



National University of Engineering (UNI)

School of Civil Engineering
Syllabus 2026-II

1. COURSE

CE3S10. Seismic Design of Civil Engineering Works (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3S10. Seismic Design of Civil Engineering Works
2.2 Semester	: 10 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	: CE3S4. Earthquake-Resistant Engineering and Disaster Prevention. (9 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Seismic Design of Civil Engineering Works introduces the seismic analysis and reinforced concrete design of special/industrial civil engineering structures – free-standing chimneys and liquid-storage tanks – extending the seismological, code, and structural-dynamics fundamentals from Earthquake-Resistant Engineering to structures whose seismic behavior differs fundamentally from that of buildings. The course opens with the professional and regulatory context of civil engineering works, framing the elevated public-safety risk profile of special/industrial structures, then reviews the seismic phenomenon, the Peruvian seismic design code, and the fundamentals of structural dynamics before applying them to the seismic analysis and reinforced concrete design of chimneys – modeled as equivalent cantilever systems – and liquid-storage tanks, whose seismic response is governed by the hydrodynamic impulsive-convective interaction between the contained liquid and the tank walls, following ACI 307 and ACI 350.3.

5. GOALS

- Explain the professional and regulatory context of civil engineering works, with emphasis on the public-safety risk profile of special/industrial structures.
- Explain the seismic phenomenon and apply the Peruvian seismic design code to determine seismic hazard parameters and structural configuration criteria.
- Analyze the dynamic response of structural systems subjected to earthquake ground motion.
- Analyze the seismic behavior of free-standing chimneys and design their reinforced concrete shell for seismic loading according to ACI 307.
- Analyze the hydrodynamic seismic response of liquid-storage tanks and design their reinforced concrete walls and base for seismic-induced hydrodynamic pressures according to ACI 350.3.

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)

7. TOPICS

Unit 1: Professional and Regulatory Context (12 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Typology of civil engineering works: buildings, transportation and hydraulic infrastructure, and special/industrial structures (chimneys, tanks, silos) • Peruvian regulatory framework (Reglamento Nacional de Edificaciones) and applicable international standards (ACI, ASCE) for special/industrial structures • Professional responsibility and public-safety risk considerations specific to special/industrial structures under seismic hazard • Design process and stakeholders involved in a special/industrial structures project: owner, design engineer, and regulatory authority	• Classify civil engineering works by typology and identify the regulatory framework applicable to special/industrial structures [Familiarity] • Explain the professional responsibility and public-safety risk considerations specific to the design of special/industrial structures [Familiarity] • Describe the design process and the stakeholders involved in a special/industrial structures project [Usage]
Readings : [Ser18]	

Unit 2: Seismology and Natural Hazards (6 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Plate tectonics and earthquake generation mechanisms through fault rupture • Seismic waves: types (P, S, surface) and their propagation • Magnitude (seismic moment) and intensity (Modified Mercalli) scales • Historical seismicity and subduction tectonic context of Peru • Typology of natural disasters: seismic, volcanic, tsunami, and mass movement • Disaster risk management: prevention, mitigation, preparedness, and response (SINAGERD framework) • Seismological instrumentation: seismographs, accelerographs, and national monitoring networks	• Explain plate tectonics and earthquake generation mechanisms through fault rupture [Familiarity] • Differentiate types of seismic waves and their effects on buildings [Usage] • Interpret and distinguish between earthquake magnitude and intensity scales [Usage] • Describe the historical seismicity and subduction context of Peru [Familiarity] • Classify the main types of natural disasters affecting Peruvian territory [Familiarity] • Analyze the disaster risk management framework for earthquake prevention and response [Assessment]
Readings : [Bol05], [Kra96]	

Unit 3: Seismic Design Code and Structural Configuration Criteria (6 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], [BM02]	

Unit 4: Structural Dynamics and Earthquake Engineering (12 hours)	
Competences Expected: ABET-1	
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 : [Cho17]	

Unit 5: Industrial Structures: Chimneys and Tanks (48 hours)	
Competences Expected: ABET-1, ABET-2	
Topics	Learning Outcomes
• Dynamic idealization of a free-standing chimney as an equivalent cantilever stick model • Seismic force and overturning moment distribution along the height of a chimney per ACI 307 • Flexural and shear design of reinforced concrete chimney shell sections under seismic loading • Seismic reinforcement detailing for chimney shells, openings, and construction joints • Housner's impulsive-convective two-mass model for the hydrodynamic seismic response of liquid-storage tanks • Impulsive and convective (sloshing) hydrodynamic pressure distribution on tank walls and base per ACI 350.3 • Design of reinforced concrete tank walls and base slab for seismic-induced hydrodynamic pressures • Sloshing wave height, freeboard requirements, and anchorage design for storage tanks	• Explain the dynamic idealization of a free-standing chimney as an equivalent cantilever stick model for seismic analysis [Familiarity] • Determine the seismic force and overturning moment distribution along the height of a reinforced concrete chimney [Usage] • Design the reinforced concrete shell section of a chimney for flexure and shear under seismic loading [Assessment] • Detail seismic reinforcement for chimney shells, openings, and construction joints [Usage] • Explain Housner's impulsive-convective mass model for the hydrodynamic seismic response of liquid-storage tanks [Familiarity] • Determine impulsive and convective hydrodynamic pressure distributions on tank walls and base [Usage] • Design reinforced concrete tank walls and base slab for seismic-induced hydrodynamic pressures [Assessment] • Calculate sloshing wave height and freeboard requirements, and design anchorage for a storage tank [Usage]
Readings : [30722], [35020], [Hou63]	

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

- [Hou63] George W. Housner. "The Dynamic Behavior of Water Tanks". In: *Bulletin of the Seismological Society of America* 53.2 (1963), pp. 381–387.
- [Kra96] Steven L. Kramer. *Geotechnical Earthquake Engineering*. Prentice Hall, 1996.
- [BM02] Enrique Bazán and Roberto Meli. *Diseño Sísmico de Edificios*. Editorial Limusa, 2002.
- [Bol05] Bruce A. Bolt. *Earthquakes*. 5th. W.H. Freeman, 2005.
- [Cho17] Anil K. Chopra. *Dynamics of Structures: Theory and Applications to Earthquake Engineering*. 5th. Pearson, 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.
- [35020] ACI Committee 350. *Seismic Design of Liquid-Containing Concrete Structures (ACI 350.3-20)*. Tech. rep. American Concrete Institute, 2020.
- [30722] ACI Committee 307. *Standard Practice for the Design and Construction of Cast-in-Place Reinforced Concrete Chimneys (ACI 307-22)*. Tech. rep. American Concrete Institute, 2022.