



National University of Engineering (UNI)

School of Civil Engineering
Syllabus 2026-II

1. COURSE

CE3S7. Structural Rehabilitation and Retrofitting (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3S7. Structural Rehabilitation and Retrofitting
2.2 Semester	: 10 th Semester.
2.3 Credits	: 3
2.4 Hours	: 4 HT; 2 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	: CE3S4. Earthquake-Resistant Engineering and Disaster Prevention. (9 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Structural Rehabilitation and Retrofitting addresses the assessment, strengthening, and retrofit of Peru's existing civil infrastructure. Building on the seismic engineering fundamentals of Earthquake-Resistant Engineering and Disaster Prevention, the course begins with the national context of Peru's aging and deficient infrastructure and a review of the seismic design code criteria that establish the baseline performance expectations against which existing structures are evaluated. Students then characterize the permanent, live, environmental, and deterioration-induced loads acting on existing structures, and study the nonlinear behavior of structural components – including hysteretic response, plastic hinge modeling, and pushover analysis – required to evaluate structural performance beyond the elastic range. The course closes with the field evaluation procedures, and the strength, ductility, durability, and serviceability rehabilitation techniques used to retrofit existing structures.

5. GOALS

- Describe the national context and condition of Peru's existing civil infrastructure and the regulatory framework applicable to its assessment and rehabilitation.
- Characterize the permanent, live, environmental, and deterioration-induced loads acting on existing structures.
- Apply nonlinear structural analysis methods, including pushover analysis and displacement-based assessment, to evaluate the performance of existing structures.
- Conduct field evaluation procedures, including nondestructive testing, to assess the condition of existing structures.
- Design strengthening and retrofit interventions to improve the strength, ductility, durability, and serviceability of existing structures.

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: National Context of Existing Civil Infrastructure (2 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Overview of Peru's existing civil infrastructure inventory and condition: buildings, bridges, and life-lines • Causes and consequences of infrastructure deficiency: aging, inadequate maintenance, unregulated construction, and seismic vulnerability • Economic, social, and risk-management implications of infrastructure rehabilitation versus replacement • Institutional and regulatory framework for the rehabilitation of existing structures in Peru	• Describe the condition and typology of Peru's existing civil infrastructure [Familiarity] • Explain the causes and consequences of infrastructure deficiency in the Peruvian context [Familiarity] • Discuss the economic and risk-management criteria used to decide between rehabilitation and replacement of existing infrastructure [Usage]
Readings : [Civ21]	

Unit 2: Seismic Design Code and Structural Configuration Criteria (4 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Scope and structure of the Peruvian seismic design code E.030 • Seismic hazard parameters: seismic zonation (Z), usage factor (U), and soil profile (S) • Structural systems and seismic force reduction coefficient (R) • Plan structural irregularities: torsional irregularity, re-entrant corners, and diaphragm discontinuity • Vertical structural irregularities: soft story, weak story, and mass irregularity • Structuring principles: symmetry, redundancy, hyperstaticity, and continuity • Minimum base shear and inter-story drift limits	• Explain the scope and structure of the Peruvian seismic design code E.030 [Familiarity] • Determine the seismic hazard parameters (Z, U, S) applicable to a given site [Usage] • Select the structural system and corresponding reduction coefficient R [Usage] • Classify the plan and vertical structural irregularities of a building [Assessment] • Apply structuring principles to propose a regular structural configuration [Usage] • Verify the minimum base shear and inter-story drift limits [Assessment]
Readings : [Ser18]	

Unit 3: Nature and Characterization of Loads on Existing Infrastructure (10 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Permanent (dead) and live load characterization for existing structures • Environmental loads: wind, thermal, and differential settlement effects on infrastructure • Deterioration-induced load effects: corrosion, creep, shrinkage, and fatigue • Load history reconstruction and service load estimation for existing structures • Overload and abnormal load events: impact, blast, and accidental actions • Load combinations for structural assessment and rehabilitation design	• Characterize the permanent and live loads applicable to existing civil infrastructure [Familiarity] • Determine environmental load effects, including wind, thermal, and differential settlement, on existing structures [Usage] • Identify deterioration-induced load effects such as corrosion, creep, shrinkage, and fatigue [Assessment] • Reconstruct the load history and estimate in-service loads for an existing structure [Usage] • Recognize overload and abnormal load events relevant to infrastructure assessment [Familiarity] • Establish load combinations appropriate for structural assessment and rehabilitation design [Assessment]
Readings : [Civ22]	

Unit 4: Nonlinear Behavior of Structures (18 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	Learning Outcomes
• Material nonlinearity: stress-strain behavior of concrete and reinforcing steel beyond yield • Geometric nonlinearity and P-delta effects in structural response • Hysteretic behavior and energy dissipation of structural components under cyclic loading • Plastic hinge formation, hinge length, and moment-curvature relationships • Nonlinear static (pushover) analysis and capacity curve development • Displacement ductility and curvature ductility demand • Performance levels and acceptance criteria for structural and nonstructural components • Displacement-based assessment methods for existing structures	• Explain the material and geometric sources of nonlinear structural behavior [Familiarity] • Determine moment-curvature relationships and plastic hinge properties for structural members [Usage] • Perform nonlinear static (pushover) analysis to develop a structure's capacity curve [Usage] • Calculate displacement and curvature ductility demands for structural components [Assessment] • Evaluate structural and nonstructural performance levels against acceptance criteria [Assessment] • Apply displacement-based methods to assess the seismic performance of existing structures [Usage]
Readings : [PCK07]	

Unit 5: Structural Rehabilitation, Strengthening, and Retrofit (50 hours)	
Competences Expected: ABET-2, ABET-6	
Topics	Learning Outcomes
• Condition assessment and structural evaluation procedures • Load rating and capacity evaluation of existing structures • Concrete repair materials and techniques • Strengthening techniques using external reinforcement • FRP strengthening systems for flexure and shear • Seismic retrofit strategies for buildings and bridges • Steel jacketing and external post-tensioning • Masonry rehabilitation and historic structure preservation • Performance-based assessment and retrofit design • Nondestructive evaluation and structural health monitoring	• Conduct comprehensive condition assessments of existing structures [Assessment] • Evaluate load-carrying capacity of existing structural members [Usage] • Select appropriate concrete repair materials and application methods [Familiarity] • Design strengthening interventions using conventional techniques [Assessment] • Apply FRP systems for flexural and shear strengthening of concrete members [Usage] • Develop seismic retrofit strategies for deficient structures [Assessment] • Implement steel jacketing and external post-tensioning systems [Usage] • Rehabilitate masonry structures while preserving historic character [Assessment] • Perform performance-based assessment and design retrofit interventions [Usage] • Utilize nondestructive testing and monitoring technologies for damage assessment [Familiarity]
Readings : [Ins21], [Civ17], [Age00], [Ins17]	

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

- [Age00] Federal Emergency Management Agency. *FEMA 356: Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. Tech. rep. Federal Emergency Management Agency, 2000.
- [PCK07] M. J. N. Priestley, G. M. Calvi, and M. J. Kowalsky. *Displacement-Based Seismic Design of Structures*. IUSS Press, 2007.
- [Civ17] American Society of Civil Engineers. *ASCE/SEI 41-17: Seismic Evaluation and Retrofit of Existing Buildings*. Tech. rep. American Society of Civil Engineers, 2017.
- [Ins17] American Concrete Institute. *ACI 440.2R-17: Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures*. Tech. rep. American Concrete Institute, 2017.

- [Ser18] Construcción y Saneamiento del Perú Servicio Nacional de Capacitación para la Industria de la Construcción (SENCICO) / Ministerio de Vivienda. *Norma Técnica E.030: Diseño Sismorresistente*. Tech. rep. Reglamento Nacional de Edificaciones del Perú, 2018.
- [Civ21] American Society of Civil Engineers. *2021 Infrastructure Report Card*. Tech. rep. American Society of Civil Engineers, 2021.
- [Ins21] American Concrete Institute. *ACI 562: Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures*. Tech. rep. American Concrete Institute, 2021.
- [Civ22] American Society of Civil Engineers. *ASCE/SEI 7-22: Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Tech. rep. American Society of Civil Engineers, 2022.