UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2022

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) What are the advantages and disadvantages of "suspension bridge" over the other types of bridges?

[3 Marks]

b) A suspension bridge has been constructed over a wide river. The bridge supports a two lane highway and each lane is designed for an imposed load of 20 kN/m per lane. The dead load, including weight of the suspension cables, hangers, stiffening girder and the deck, is estimated as 30 kN/m. The suspension cables are supported at two points, 120 m apart, having a maximum dip of 8 m. Consider above loads as final factored design loads.

i.) Calculate the maximum tension in a cable.

ii.) Determine the force in a backstay assuming that it is inclined 40° to the horizontal and also that it is anchored to the cable through a pulley.

iii.) Determine the maximum bending moment in the pier. The height of the pier is 22.5 m.

[9 Marks]

Q2. a) Ignoring the strain energy due to axial effect, show that the horizontal thrust '*H*' in a two hinged arch having supports at the same level is given by the equation:

$$H = \frac{\int \frac{M_s y dx}{EI_c} - \delta}{\int \frac{y^2 dx}{EI_c}}$$ when any support is deflected by 'δ'.

Where $y = \frac{4dx(L-x)}{L^2}$ and $I = I_c \sec\theta$.

M_s is the bending moment due to vertical loading at any point and the terms E, I, L and d in the above formula have their usual meanings.

[6 Marks]

b) A two hinged parabolic arch constructed across a wider river has to be renovated. The bridge has a width of 4 m, a span of 24 m and central rise of 4 m. Due to renovating activities, the bridge will be subjected to a concentrated load of 15 kN at 6 m from the left support. When a support is deflected by 10 mm, determine the horizontal thrust at the supports. Assume that the second moment of area (I) at any section is equal to $I_c \sec\theta$, and the product of $EI_c = 20 \times 10^3$ kNm^2.

[6 Marks]

Q3. a) What is meant by an influence line? Briefly explain the uses of influence line diagrams.

[2 Marks]

b) Figure Q3 shows a frame structure used to support a hoist for transferring loads for storage at points underneath it. It is found that the load on the dolly is 5 kN and the beam *CB* has a mass of 24 kg/m. Assume the dolly has negligible size and can travel the entire length of the beam. Also, assume *A* is a pin and *B* is a roller. Determine,

i.) the maximum vertical support reactions at *A* and *B*, and

ii.) the maximum moment in the beam at *D*.

[5 Marks]

c) A series of five wheel loads having magnitudes 5kN, 20kN, 20kN, 15kN and 15kN spaced 1m centre to centre, cross over a simply supported girder of span 10m. If loads in given order can move from left to right or opposite direction, find the position and the absolute maximum shear force which may occur in the girder.

[5 Marks]

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

[4 Marks]

b) A round cantilever bar is subjected to torsion and a transverse load at the free end as shown in Figure Q4. The bar is made of a ductile material having yield strength of 25 MPa. The transverse force (P) is 2500 N and the torque is 1000 Nm applied to the free end. The bar is 100 mm long (L) and a safety factor of 2 is assumed. Transverse shear can be neglected. Determine the minimum diameter to avoid yielding at point **A**, according to the following failure theories.

i.) Maximum Principal Stress Theory

ii.) Maximum Shear Stress Theory

iii.) Maximum Shear Strain Energy Theory

[8 Marks]

Q5. a) Briefly discuss the advantage of plastic analysis in structural design. [2 Marks]

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

[2 Marks]

c) A portal frame (ABCD) supports three vertical loads of 50 kN each along the beam BC as shown in Figure Q5. A horizontal load of 50 kN is also applied at the node B. Plastic moment capacities of the members AB, BC and CD are 150 kNm, 150 kNm and 75 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 corresponding collapse mechanism.

[8 Marks]

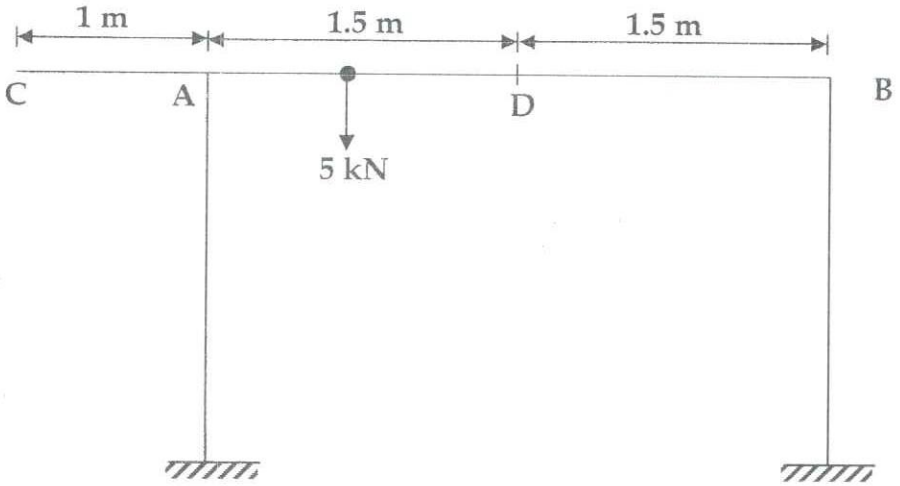

Figure Q3

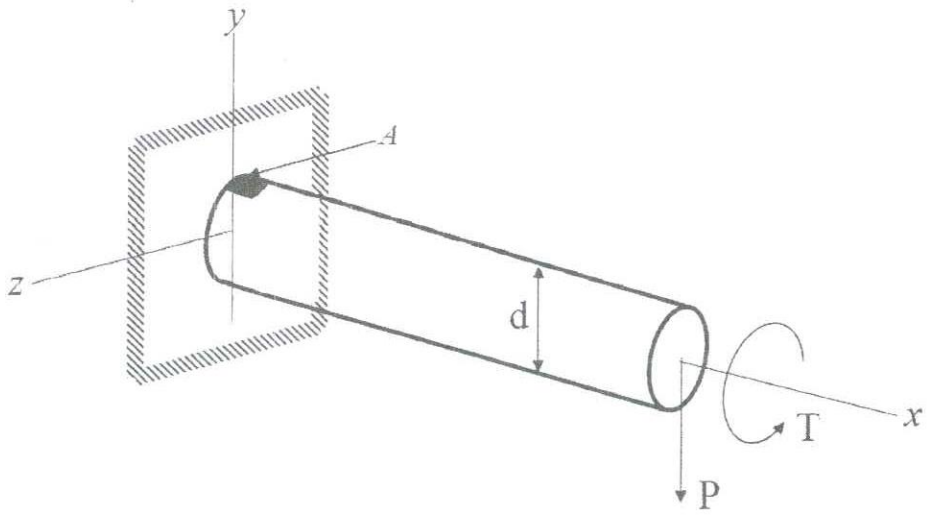

Figure Q4

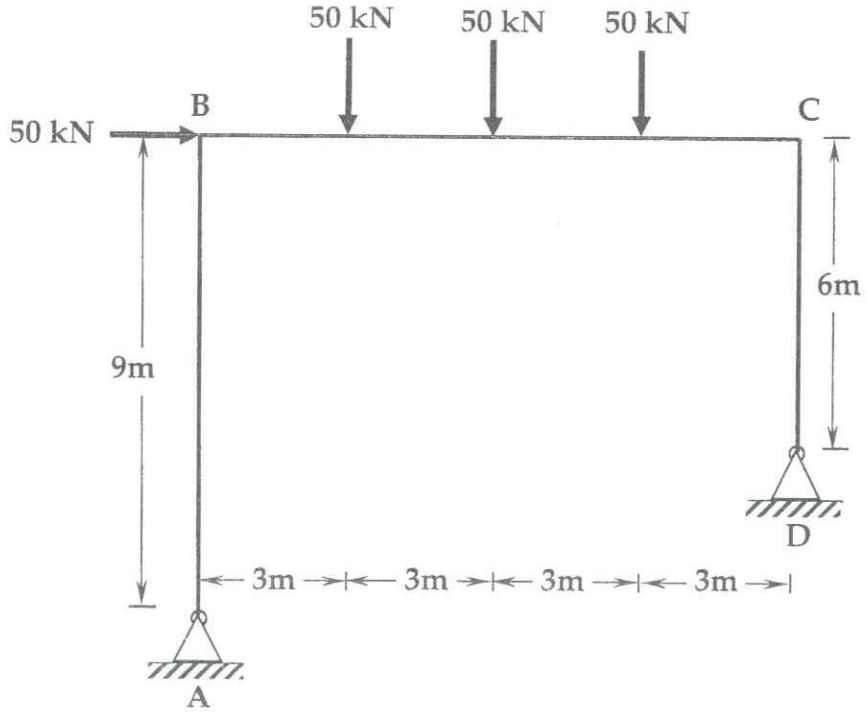

Figure Q5