BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Environmental, Water Resources, and Coastal Engineering, Term Final (Spring) Examination 2024: Oct 2024 - Nov 2024

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: EWCE 211, Mechanics of Solids

Time: 3.00 hours **Full Marks: 240**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1** in **Section-A** and **Question-5** in **Section-B** are compulsory.
c. Answer any other **TWO** out of the remaining **THREE** questions from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question 1 (Compulsory)

a. What is pure bending? Illustrate with an example (Answers must be supported with diagrams). **10**

b. Derive the flexural formula for bending stress of a simply supported beam in the form- **15**

$$\sigma_{max} = \frac{M_{max}}{S}$$

where S is called the section modulus of the beam.

c. A rectangular beam of breadth 150 mm and depth 300 mm is simply supported over a span of 5 m. The beam is loaded with an uniformly distributed load of 6 KN/m over the entire span. Find the maximum bending stress developed in the beam. **15**

Question 2

a. Draw the Shear Force and Bending Moment Diagram for the overhanging beam subjected to loading as shown in Figure 1. Find out the point of contra-flexure and maximum moment developed in the beam. **40**

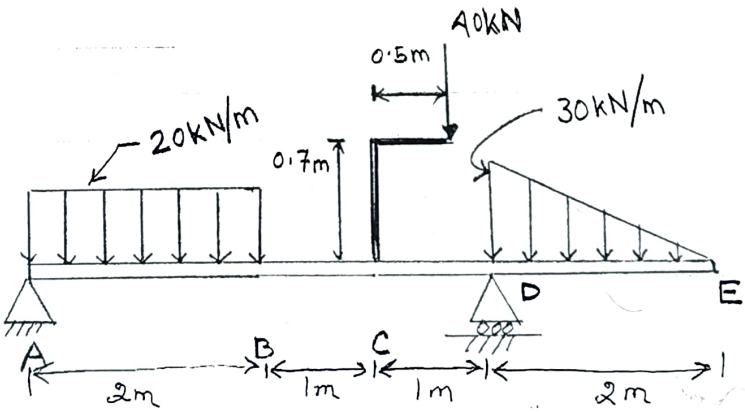


Figure 1 for Question 2(a)

Question 3

a. The 100 mm by 150 mm wooden beam shown in Figure 2 is used to support a uniformly distributed load of 4 kN (total) on a simple span of 3 m. The applied load acts in a plane making an angle of 30° with the **20**

vertical. Calculate the maximum bending stress at mid span and locate the neutral axis. Neglect the weight of the beam.

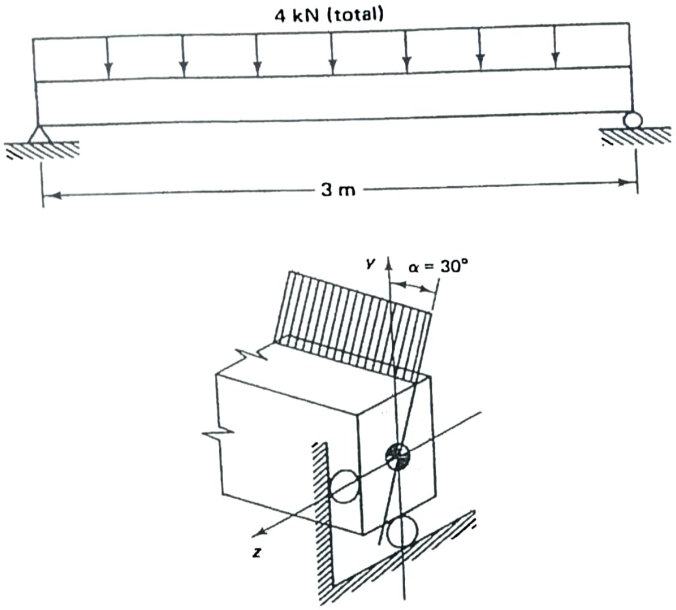


Figure 2 for Question 3(a)

b. Determine (i) the principal stress (ii) the orientation of the principal plane (iii) maximum shear stress for the state of plane stress shown in Figure 3. **20**

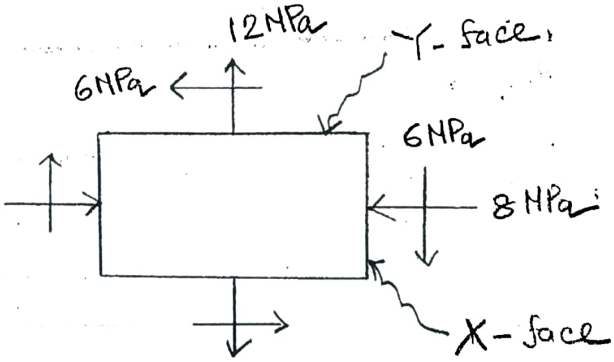


Figure 3 for Question 3(b)

Question 4

a. Draw axial, shear force and bending moment diagram of each members of the frame shown in Figure 4. (Show detail calculation with diagram). **25**

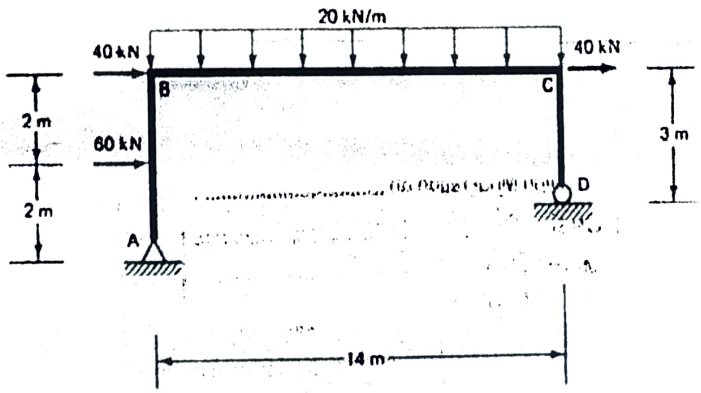


Figure 4 for Question 4(a)

b. Find the shortest length L for a steel column with pinned ends having a cross sectional area of 60 mm by 100 mm for which the elastic Euler formula applies. E = 200 GPa and the proportional limit be 250 MPa. **15**

SECTION-B

Question 5 (Compulsory)

a. Two wooden planks, each 12 inch thick and 9 inch wide, are joined by the dry mortise joint shown in Figure 5(a). The wood shears off along its grain when the average shearing stress reaches 1.20 Ksi. Determine the magnitude P of the axial load that will cause the joint to fail. **10**

b. Determine the deformation of the steel rod shown in Figure 5(b) under the given load. Assume $E = 29\times10^6$ psi. **10**

c. Define factor of safety. Three 18-mm diameter steel bolts are to be used to attach the steel plate shown to a wooden beam as indicated in Figure 5(c). The plate supports a 110 KN load and the ultimate tensile and shear stress for the steel used (for both screw and plate) are 500 Mpa and 360 Mpa respectively. Determine the factor of safety of the design. **10**

d. A 500-mm long, 16-mm diameter rod made of a homogeneous, isotropic material is observed to increase in length by 300 μm, and to decrease in diameter by 2.4 μm when subjected to an axial 12 KN load. Determine the modulus of elasticity and poisson's ratio of the material. See Figure 5(d) for details of the structure. **10**

Question 6

a. A hollow cylinder steel shaft is 1.5 m long and has inner and outer diameters respectively equal to 40 mm and 60 mm (Figure 6(a)). (i) Find out the largest torque that can be applied to the shaft if shearing stress is not to exceed 120 Mpa. (ii) Determine the corresponding minimum value of shearing stress in the shaft. (iii) Determine the value of torque to produce a twist of 2°. Use G = 77 Gpa for the modulus of rigidity of steel. (iv) Find out the angle of twist that will create a shearing stress of 70 Mpa on the inner surface of the hollow steel shaft. **30**

b. Consider a steel spherical pressure vessel of radius 1000 mm with a wall thickness of 10 mm. (i) Determine the maximum membrane stresses caused by an internal pressure of 0.80 Mpa. (ii) Calculate the change in diameter in the sphere caused by pressurization. Assume E = 200 Gpa; υ=0.25 and $r_i \approx r_o \approx r$. **10**

Question 7

a. Using moment area method determine the deflection at point C of the beam shown in Figure 7(a). Assume E = 29000 Ksi and I = 600 in^4. **20**

b. A simply supported prismatic beam is subjected to a uniformly distributed load of w per unit length. Determine the equation of the elastic curve and maximum deflection of the beam using integration method. The beam span is L unit. **20**

Question 8

a. An aluminum column of length L and rectangular cross section has a fixed end B and supports a centric load at A. (Figure 8(a)). Two smooth and rounded fixed plates restrain end A from moving in one of the vertical planes of symmetry of the column, but allow **20**

it to move in the plane. (i) Determine the ratio a/b of the two sides of the cross section corresponding to the most efficient design against buckling. (ii) Design the most efficient cross section for the column if L = 20 inch, E = 10.1×10^6 psi, P = 5 kips and a factor of safety 2.5 is required.

b. A steel plate 5/16 inch thick is embedded in a horizontal concrete slab and is used to anchor a high-strength vertical cable shown in Figure 8(b). The diameter of the hole in the plate is 3/4 inch, the ultimate strength of the steel used is 36 Ksi, and the ultimate bending stress between plate and concrete is 300 Psi. If P = 2.5 Kips and F.S. = 3.6, determine (i) the required width of the plate, (ii) the minimum depth b to which a plate of that width should be embedded in the concrete slab. **20**

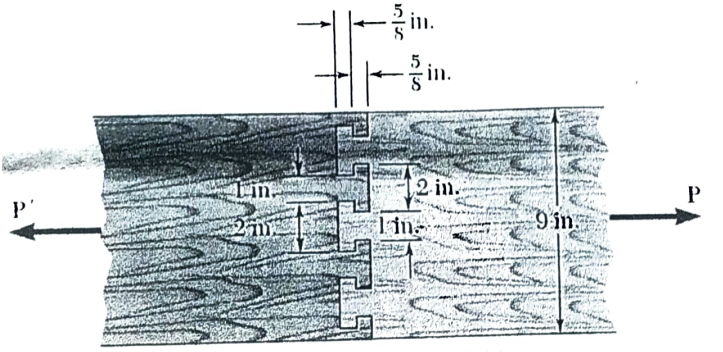


Figure 5 (a) for Question 5 (a)

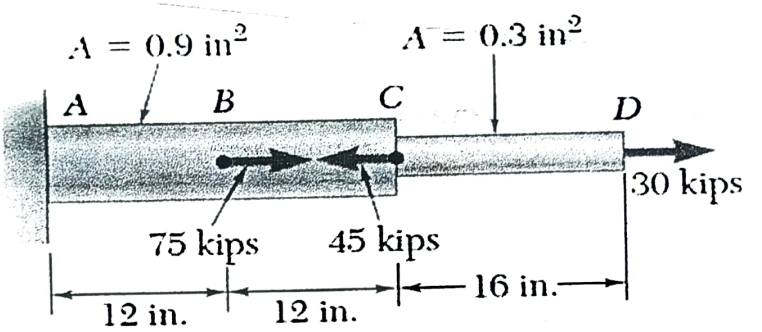


Figure 5 (b) for Question 5 (b)

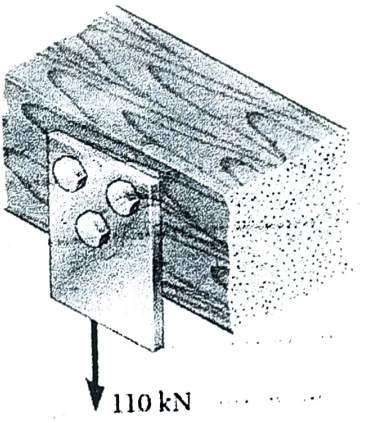


Figure 5 (c) for Question 5 (c)

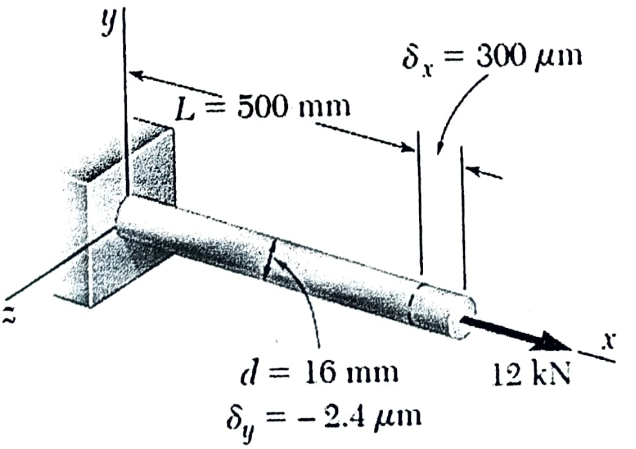


Figure 5 (d) for Question 5 (d)

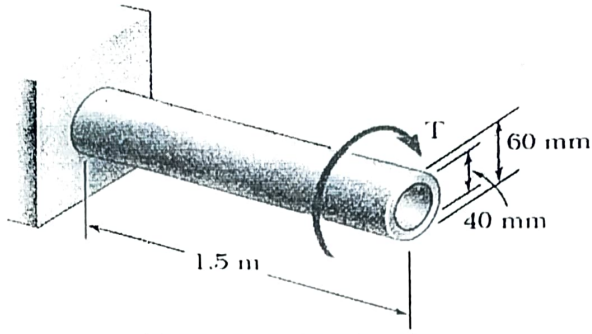


Figure 6 (a) for Question 6 (a)

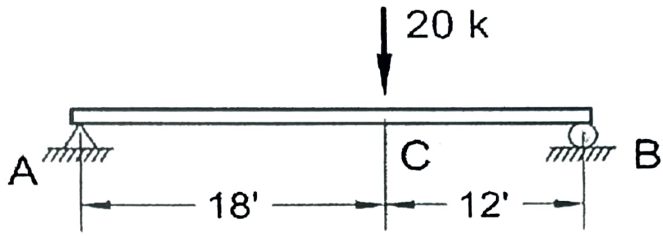


Figure 7 (a) for Question 7 (a)

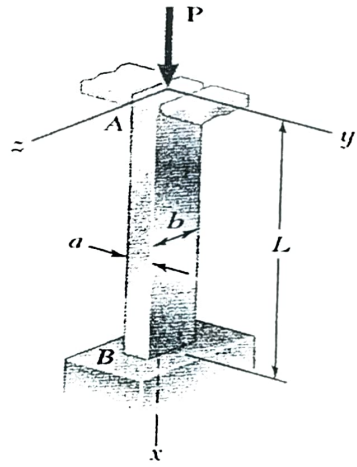


Figure 8 (a) for Question 8 (a)

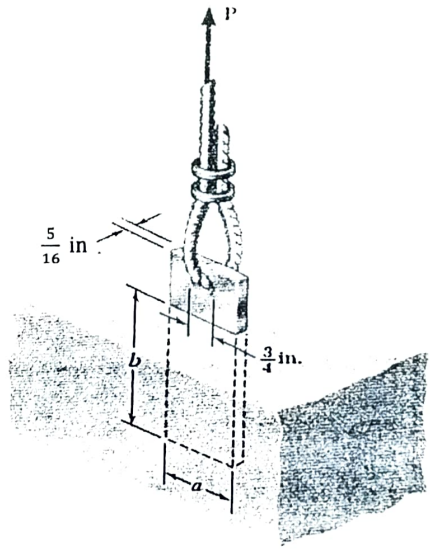


Figure 8 (b) for Question 8 (b)

$$\sigma_1 = \frac{pr}{t} \qquad \delta = \sum_i \frac{P_i L_i}{A_i E_i}$$

$$\sigma_2 = \frac{pr}{2t}$$

$$\sigma_1 = \sigma_2 = \frac{pr}{2t}$$

$$\epsilon_x = +\frac{\sigma_x}{E} - \frac{\nu\sigma_y}{E} - \frac{\nu\sigma_z}{E}$$
$$\epsilon_y = -\frac{\nu\sigma_x}{E} + \frac{\sigma_y}{E} - \frac{\nu\sigma_z}{E}$$
$$\epsilon_z = -\frac{\nu\sigma_x}{E} - \frac{\nu\sigma_y}{E} + \frac{\sigma_z}{E}$$

$$\epsilon_x = \frac{\sigma_x}{E} \qquad \epsilon_y = \epsilon_z = -\frac{\nu\sigma_x}{E} \qquad \nu = -\frac{\text{lateral strain}}{\text{axial strain}}$$

$$P_{cr} = \frac{\pi^2 EI}{L_e^2} \qquad \sigma_{cr} = \frac{\pi^2 E}{(L_e/r)^2} \qquad \sigma = \frac{P}{A}$$

