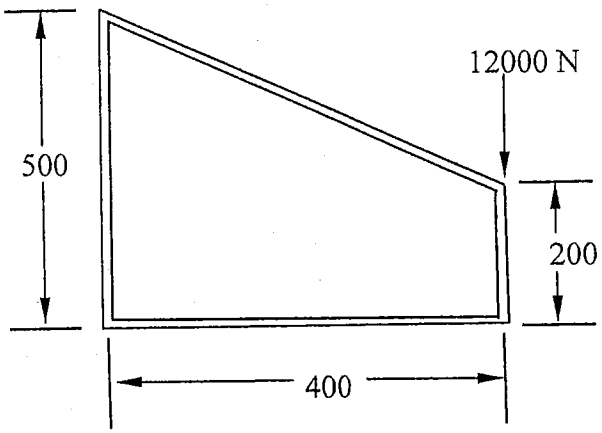
Stringer	Area (m^2)
1	$300x10^{-6}$
2	$300x10^{-6}$
3	$500x10^{-6}$
4	$650x10^{-6}$
5	$650x10^{-6}$
6	$500x10^{-6}$

4. A cantilever bar (rigidly supported at one end) of solid square cross-section (**w** by **w**) is subjected at its free end to a compressive axial force of magnitude $P = 50 \times 10^3$ lb and a torque $T = 30 \times 10^3$ lb.in. This bar is to be designed in accordance with the maximum-shear-stress criterion of failure, with a safety factor of 2.

a. What is the minimum allowable dimension **w** if $\sigma_{yielding} = 45$ ksi? (10 marks)
b. What would your answer be if the Von-Mises stress criterion is used? (10 marks)

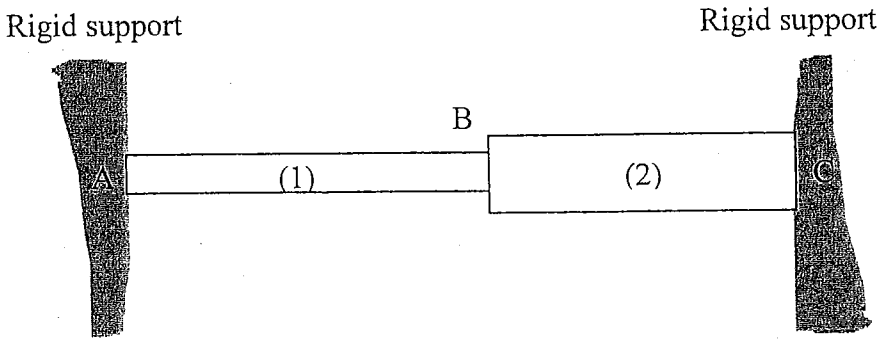
5. The closed thin wall beam with the cross section shown below (all dimensions are median distances in mm) and a wall thickness of 3 mm is subjected to the vertical force shown. If the webs are effective in bending as well as in shear, determine:

   a. The shear flow around the section (10 marks)
   b. The bending stresses at the 4 corners of a section on the beam located 300 mm behind the one shown (10 marks)



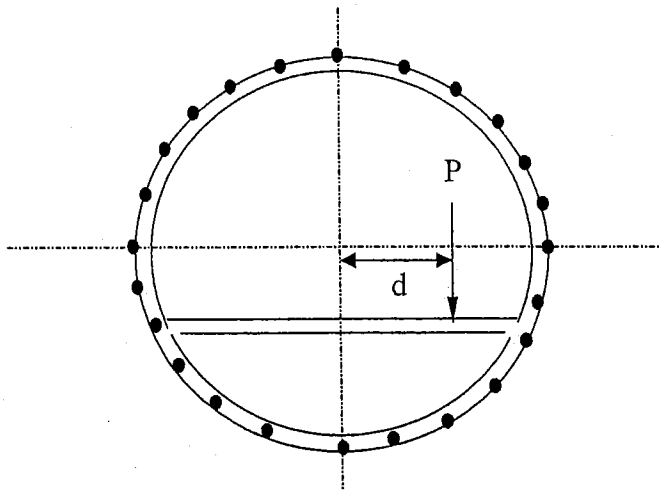
6. Two uniform linearly elastic rods are welded together at B, and the resulting two-segment rod is attached to rigid supports at A and C. Rod (1) has a modulus E_1 = 35,000 ksi, cross-sectional area $A_1 = 3.5$ in^2, length $L_1 = 60$ in., and coefficient of thermal expansion $\alpha_1 = 6 \times 10^{-6}$/°F. Rod (2) has a modulus $E_2 = 20{,}000$ ksi, cross-sectional area $A_2 = 4.0$ in^2, length $L_2 = 50$ in., and coefficient of thermal expansion $\alpha_2 = 12 \times 10^{-6}$/°F.

   a. Determine the axial stresses in the rods if the temperature of both is raised by 100 °F. (10 marks)
   b. Determine whether joint B moves to the right or left and by how much? (10 marks)



7. The figure below shows a 2.5 m outer-diameter circular fuselage frame with a vertical load P = 6000 N applied to the floor beam at a distance d = 500 mm from the vertical axis. The 24 equally spaced stringers all have the same 150 mm^2 area.

a. Calculate the shear flow distribution around the frame assuming that the skin is not effective in bending. (10 marks)
b. Determine the axial stress in the wall panels and the stringers due to an applied cabin pressure of 70 KPa. For this calculation assume wall thickness to be 1.0 mm. and the Poisson's ratio of the material to be equal to 0.3. (10 marks)



8. An isotropic ductile solid with a yielding strength of 250 MPa is subjected to x-y-z state of stress depicted below (in MPa). Predict whether such stresses will cause failure according to the:
a. maximum shear stress theory (10 marks)
b. energy of distortion theory. (10 marks)