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Question Paper Code : 71353

M.E./M.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Second Semester

Structural Engineering

ST 4203 — FINITE ELEMENT ANALYSIS IN STRUCTURAL ENGINEERING

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define discretszation in FEA.
2. What is nodal displacement in FEA?
3. Differentiate between natural coordinates and simple natural coordinates in FEA.
4. Write down the element stiffness matrix of a uniform axial rod of length 'L' having a cross-sectional area 'A'.
5. Define stiffness coefficient.
6. Define the space frame with a neat sketch.
7. Write a short note on the element load matrix in FEA.
8. What is Linear Strain Triangle (LST).
9. Classify the types of plates based on their thickness to (least plan) dimension ratio.
10. Define lumped mass in FEA.

PART B — (5 × 13 = 65 marks)

11. (a) A simply supported beam of uniform flexural rigidity having a length 'l' is subjected to a single concentrated load 'P' at the mid-span. The displacement function for the beam is given by $y=\frac{\Delta}{l^3}\left(3l^2x-4x^3\right); 0<x<\frac{1}{2}$ Compute the value of Δ by the principle of virtual work.

Or

(b) A simply supported beam of uniform flexural rigidity having a length 'l' is subjected to a uniformly varying toad (intensity is '0' at the left on hinge support, to 'q/l' on the right side, on the roller support). Analyze the beam using the Galerkin method and determine the expression for the deflection of the beam.

12. (a) Derive an element stiffness matrix for a linear serendipity rectangle. Illustrate the natural coordinate system and shape functions.

Or

(b) Using the isoparametric concept, formulate the element stiffness matrix for a unidimensional two-noded element with a constant cross-sectional area, 'A' and Young's modulus, 'E', as shown in Figure 1.

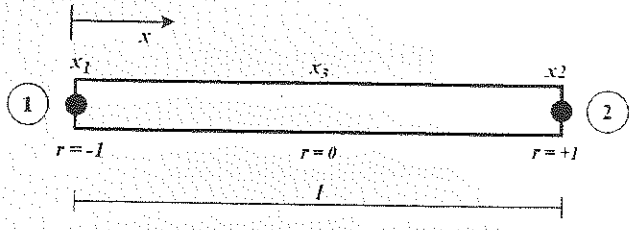

Figure 1

13. (a) In the two-member truss shown in Figure 2, let $\theta_1 = 45°, \theta_2 = 20°, x_1 = y_1 = 0, E_1 = E_2 = 200$ GPa, $A_1 = A_2 = 800\,\text{mm}^2$, $F_{3x} = 400\,N$ and $F_{3y} = 250\,N$. Determine the displacement components of node 3.

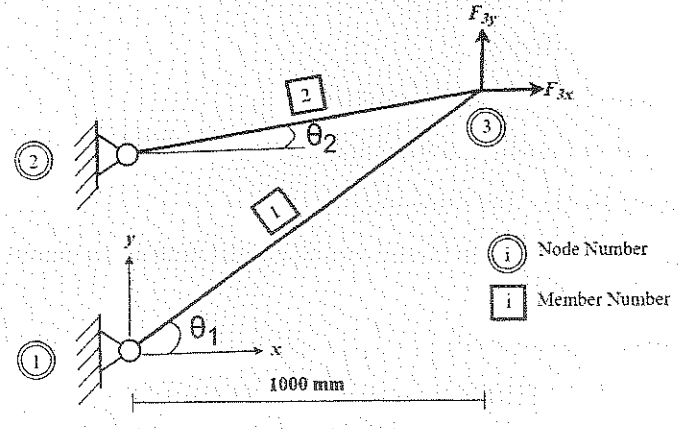

Figure 2

Or

(b) Explain the computation procedure for the analysis of a simple space frame using FEA.

14. (a) Determine the stiffness matrix for the CST element shown in Figure 3. The coordinates are in 'mm'. Assume plane strain conditions. Take, E = 210 GPa, v = 0.25, and t = 10 mm.

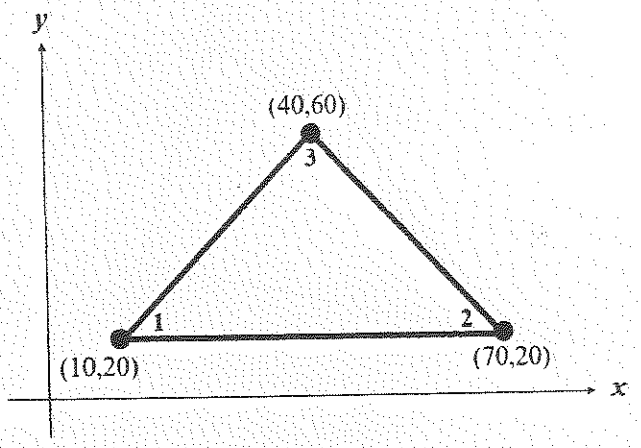

Figure 3

Or

(b) Derive the condensed stiffness matrix for a uniaxial rod with an internal node shown in Figure 4 using the static condensation procedure.

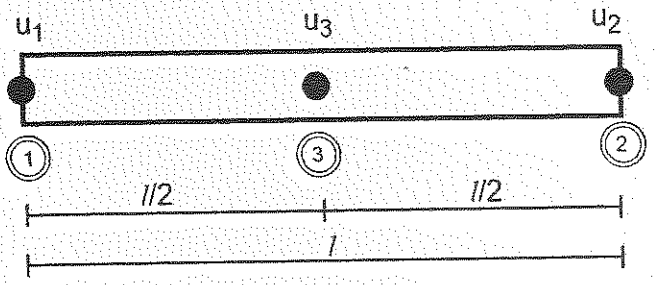

Figure 4

15. (a) Discuss the sub-domain approach in determining the stiffness matrix for a standard rectanaular plate element.

Or

(b) Discuss the procedure for finite element analysis of the shell as an assemblage of flat elements with a neat illustration.

PART C — (1 × 15 = 15 marks)

16. (a) Establish the Jacobian operator [J] for the two-dimensional element shown in Figure 5. Also, determine the Jacobian determinants.

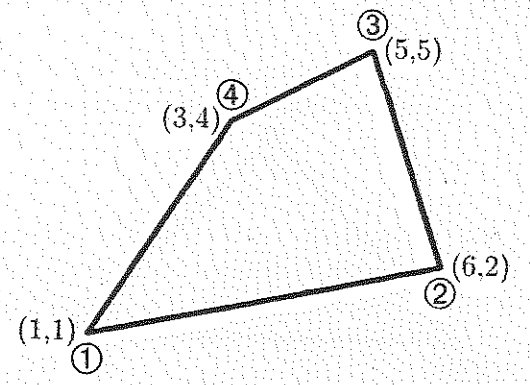

Figure 5

Or

(b) Derive the interpolation functions of a three-noded isoparametric uniaxial element.

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