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B. Sc. Engg. (CEE)/ 3rd Sem. 08 December, 2023 (Afternoon).

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TERM : SEMESTER FINAL EXAMINATION WINTER SEMESTER: 2022-2023

COURSE NO. : CEE 4311 TIME : 3.0 Hours

COURSE TITLE: Mechanics of Solids I FULL MARKS: 150

There are 6 (SIX) questions. Answer ALL questions. The marks and CO-PO mapping are given in the right side of each question. Programmable calculators are not allowed. Do not write on this question paper. Assume reasonable data, if necessary.

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1 Refer to the following beam ABCD. An internal hinge is placed at C. CO2-PO2

(i) Draw the free body diagram (FBD) of the beam ABCD and find the reactions at the supports, (25)

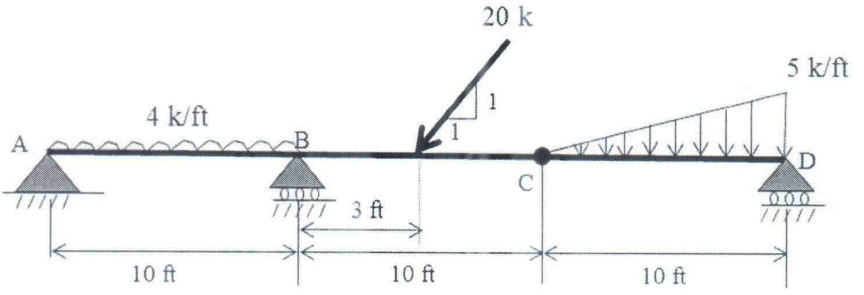
(ii) Draw AFD, SFD, and BMD,

(iii) Draw elastic curve of the beam,

(iv) Cut the beam at the right of the support B and then draw the FBDs (for AB and BCD). Also calculate the internal forces at this section from the reactions and verify the results with AFD, SFD, and BMD.

(v) If the beam is continuous at C (i.e., internal hinge is removed); is it possible to solve the problem using the equations of equilibrium? What will be the DOSI of the beam for this case?

(vi) Determine the locations for maximum positive and negative bending moments. Make comments on these locations keeping in mind the variation of shear force along the beam, i.e. SFD.



2 Refer to the following compound bar ABC subject to axial forces. $P_1 = 50$ KN, $P_2 = 80$ KN, Cross sectional area of AB = 300 mm^2, Cross section area of BC = 600 mm^2, E = 200 GPa. CO2-PO2 (25)

(i) Is it a statically determinant structure?

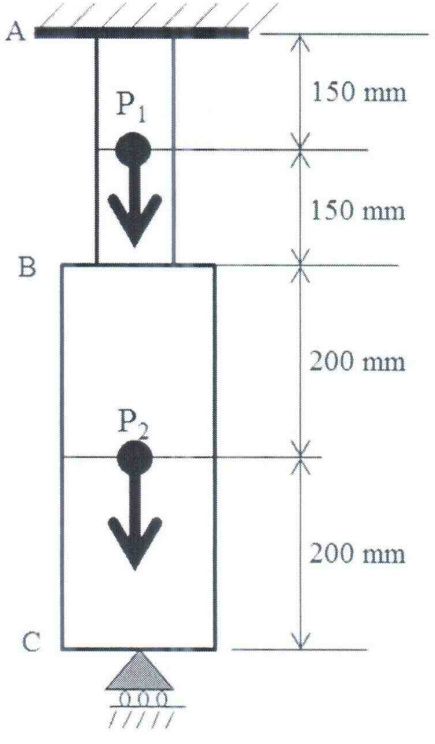
(ii) Calculate reactions at A and C,

(iii) Draw axial force diagram of the bar ABC,

(iv) Calculate maximum stress (tension/compression) in AB and BC,

(v) If the allowable stress (for the both tension and compression) is 420 MPa, calculate the factor of safety (FS).

(vi) If the bottom support yields (failed to take any reactions), what will happen against the safety of the bar?



3 Refer to the following stresses on an element taken from a beam. Calculate the following by analytical procedure: CO2-PO2 (25)

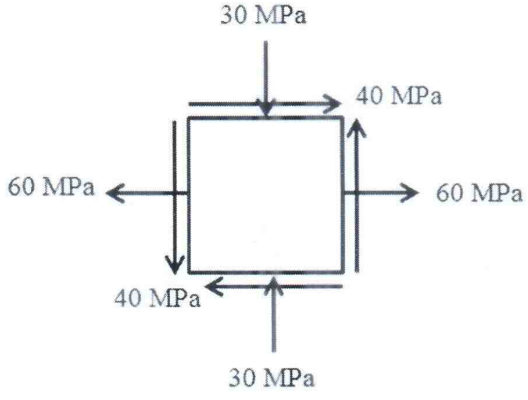
(i) Principal stresses and principal planes (also draw the orientation of the element with principal stresses and show the direction of cracks, if the material of the beam is very weak in tension),

(ii) Maximum shear stresses with orientations (also draw the orientation of the element with maximum shear stresses and normal stresses, if any.)

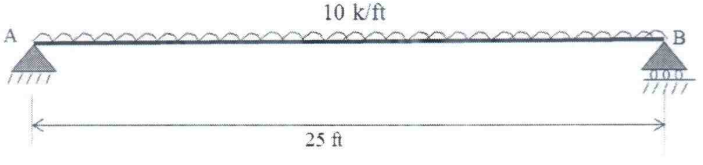
(iii) Make a brief discussion on the results of (i) and (ii),

(iv) If the element is rotated by 30^{o} anti-clockwise, calculate the stresses on the element at this orientation.

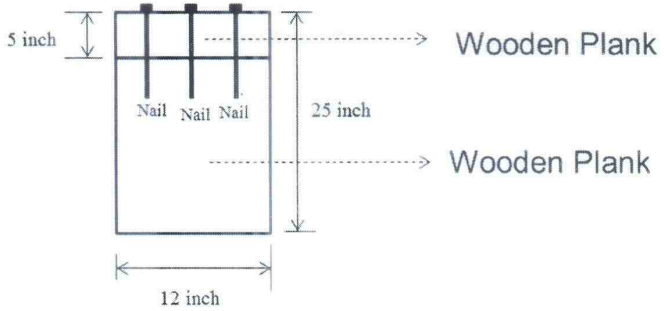
Solve the above problems graphically and make a brief comparison of the analytical and graphical results.



4 A wooden beam has been fabricated by nailing two wooden planks as shown in the figure below. The beam is subjected to a uniform load (UDL) of 10 k/ft. CO2-PO2 (25)



SS Beam under UDL



Cross-Section

(i) Derive the expression for shear stress distribution along the depth of the beam and draw the shear stress profile.

(ii) Calculate the ratio of maximum shear stress to average shear stress.

(iii)Calculate shear stress and shear flow at the joint between two

wooden planks.

(iv) Three nails are used in each row as shown in the figure. The allowable shear capacity of each nail is 4 K. Calculate the spacing of nails. Draw SFD and make comments on the spacing of the nails along the span of the beam.

(v) If the shear capacity of each nail is increased, how it will influence the spacing of the nails?

5 Refer to the following simply supported beam and beam section. Assume, E = 200 GPa and yield strength of the material (both tension and compression) = 420 MPa, UDL = 40 KN/m. CO2-PO2 (25)

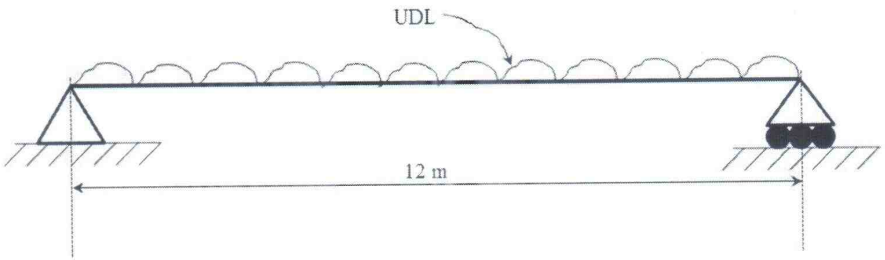
(i) Calculate bending stress distribution along the depth of the beam at the mid-span section of the beam,

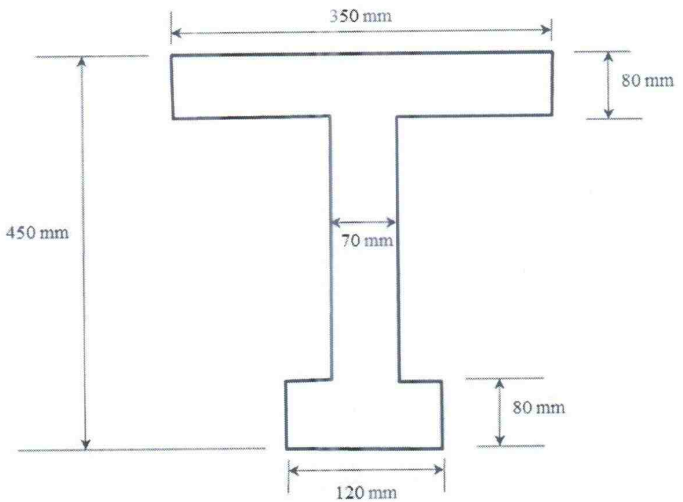
(ii) Draw the strain distribution along the depth of the beam and compare the strain with the yield strain of the material,

(iii) Calculate the moment that will cause yielding of material,

(iv) Calculate plastic moment of the section,

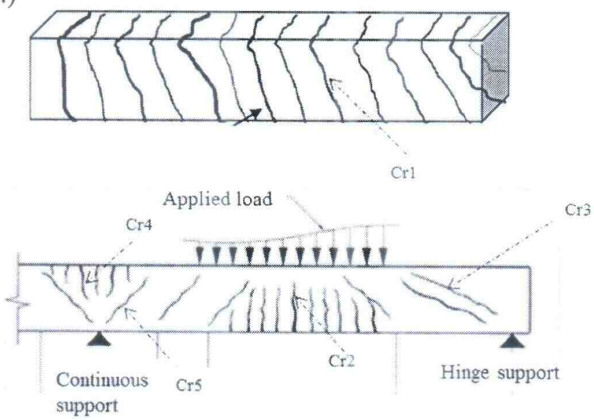
(v) Calculate shape factor.





Beam Section

6(a) Refer to the following cracks (Cr1, Cr2, Cr3, Cr4, Cr5) in beams. Explain the causes against the formation of the cracks (Hints : due to positive bending moment, due to negative bending moment, due to shear, due to torsion, etc.) CO1-PO1 (7.5)



(b) Refer to the following shaft subjected to torsion. Allowable torsional shear stress = 10 ksi and G = 12000 ksi. CO2-PO2 (17.5)

(i) Find the minimum diameters (both for solid circular shaft (D1) and hollow circular shaft (D2) with thickness 0.5 inch) of the sections to resist the torsional shear stress.

(ii) Calculate the angle of twist at the free end of the shaft for solid circular shaft and hollow circular shaft,

(iii)Compare the results (for the both sections) with respect to angle of twist, volume of materials, cost, sustainability, and environment.