



National University of Engineering (UNI)
School of Civil Engineering
Syllabus 2027-I

1. COURSE

CE3S1. Structural Analysis II (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3S1. Structural Analysis II
2.2 Semester	: 9 th Semester.
2.3 Credits	: 4
2.4 Hours	: 2 HT; 4 HP;
2.5 Duration of the period	: 16 weeks
2.6 Type of course	: Mandatory
2.7 Learning modality	: Face to face
2.8 Prerequisites	: CE2S1. Structural Analysis I. (7 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Structural Analysis II extends the matrix methods introduced in Structural Analysis I to the practical, computer-based analysis of building structural systems. Students deepen their command of the direct stiffness method through its application to plane trusses and frames, incorporate seismic loading through dynamic and response-spectrum analysis, and apply these tools in team seminars to the analysis of real building case studies. The course concludes with an introduction to the finite element method and to material and geometric nonlinear analysis, providing the computational foundation required for advanced structural design and specialized graduate study.

5. GOALS

- Apply the direct stiffness method to formulate and solve the analysis of plane trusses and frames using matrix-based computer methods.
- Apply dynamic and response-spectrum analysis to determine the seismic response of building structural systems.
- Analyze real building structural systems in team-based seminars, integrating stiffness-method and seismic-analysis techniques into practical models.
- Formulate finite element models of structural systems, including an introduction to material and geometric nonlinear analysis.

6. COMPETENCES

- ABET-1)** An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. (Usage)
- ABET-2)** An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. (Usage)
- ABET-6)** An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. (Usage)

7. TOPICS

Unit 1: Matrix Structural Analysis (38 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Displacement method and stiffness approach • Direct stiffness method and matrix formulation • Coordinate transformations and assembly of global stiffness matrices	• Implement the displacement method for structural analysis [Assessment] • Formulate structural problems using the direct stiffness method in matrix form [Usage] • Assemble global stiffness matrices and solve for nodal displacements [Assessment]
Readings : [McGuire2000], [KassimaliMatrix2012]	

Unit 2: Structural Dynamics and Earthquake Engineering (14 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Single-degree-of-freedom systems and free vibration • Forced vibration and harmonic excitation • Damping models and energy dissipation mechanisms • Response spectrum analysis • Earthquake ground motion characteristics and seismicity • Multi-degree-of-freedom systems and modal analysis • Time-history analysis and numerical integration methods • Seismic design philosophy and capacity design principles • Base isolation and energy dissipation devices • Performance-based seismic design methodology	• Analyze free vibration of single-degree-of-freedom systems and determine natural frequencies [Assessment] • Calculate structural response to harmonic and periodic loads [Usage] • Explain the role of damping in reducing dynamic response [Familiarity] • Apply response spectrum method for seismic analysis [Usage] • Interpret earthquake ground motion parameters and seismic hazard maps [Familiarity] • Perform modal analysis for multi-degree-of-freedom systems [Assessment] • Conduct time-history analysis using numerical integration techniques [Usage] • Design structures following capacity design and ductile detailing principles [Assessment] • Evaluate the effectiveness of base isolation and damping systems [Familiarity] • Implement performance-based seismic design procedures [Assessment]
Readings : [Chopra2017]	

Unit 3: Building Structural Analysis and Modeling Practicum (12 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Overview of case-study buildings: geometry, structural systems, and load paths • Development of plane frame and truss models of real buildings using stiffness-method-based structural analysis software • Application of static and seismic response-spectrum analysis to representative building case studies • Presentation and peer discussion of structural analysis results and their design implications • Definition of geometry, materials, sections, and boundary conditions for a three-dimensional building model in commercial structural analysis software (ETABS, Midas Gen) • Assignment of gravity, seismic, and wind loads and their combinations to a three-dimensional building model • Static and dynamic (modal) analysis of building models and interpretation of results, including story drifts, member forces, and vibration periods • Verification of software-generated results against simplified hand calculations and code checks	• Model real building structural systems for stiffness-method-based static and seismic analysis using structural analysis software [Usage] • Interpret and validate computer-generated analysis results against expected structural behavior [Assessment] • Present and defend structural analysis results and their design implications to peers [Usage] • Assign gravity, seismic, and wind loads and load combinations to a three-dimensional building model in commercial structural analysis software [Usage] • Interpret dynamic analysis results, including story drifts, member forces, and vibration periods [Assessment] • Verify software-generated results against simplified hand calculations [Assessment]
Readings : [McGuire2000], [Chopra2017]	

Unit 4: Finite Element Methods in Structural Engineering (20 hours)	
Competences Expected: ABET-6	
Topics	Learning Outcomes
• Fundamentals of finite element theory and discretization • Element types including truss, beam, and frame elements • Stiffness matrix formulation and assembly • Plane stress and plane strain elements • Modeling techniques, boundary conditions, and mesh refinement • Shell and plate elements • Solid elements and three-dimensional analysis • Nonlinear analysis including material and geometric nonlinearity • Dynamic analysis using finite element methods • Verification, validation, and error estimation in FEA	• Explain the fundamental principles and assumptions of finite element analysis [Familiarity] • Formulate element stiffness matrices for basic element types [Usage] • Assemble global stiffness matrices and apply boundary conditions [Assessment] • Apply plane stress and plane strain elements to two-dimensional problems [Usage] • Develop appropriate finite element models with proper mesh density [Assessment] • Utilize shell and plate elements for thin-walled structure analysis [Usage] • Model complex three-dimensional structures using solid elements [Assessment] • Perform nonlinear finite element analysis for material and geometric effects [Usage] • Conduct dynamic finite element analysis including modal and time-history analysis [Assessment] • Validate finite element results and estimate discretization errors [Assessment]
Readings : [Bathe2014]	

8. WORKPLAN

8.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

8.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

8.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

9. EVALUATION SYSTEM

***** EVALUATION MISSING *****

10. BASIC BIBLIOGRAPHY