



National University of Engineering (UNI)

School of Civil Engineering

Syllabus 2027-I

1. COURSE

CE3S11. Professional Competency Workshop - Structures (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3S11. Professional Competency Workshop - Structures
2.2 Semester	: 9 th Semester.
2.3 Credits	: 3
2.4 Hours	: 1 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. (8 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Professional Competency Workshop - Structures is an integrative review course that consolidates and applies the structural engineering competencies developed throughout the Structures specialization track. It revisits mechanics of materials and structural behavior, standardized testing and quality control, structural dynamics and seismic-resistant engineering, reinforced concrete and prestressed concrete design, structural health monitoring technologies, resilient design for natural hazards and climate change, and engineering ethics and professional responsibility, preparing students to face the professional practice of structural engineering as a whole.

5. GOALS

- Review and apply mechanics of materials and structural behavior principles to real structural elements.
- Apply standardized testing, quality control, and failure analysis methods to structural materials and systems.
- Analyze the seismic response of structures and apply seismic-resistant design criteria.
- Design reinforced concrete and prestressed concrete structural elements.
- Apply structural health monitoring (SHM) and sensor technologies to assess the condition of civil infrastructure.
- Formulate resilient design solutions for natural hazards and climate change.
- Apply engineering ethics and professional responsibility principles to structural engineering practice.

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: Mechanics of Materials and Structural Behavior (10 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Stress and strain concepts including normal, shear, and principal stresses • Axial loading and deformation of members • Torsion of circular and non-circular sections • Bending stress and deflection in beams • Shear stress distribution in beams • Combined loading and stress transformation • Buckling of columns and stability analysis • Fatigue and fracture mechanics • Elastic and plastic behavior of materials • Energy methods for structural analysis	• Define stress, strain, and their relationships through constitutive laws [Familiarity] • Calculate stresses and deformations in members under axial loading [Usage] • Determine torsional stresses and angles of twist in shafts [Usage] • Analyze bending stress distribution and deflection in beams [Assessment] • Compute shear stress distribution in beam cross-sections [Usage] • Apply stress transformation equations for combined loading conditions [Assessment] • Evaluate column stability and calculate critical buckling loads [Assessment] • Explain fatigue failure mechanisms and predict fatigue life [Familiarity] • Distinguish between elastic and plastic material behavior under loading [Usage] • Use energy methods to solve deflection and indeterminate structural problems [Usage]
Readings : [Gere2017], [Hibbeler2017Mat]	

Unit 2: Standardized Testing, Quality Control, and Failure Analysis (6 hours)	
Competences Expected: ABET-6	
Topics	Learning Outcomes
• Standard test methods for material characterization and acceptance testing • Sampling procedures and representative sample selection • Quality control and quality assurance protocols in construction • Statistical analysis of test data and acceptance criteria • Non-destructive testing methods for materials and structures • Advanced material characterization techniques including microscopy and spectroscopy • Failure analysis methodology and root cause investigation • Forensic engineering and distress evaluation • Performance-based testing and specification approaches • Certification, compliance, and third-party testing requirements	• Perform standard material tests according to ASTM or equivalent specifications [Usage] • Develop appropriate sampling plans for construction material acceptance [Assessment] • Implement quality control procedures for construction materials and processes [Usage] • Analyze test data using statistical methods and establish acceptance criteria [Assessment] • Apply non-destructive testing techniques for in-situ material evaluation [Familiarity] • Utilize advanced characterization techniques to investigate material microstructure [Usage] • Conduct systematic failure analysis to determine root causes of material distress [Assessment] • Investigate structural failures using forensic engineering methodologies [Assessment] • Design performance-based test protocols for innovative materials [Usage] • Interpret certification requirements and coordinate third-party testing programs [Familiarity]
Readings : [Neville2011]	

Unit 3: Structural Dynamics and Earthquake Engineering (10 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 : [Chopra2017]	

Unit 4: Seismic Design Code and Structural Configuration Criteria (10 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 : [E030-2018], [BazanMeli2002]	

Unit 5: Reinforced Concrete Design (10 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Design philosophy and limit state methodology for concrete structures • Flexural design of rectangular and T-beams • Shear and torsion design of concrete members • Compression members and column design • Slab design including one-way and two-way systems • Development length and splicing of reinforcement • Deflection control and serviceability requirements for concrete beams and slabs	• Explain limit state design philosophy and load factor combinations [Familiarity] • Design reinforced concrete beams for flexure and check serviceability [Assessment] • Calculate shear and torsional reinforcement requirements [Usage] • Proportion columns for axial load and biaxial bending [Assessment] • Design one-way and two-way slab systems with appropriate reinforcement [Usage] • Determine development lengths and design lap splices for reinforcing bars [Assessment] • Control deflections and verify serviceability requirements through adequate member sizing and reinforcement [Usage]
Readings : [Wight2016], [ACI31819], [McCormac2021]	

Unit 6: Seismic Detailing of Reinforced Concrete (3 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Beam-column joints and moment-resisting frame connections • Seismic detailing and ductile design of concrete structures • Design of special reinforced concrete structural walls (shear walls) for seismic lateral force resistance • Special seismic detailing provisions for reinforced concrete moment-resisting frames	• Detail beam-column joints for moment transfer and shear resistance [Assessment] • Implement seismic detailing requirements for ductile concrete frames [Assessment] • Design special reinforced concrete structural walls for combined axial, flexural, and shear demands under seismic loading [Assessment] • Apply special seismic detailing provisions to reinforced concrete moment frame members and beam-column joints [Usage]
Readings : [Wight2016], [ACI31819], [Moehle2015]	

Unit 7: Prestressed Concrete Analysis (3 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Prestressed concrete principles and pre-tensioning methods • Elastic analysis of stresses in prestressed concrete sections under service loads • Composite prestressed concrete sections: precast members with cast-in-place topping • Immediate and time-dependent losses of prestress	• Apply prestressing principles to design pre-tensioned members [Usage] • Analyze stresses in prestressed concrete sections under service loads using elastic theory [Usage] • Design composite prestressed concrete sections combining precast members and cast-in-place concrete [Assessment] • Calculate immediate and time-dependent losses of prestress [Usage]
Readings : [Wight2016], [ACI31819], [Moehle2015]	

Unit 8: Prestressed Concrete Design (4 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Post-tensioned concrete systems and tendon design • Deflection control and serviceability requirements • Flexural strength of prestressed concrete members at ultimate limit state • Shear and torsion design of prestressed concrete members • Statically indeterminate prestressed concrete structures, including secondary moments	• Design post-tensioned slabs and beams including tendon layout [Assessment] • Control deflections through appropriate member sizing and reinforcement [Usage] • Design prestressed concrete members for flexural strength at the ultimate limit state [Assessment] • Design prestressed concrete members for shear and torsion strength [Assessment] • Analyze statically indeterminate prestressed concrete structures, including secondary moments [Assessment]
Readings : [Wight2016], [ACI31819], [Moehle2015]	

Unit 9: Structural Health Monitoring (SHM) and Sensor Technologies (2 hours)	
Competences Expected: ABET-6	
Topics	Learning Outcomes
• SHM objectives, paradigms, and lifecycle cost-benefit analysis • Sensor types: strain gauges, accelerometers, tilt-meters, fiber optics, piezoelectrics • Data acquisition systems, signal conditioning, and sampling theory • Wireless sensor networks (WSN) and IoT communication protocols • Vibration-based damage detection and modal analysis • Advanced sensing: distributed fiber optics, computer vision, and radar interferometry • Data management, cloud storage, and cybersecurity for SHM systems • Statistical pattern recognition and anomaly detection algorithms • Decision-support systems for maintenance planning based on SHM data	• List the primary objectives and potential benefits of a Structural Health Monitoring (SHM) system [Familiarity] • Select appropriate sensor types for monitoring specific structural responses (strain, vibration, deflection) [Assessment] • Design the layout of a basic sensor network for a simply supported beam or a bridge pier [Usage] • Explain the advantages and challenges of wireless sensor networks over wired systems [Familiarity] • Perform a basic modal analysis on a set of acceleration data to identify natural frequencies [Usage] • Compare advanced sensing technologies for detecting crack propagation or settlement [Assessment] • Develop a data management plan for a long-term SHM project, considering cloud storage [Usage] • Apply a simple statistical control chart to identify anomalies in time-series sensor data [Assessment] • Propose a maintenance action based on the output of a SHM-based decision-support system [Usage]
Readings : [Farrar2013]	

Unit 10: Resilient Design for Natural Hazards and Climate Change (8 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Resilience concepts: robustness, redundancy, resourcefulness, rapid recovery • Hazard identification and probabilistic risk assessment • Multi-hazard design approaches and trade-offs • Climate change projections and their translation into design parameters • Structural resilience: performance-based design and damage-control technologies • System-of-systems resilience for interconnected infrastructure networks • Adaptive capacity and flexible design for uncertain futures • Community resilience and social dimensions of infrastructure recovery • Financing resilience: benefit-cost analysis and innovative funding mechanisms	• Describe the four key properties (4Rs) of a resilient system [Familiarity] • Perform a qualitative risk assessment for a site exposed to multiple natural hazards [Assessment] • Incorporate projected sea-level rise or increased precipitation into the design basis for a coastal or drainage structure [Usage] • Explain how base isolation or damping devices enhance structural resilience [Familiarity] • Analyze the cascading failures in interconnected water and power networks after an earthquake [Assessment] • Design a flexible foundation system that can be adapted for future increased loads [Usage] • Evaluate the role of social capital and community preparedness in post-disaster recovery [Assessment] • Conduct a benefit-cost analysis for a proposed infrastructure resilience upgrade [Usage]
Readings : [ASCE2018]	

Unit 11: Engineering Ethics and Professional Responsibility (4 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Ethical theories: utilitarianism, duty ethics, virtue ethics • Professional codes of conduct (e.g., ASCE, NSPE) and their fundamental canons • Engineer's paramount responsibility to public safety, health, and welfare • Ethical dilemmas in practice: conflicts of interest, whistleblowing, gift-giving • Ethical decision-making frameworks and case study analysis • Global engineering ethics and cross-cultural challenges • Ethical obligations for sustainable development and environmental stewardship • Ethical implications of emerging technologies (AI, automation, data privacy) • Ethical conduct in dispute resolution and litigation	• Explain the primary tenets of the engineer's code of ethics [Familiarity] • Apply an ethical decision-making framework to a hypothetical engineering scenario [Assessment] • Identify conflicts of interest and other common ethical pitfalls in project work [Familiarity] • Analyze a historical engineering failure case from an ethical perspective [Assessment] • Evaluate the ethical dimensions of a project with significant social or environmental impacts in a different cultural context [Assessment] • Articulate the ethical argument for incorporating sustainability into all engineering work [Familiarity] • Discuss the ethical responsibilities related to data collection and use in smart infrastructure projects [Assessment] • Describe the role of ethics in alternative dispute resolution processes [Familiarity]
Readings : [Harris2019]	

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