UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: CE4204 **Module Name: Structural Analysis II**

[Three Hours]

[Answer **all questions**. Each question carries 12 marks]

All Standard Notations denote their regular meanings

Q1. a) Discuss three different functions of the stiffening girder in suspension bridges.

[3 Marks]

b) The cables of a suspension bridge run over frictionless pulleys on the top of each towers, and were fixed to anchor blocks through back stays. The height of the towers is 75 mm. Each suspension cable having supports at the same level, has a span of 300 m and the maximum dip of 30 m. Each cable carries a uniformly distributed load of 120 kN/m throughout its length. The back stays are inclined 40° to the horizontal. *Neglect the weight of towers.*

i.) Calculate the bending moment and the axial force at the base of each tower.

ii.) Determine the force in a backstay. Evaluate the required weight of each anchor block.

iii.) Determine the required diameter of the cable, if the maximum permissible stress of the cable material is 600 N/mm^2.

[9 Marks]

Q2. a) Compare the load carrying mechanics of "arch bridge" and a "beam bridge".

[4 Marks]

b) A three-hinged parabolic arch is planned to be constructed across a wider river. The bridge has a width of 8 m, a span of 30 m and central rise of 4 m. The bridge supports a two lane highway and each lane is designed for an imposed load of 10 kN/m. The total dead load of the bridge is estimated as 30 kN/m. The arch rib has the thickness of 0.6 m. You may assume that these loads are factored loads.

i.) Determine the reactions at supports.

ii.) Determine the axial force, shear force and bending moment at 4 m away from the left support. Hence determine the stress distributions at this location of the arch rib.

[8 Marks]

Q3. a) Draw the influence line diagram for a simply supported beam of span 10 m and hence determine the maximum positive shear developed at a point 2.5 m away from the left-hand support, due to:

i.) a concentrated moving load of 10 kN, and

ii.) a uniform moving load of 5 kN/m.

[4 Marks]

b) Two point loads of 100 kN and 200 kN are spaced 3 m apart and cross over a girder of span 12 m, from left to right with the 100 kN leading. Draw the influence line diagrams for shear force and bending moment and hence find the values of maximum shear force and bending moment at a section 4 m from the left-hand support. Also evaluate the absolute maximum bending moment due to the given loading system.

[8 Marks]

Q4. a) Define the "Maximum Shear Strain Energy Theory" and derive the expression for the failure criterion.

[4 Marks]

b) A section of circular hollow beam made of ductile material having yield strength (σ_Y) of 300 MPa is shown in Figure Q4.

i.) Discuss the moment-curvature relationship of the section when it is undergoing elastic-plastic deformation. Mark elastic moment (M_Y) and plastic moment (M_P) in the moment-curvature diagram.

ii.) Calculate the elastic (M_Y) and the plastic (M_P) moment capacities of the given beam. Determine the shape factor for the beam.

[8 Marks]

Q5. a) Briefly discuss the three important criteria in plastic analysis to identify the correct load factor.

[2 Marks]

b) Explain the "basic collapse mechanisms" in related to plastic analysis of frame structures.

[2 Marks]

c) A portal frame (ABCD) is shown in Figure Q5. Frame supports a vertical load, 40 kN, at the centre of the beam BC. A horizontal load of 20 kN is also applied at the node C. Plastic moment capacity of the beam (BC) and columns (AB, CD) are 100 kNm and 50 kNm respectively. Determine;

i.) The collapse load factor for each basic collapse mechanisms.

ii.) The collapse load factor for portal frame and sketch the bending moment diagram for the corresponding collapse mechanism.

[8 Marks]

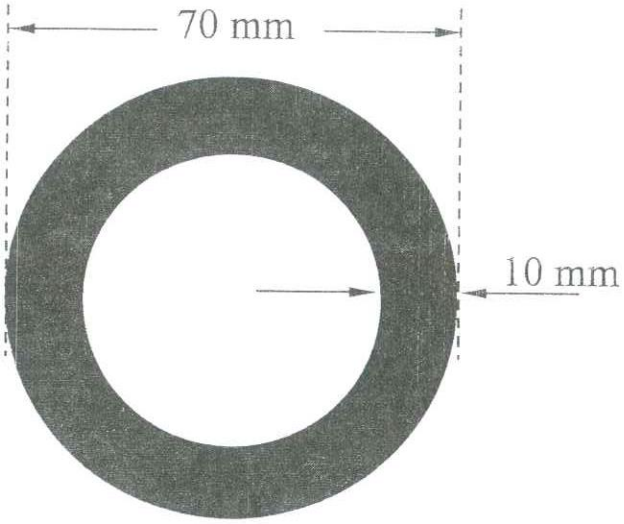

Figure Q4

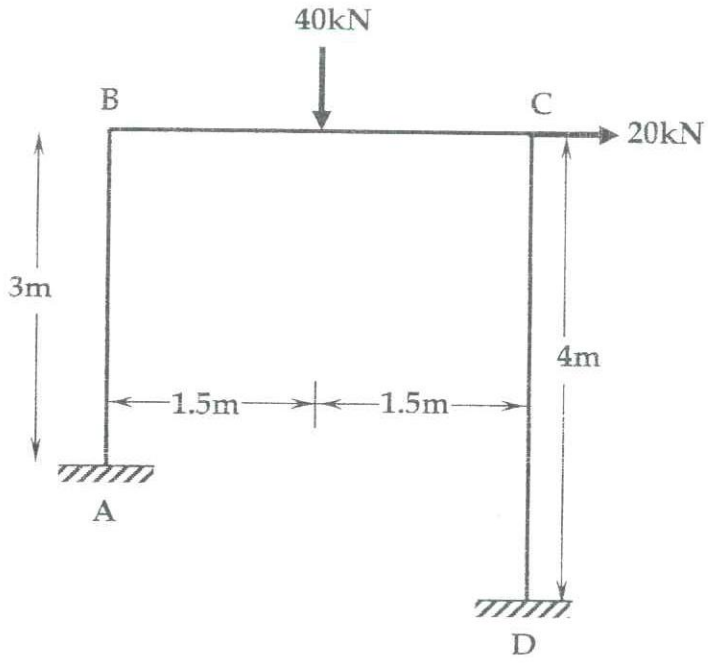

Figure Q5