THEORY OF STRUCTURES II

ENCE 252

Lecture : 4 **Year : II**
Tutorial : 2 **Part : II**
Practical : 2/2

Course Objectives:

The course is designed to introduce key terminology and concepts related to displacements, stresses, strains, stiffness, and other parameters essential for understanding indeterminate systems. It provides practical examples to illustrate the fundamental concepts and theorems concerning static equilibrium, geometrical compatibility, and physical conditions such as forces, stiffness, and displacements within these systems. Additionally, the course equips students with the necessary skills for more advanced structural mechanics courses by introducing analytical tools, including the matrix method, force method, displacement method, and plastic analysis.

1 Introduction (4 hours)

1.1 Types of indeterminate structures
1.2 Boundary conditions and degree of freedoms
1.3 Static and kinematic indeterminacy
1.4 Structure idealization, local and global coordinate systems, deformations and their sign conventions
1.5 Determination of degree of static indeterminacy of a system: Use of formula, necessity of visual checking for plane systems in the form of beam, frame, truss and arch
1.6 Degree of kinematic indeterminacy of a system and its determination: Use of formula, necessity of visual checking for plane systems in the form of beam, frame, truss and arch
1.7 Definitions and explanations of force and displacement, flexibility and stiffness and their relationship

2 Theorem of Displacements (6 hours)

2.1 Force and displacements as cause and effects
2.2 Castigliano's theorems and their applications
2.3 Analyses of simple systems like beam, frame and truss
2.4 Bending moment, shear force and normal thrust diagrams for beam, truss and frames

3 Force Method (10 hours)

3.1 Definitions and explanations; Specialties of force method and its limitations
3.2 Consistent deformation systems; Compatibility equations, primary structures, choice of redundant
3.3 Flexibility method: Use in beam, frame and trusses; Yielding of supports in beam, truss and frames; Temperature effects and misfits in truss
3.4 Flexibility matrix method
3.5 Graph multiplication approach for simple cases
3.6 Three moment theorem and its application
3.7 Introduction to focal point method

4 Analysis of Indeterminate Arches (6 hours)

4.1 Use of arches in modern constructions
4.2 Horizontal reaction for parabolic and circular two-hinged and fixed arches
4.3 Bending moment, shear force and normal thrust diagrams
4.4 Yielding of supports, temperature effect and rib shortening
4.5 Influence line diagrams for horizontal thrust, bending moment at span, normal thrust and radial shear for two hinged arches

5 Slope Deflection Method (5 hours)

5.1 Introduction and sign conventions
5.2 Formulation of slope deflection equation
5.3 Fixed end moments
5.4 Application in beam and frames with support settlements and rotations
5.5 Bending moment, shear force and normal thrust diagrams for beam and frames

6 Moment Distribution Method (5 hours)

6.1 Introduction, terminology and development of method
6.2 Distribution factors
6.3 Carry over moments
6.4 Application in beam and frames: Symmetry and anti-symmetry, sway conditions and support yielding
6.5 Bending moment, shear force and normal thrust diagrams for beam and frames

7 Stiffness Matrix Method (12 hours)

7.1 Definition of stiffness, choice of redundant and degree of freedoms
7.2 Member stiffness matrix for spring, bar, truss and beam elements
7.3 Rotation matrices
7.4 Analysis of multiple spring connected systems, bar and string combinations, simple two-dimensional trusses

7.5 Applications to beams and two-dimensional frames, effects of settlement of support and temperature
7.6 Application in space/three-dimensional truss
7.7 Bending moment, shear force and normal thrust diagrams for beam and frames
7.8 Introduction to structural engineering related software

8 Influence Line for Indeterminate Beams (6 hours)

8.1 Necessity of influence line diagrams
8.2 Muller Breslau principle, its physical meaning and use
8.3 Influence line diagrams for reactions, bending moment and shear force in various sections of continuous beams (Two to three spans only)
8.4 Use of influence line diagrams to calculate reactions, shear forces and bending moments for concentrated force, couple and distributed load

9 Introduction to Plastic Analysis (6 hours)

9.1 Definitions and explanations
9.2 Plastic analysis of bending members
9.3 Plastic hinge and its length
9.4 Load factor, shape factor and plastic modulus
9.5 Basic theorems on methods of limit analysis
9.6 Collapse loads: partial collapse, complete collapse
9.7 Collapse with tied loads for simple cases of statically indeterminate beams (Not more than three spans) and frames (Only portal frames)

Tutorial (30 hours)

1. Theorem of displacements on computation of bending moment, shear force and normal thrust, truss and frames
2. Analysis of beam, frame and trusses using force method
3. Analysis of beam and frame using slope deflection method
4. Application of moment distribution method on analysis of beams and two-dimensional frames
5. Stiffness matrix method
6. Influence line for indeterminate beams
7. Plastic analysis of statically indeterminate beams and frames

Practical (15 hours)

Determination of redundant reaction components and their comparative studies in the following four experiments and three project works.

1 Continuous beams (propped cantilever, two spanned beams with various end conditions)
2 Two hinged arch
3 Symmetrical portal frame
4 Unsymmetrical portal frame

5 Analysis of two-dimensional truss of at least 4 degree of redundancy, solve by flexibility matrix method and calculate axial forces
6 Analysis of two-dimensional truss of at least 4 degree of redundancy, solve by stiffness matrix method and calculate axial forces
7 Analysis of two-dimensional frame of at least 4 degree of redundancy, solve by stiffness matrix method and draw bending moment diagram, shear force diagram and axial force diagram

Students should submit individual report of both lab test and project works

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	4
2	6	6
3	10	10
4	6	6
5	5	5
6	5	5
7	12	12
8	6	6
9	6	6
Total	**60**	**60**

* There may be minor deviation in marks distribution.

References

1. Parajuli, H.R., Ojha, B. (2024). Structural Analysis -II, Indeterminate Structures. Kathmandu: Heritage Publishers & Distributors.
2. Darkov A. et al. (1979) Structural Mechanics, Mir Publishers, Moscow.
3. Ghali, A., Neville, A. M. (1989). Structural Analysis, A Unified Classical and Matrix Approach. Chapman and Hall.
4. Norris, C. H., Wilbur, J. B., Utku, S. (1991). Elementary Structural Analysis. McGraw-Hill International Editions, Civil Engineering Series.
5. Wang, C. K. (1983). Intermediate Structural Analysis. McGraw-Hill International Editions, Civil Engineering Series.
6. Joshi, H. R. (1991). Theory of Structure II - Course Manual. Katmandu : Institute of Engineering, Tribhuvan University.