UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: February 2025

Module Number: CE3205 **Module Name: Structural Analysis I (C-23)**

[Three Hours]

[Answer **all question**, each question carries ten marks]

Q1 a) Portal frame subjected to lateral loading is often found difficult to solve. Explain reason why portal frame with lateral loading is difficult to find solutions and the procedure adopted in the moment distribution method to find solutions for portal frame structures subjected lateral loading.

[4 Marks]

b) Fig. Q1 shows Portal frame structure ABCD constructed as a part of supporting structure of a building. Although the frame is loaded both in lateral direction and transverse direction, considering only lateral load of 25 kN applied at joint B, complete the bending moment and shear force diagrams of the portal frame ABCD.

[6 Marks]

Q2 a) Fig Q2 shows continuous beam ABC fixed at joints A and C and roller supported at joint B. Beam has experienced a settlement of 5mm at joint B. The loading on the beam are as shown in Fig Q2. Calculate rotation at B and hence bending moment and shear force diagram of Beam ABC. Take the Young's modulus of the beam ABC as 30 GPa and that the beam is 300mm wide and 600mm deep.

[7 Marks]

b) Explain the advantages and disadvantages of the slope deflection method over moment distribution method in calculation of bending moment and shear force diagram of beam like the one describe above in Q2 (a).

[3 Marks]

Q3. a) Express Castigliano's theorem of strain energy and complimentary strain energy in your own wards

[2 Marks]

b) Fig. Q3 shows a supporting structure of an advertisement board. Frame is made with hollow square steel tube with Young's modulus E and second moment of area I (Bending stiffness EI). Main force on the frame during wind is idealized to be acting at the top of the frame to give the frame most critical load effect.

i) Assuming that the load applied at the tip of the cantilever part of the upright column element, point D, of the frame is P, write equation to find the reaction at C using strain energy of the system and hence complete the bending moment and shear force diagram of the frame.
(Note: Consider only the bending energy for the calculation of the total energy of the system and assume that the material behave liner elastic fashion during the loading)

[4 Marks]

ii) Extend the findings above to calculate lateral deflection at point D.

[4 Marks]

Q4 a) Temperature effect and lack of fit is considered difficult problem to solve with the use of manual solution techniques available for our disposal. Explain in which type of structures the temperature effect and lack of fit issues would matter and how the use of virtual work can simplify solution procedure.

[4 Marks]

b) Fig. Q4. Shows a statically indeterminate truss subjected to lateral loading. During the erection of the truss it is found that the member AC is 5mm short of the required dimension. During the operation member BC which is in contact with the roofing structure is found subjected to 20C° elevated temperature as compared temperature of the members at the time of erecting. Coefficient of thermal expansion of steel is $12\text{x}10^{-6}\ {}^{o}C^{-1}$. Young's modulus of steel is 205 GPa. All members have cross-section area $1500mm^2$. Find all the member forces in the truss structure.

[6 Marks]

Q5. a) State two theories involved with Three Moment Theorem in your own words. Use (if any) sketches to clarify your explanations.

[3 Marks]

b) A straight elastic beam PQRS of uniform cross section with constant flexural rigidity of EI rests on soil having elastic modulus of k ($200\text{x}10^3$ kN/m) applied at joints P, Q, R, and S as shown in Fig. Q5. Uniformly distributed load of 100 kN/m is applied on the beam PQRS. Using three moment theory calculate the bending moment at joints and complete the bending moment and shear force diagram of the beam PQRS. Yong's modulus of beam PQRS is 30 GPa and the beam is 300mm wide and 600mm deep. [Three Moment Theorem with usual notations is given below]

$$\frac{M_1 l_1}{E_1 I_1} + 2M_2\left[\frac{l_1}{E_1 I_1} + \frac{l_2}{E_2 I_2}\right] + \frac{M_3 l_2}{E_2 I_2} = 6\left[\left(\frac{\delta_1 - \delta_2}{l_1}\right) + \left(\frac{\delta_3 - \delta_2}{l_2}\right) - \left(\frac{A_1 a_1}{E_1 I_1 l_1} + \frac{A_2 a_2}{E_2 I_2 l_2}\right)\right]$$

[7 Marks]

Q6 a) Fig.Q6 shows a continuous beam ABC with a hinge at point D, located within the span BC of the beam ABC. Derive expressions for support reactions at A,B and C when an unit load move across the beam ABC and hence draw the influence lines for the reactions at supports A,B and C.

[3 Marks]

b) Point E is located 3 m right to the support A. Based on the support reactions, draw the influence line of the bending moment and the shear force at E.

[4 Marks]

c) Suppose a uniformly distributed load of 8 kN/m is placed on the beam ABC calculate and confirm that the bending moment and shear forces calculated at E using the ordinates of the influence lines of the corresponding actions and that is calculated using equilibrium equations are identical.

[3 Marks]

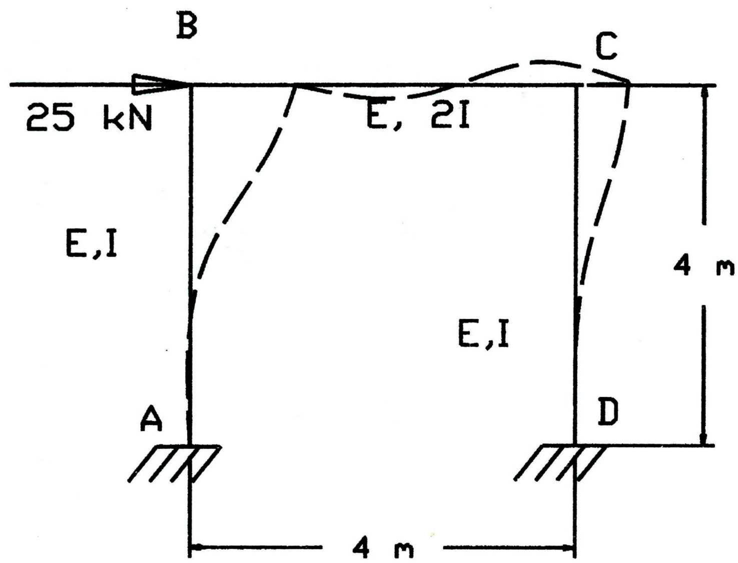


Fig. Q1

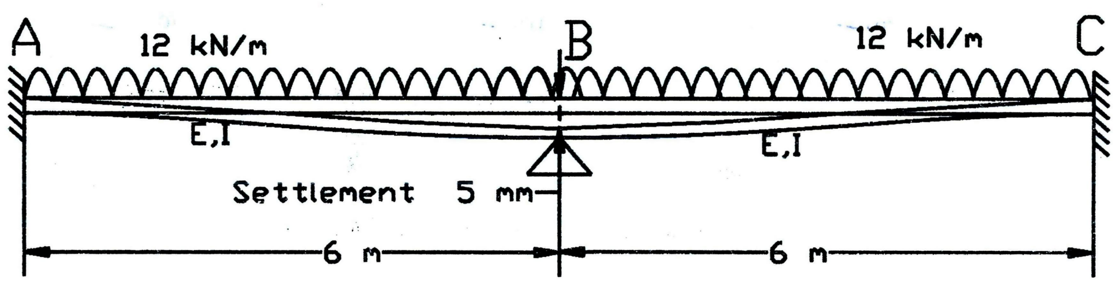


Fig. Q2

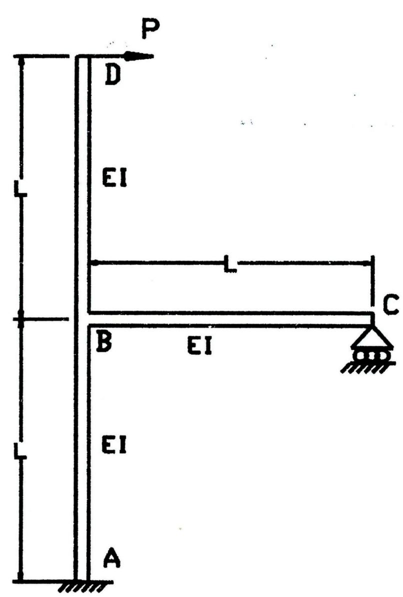


Fig. Q3

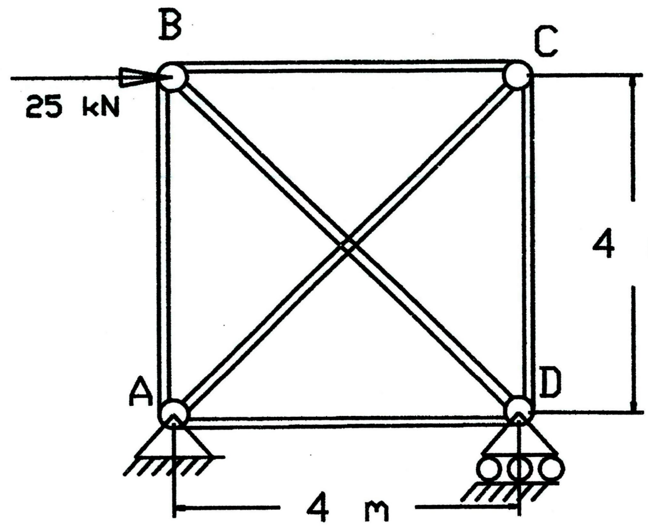
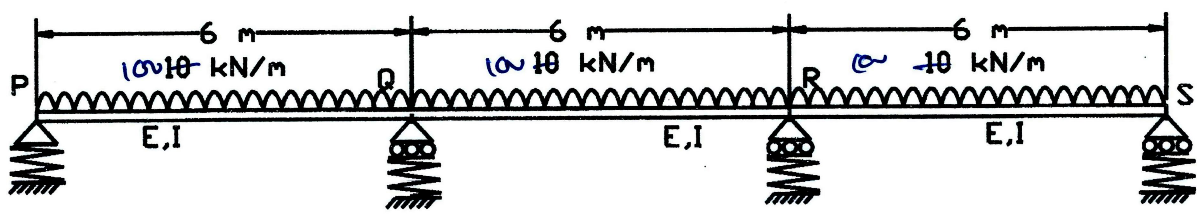


Fig. Q4



All springs have constant stiffness of $200x10^3$ kN/m

Fig. Q5

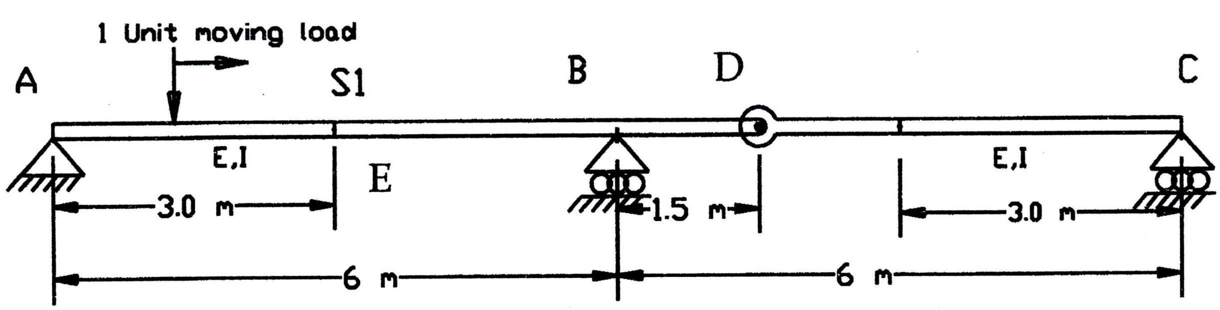


Fig. Q6