Assignment 5. Finite Element Analysis_CO4

1. Basic procedure for solving a problem using Finite Element Analysis.
2. For, a 1D element, prove that:
   $\sigma = EBq$, Also derive the equation for the B matrix
3. Derive the element stiffness matrix of a linear 1D element using any method.
4. Explain Shape functions and applications of Quad and axisymmetric elements.
5. A stepped bar is made of two materials joined together as shown in Fig. 1. The bar is subjected to an axial pull of 10 kN. Determine the displacements and stresses of each of the section, using a 1 D spar element.

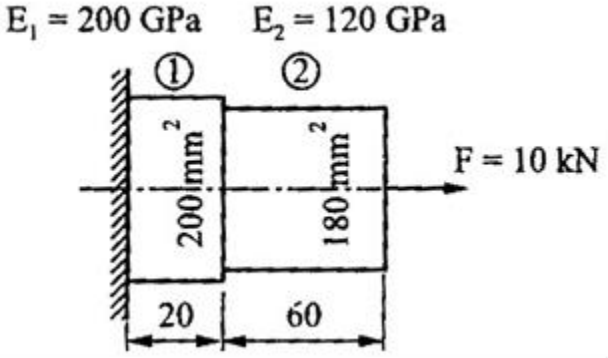

Fig. 1

6. A tapered bar 1200 mm long, having cross-sectional area 450 mm^2 at one end and 150 mm^2 at other end is fixed at the larger end. It is subjected to an axial load of 35 kN. Calculate the stress on a model bar having three finite elements 400 mm long. Assume modulus of elasticity, $E = 2 \times 10^5$ N/mm^2.
7. By using the finite element method for the loaded bar shown in Fig. 2. Determine the nodal displacements, element stresses, and support reactions using minimum number of elements. Assume $E = 200 \times 10^9$ N/m^2.

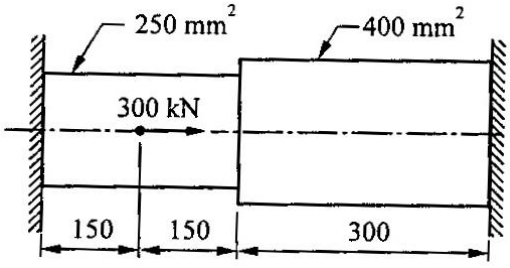

Fig. 2

8. A rectangular section steel bar is suspended vertically from the top edge. First four meter length of the bar is 100 mm x 100 mm in cross section, while the lower 1 meter is 50 mm x 50 mm in cross section, the axis of the two cross-sections being coincident. Model this as two linear elements and find the assembled stiffness matrix. Evaluate extension of the bar under self weight. Assume modulus of

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elasticity as 2.1 x 10^5 MPa and specific gravity of steel as 8. Also determine the reaction forces and the stresses developed.

9. For the loading system as shown in Fig. 3, determine the displacements, stresses and support reaction. Assume modulus of elasticity as 80 x 10^3 N/mm^2

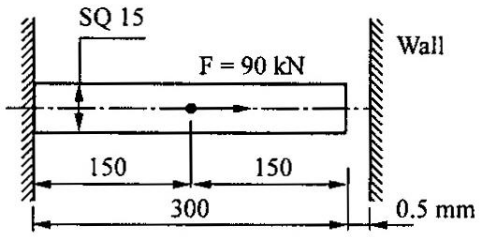

Fig. 3

10. Consider the bar as shown in Fig. 4. Determine the nodal displacements, element stresses and reactions, if the temperature rises by 60° C. Assume modulus of elasticity for the complete bar as 200 GPa and coefficient of thermal expansion as 12 x 10^{-6} per °C.

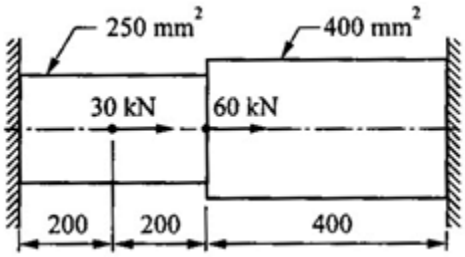

Fig. 4

11. A two member truss is as shown in Fig. **5**. The cross-sectional area of each member is 200 mm^2 and the modulus of elasticity is 200 GPa. Determine the deflections, reactions and stresses in each of the members.

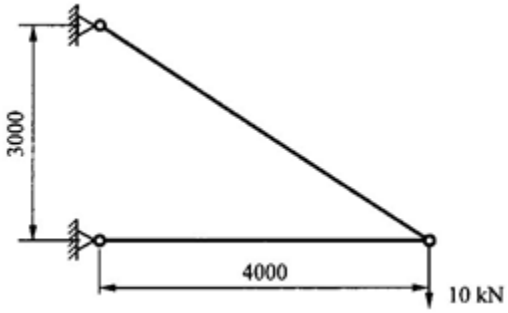

Fig. 5

12. For the truss solved in Example 7, if thermal stresses are introduced by increase in temperatures as shown in Fig. 6. Determine the deflections, reactions and stresses in each of the members. Assume a - 12 x 10^{-6} per °C.

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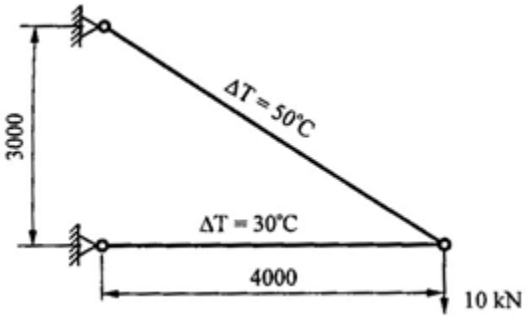

Fig. 6

13. A three bar truss is shown in Fig. 7. The modulus of elasticity of the material is 300 x 10^3 N/mm^2. The area of the bar used for the truss is 60 mm^2 for all the elements. The length L_1 = 750 mm and L_2 = 100 mm. The load P = 20 kN and P_2 = 25 kN. Determine:

    a. The element stiffness matrix for each element,
    b. The global stiffness matrix.
    c. Nodal displacement.
    d. Stresses in each element.
    e. Reaction force.

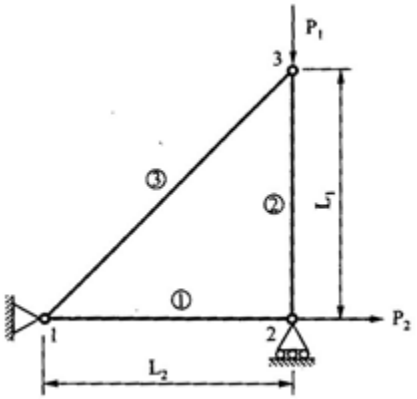

Fig. 7

14*. **Solve 1D static FEA problem using MS Excel.**

* Challenge problem (It is not compulsory for all)

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Learning Questions (No need to write):

14. Explain plain strain and plain stress problem.
15. Write engineering application of Finite Element Analysis.
16. Explain Penalty approach to solve FEA problem.
17. Discuss the properties of global stiffness matrix.
18. List types of 1D and 2D elements.
19. Derive the element stiffness matrix of a truss element.
20. Structural analysis using Euler-Bernoulli beam element.

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