

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering



Study Programme : Bachelor of Technology Honours in Engineering
Name of the Examination : Final Examination
Course Code and Title : CVX3442 Strength of Materials
Academic Year : 2023/2024
Date : 22nd February 2023
Time : 09.30 - 12.30hrs
Duration : **03 hours**

General Instructions

Read all the instructions given below carefully before answering the questions.

- Necessary additional information is provided or announced by the examination supervisors.
- Assume reasonable values for any data not given in the examination paper. Clearly state such assumptions made in the answer script.
- In a case where there is more than one interpretation or ambiguity due to the wording of a question, make your own decision but clearly state it in the answer script.
- This is a **Closed Book Test (CBT)**.
- This question paper consists of **EIGHT (08)** questions in **FIVE (05) PAGES**
- Answer **any FIVE (05)** questions.
- Answer for each question should commence from a new page.
- Answers should be in clear handwriting.
- Do not use a red colour pen.

Q1

The Figure 1 shows a simple beam with a cantilever end carrying a uniformly distributed load and a point load. The uniformly distributed load is 4 kN/m and it is acting over the span AB; the point load is 3 kN and it is acting at point C.

Q1.1 Determine the reactions at supports A and B (04 marks)

Q1.2 Write equations for variation of shear force and bending moments along the beam for the regions AB and BC separately. (08 marks)

Q1.3 Using the equations derived in Q1.2, draw Shear Force Diagram and Bending Moment Diagram indicating all important points with their coordinates. (Note: Mention the sign convention used clearly) (08 marks)

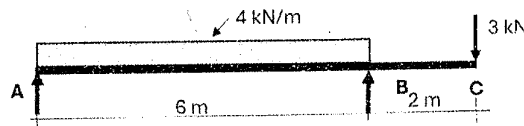


Fig. 1 - A simple Beam with a Cantilever End

Q2

Q2.1 Briefly describe Macaulay's method used to determine the slope and deflection of beams. (04 marks)

Q2.2 The Figure 2 shows a simple beam with a uniformly distributed load and a point load. The uniformly distributed load is 30 kN/m and it is acting over its entire length; the point load is 60 kN and it is acting at 3 m from the support A. Determine the maximum deflection in the beam and the location of the maximum deflection. (16 marks)

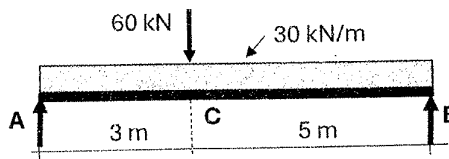


Fig. 2 - A simple Beam with a Uniformly Distributed Load and a Point Load

Q3

Q3.1 Draw typical stress strain curve for a mild steel specimen and indicate the elastic range, strain hardening range, necking range, the point representing the yield strength, and the point representing the ultimate strength. (04 marks)

Q3.2 The Figure 3 shows a cross section of a 4.0 m high reinforced concrete column. The diameter of the four reinforcement bars is 20 mm each. The column is subjected to 1000 kN axial compressive force. Young's Modulus of steel and concrete are 200 kN/mm² and 15 kN/mm² respectively. Determine the stresses in steel bars and concrete and the shortening of the column. (16 marks)

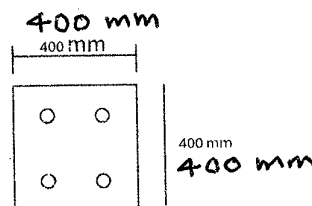


Fig. 3 - A cross section of a reinforced concrete column

Q4

Q4.1 Describe 'principal planes' and 'principal stresses.'

(04 marks)

Q4.2 The Figure 4 shows the principal stresses at a point across two perpendicular planes. They are 75 MN/m^2 (tensile) and 35 MN/m^2 (tensile). Determine the normal and tangential stresses on a plane at 20° with the major principal plane as shown in the figure. (16 marks)

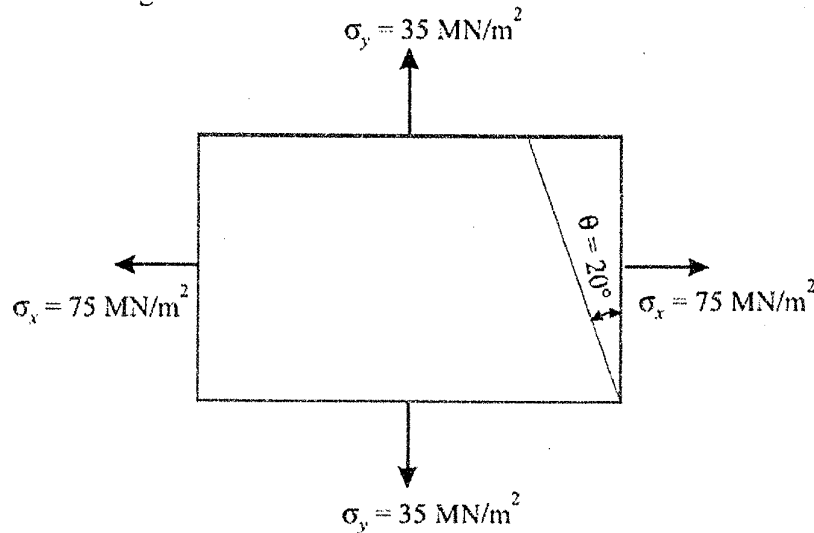


Fig. 4 - Principal Stresses at a Point Across Two Perpendicular Planes

Q5

Q5.1 Describe elastic constants, Young's modulus (E), Bulk modulus (K), Rigidity modulus also known as Shear Modulus (G) and Poisson's ratio (ν) and the relationships between them.

[10 marks]

Q 5.2 As shown in Figure 5, a short column is subjected to an increasing compressive stress, σ_c . The maximum compressive strength and the shear strength of the material are 105 N/mm^2 and 45 N/mm^2 respectively. Determine how failure will occur and the compressive stress at failure.

[10 Marks]

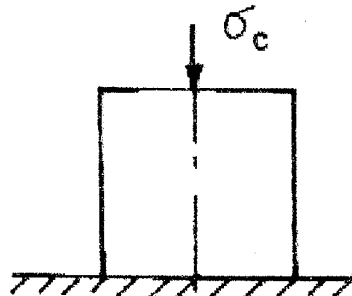


Fig. 5- A Short Column Subjected to an Increasing Compressive Stress

Q6

Q6.1 Describe Flexural Rigidity [05 marks]

Q6.2 A 250 mm deep and 150 mm wide rectangular beam is subjected to maximum bending moment of 750 kNm. The modulus of elasticity (E) for the beam material is 200 GN/m²

Q 6.2.1 Determine the maximum stress in the beam [05 marks]

Q 6.2.2 Determine the radius of curvature for that portion of the beam where the bending is maximum. [05 marks]

Q 6.2.3 Determine the value of the longitudinal stress at a distance of 65 mm from the top surface of the beam [05 marks]

Q7

Q7.1 Describe Torsional Rigidity [05 marks]

Q7.2 A solid shaft of 50 mm diameter carries a torque of 1500 Nm. It has to be replaced by a hollow shaft made of same material. External diameter of the new shaft should be same as the solid shaft, that is 50 mm. The internal diameter of the new shaft is 25 mm. Take $G = 83 \times 10^3 \text{ N/mm}^2$.

Q7.2.1 What is the percentage change in maximum shear stress and the angle of twist per meter length of the shaft? [08 marks]

Q7.2.2 What is the percentage reduction in weight? [07 marks]

Q8

Q8.1 Define Radius of gyration and Slenderness ratio [05 marks]

Q8.2 Buckling load, P_e , of a column is given by $P_e = \pi^2 EI / L_e^2$.

Where, E = modulus of elasticity, I = Moment of inertia and L_e is the 'Equivalent Length' of a column.

Buckling load, P_e , of a 3.0 m long column having both ends pinned is 3.0 kN. Three different columns made of the same material having the same cross section and length while having the following end conditions. Determine equivalent lengths (L_e) and buckling loads (P_e) for each of the following conditions.

Q8.2.1 One end is fixed, and the other end is free. [05 marks]

Q8.2.2 Both ends are fixed. [05 marks]

Q8.2.3 One end is fixed, and the other end is pinned. [05 marks]