



National University of Engineering (UNI)

School of Civil Engineering
Syllabus 2026-II

1. COURSE

CE3G7. Professional Competencies Workshop - Geotechnical (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3G7. Professional Competencies Workshop - Geotechnical
2.2 Semester	: 10 th Semester.
2.3 Credits	: 3
2.4 Hours	:
2.5 Duration of the period	: 16 weeks
2.6 Type of course	: Mandatory
2.7 Learning modality	: Face to face
2.8 Prerequisites	: CE3G3. Applied Geology. (9 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Professional Competencies Workshop is the capstone/synthesis course of the Geotechnical Engineering specialization track. It integrates, around real project scenarios, the shear-strength and stress-distribution framework and the site investigation and in-situ testing techniques developed earlier in the track with the four principal design domains of geotechnical practice: slope stability and landslide mitigation, geotechnical earthquake engineering and liquefaction, shallow and deep foundation design, earth retaining systems, ground improvement and geosynthetics engineering, and the geotechnical design of earth and rockfill dams – including dam typology selection and the geotechnical characterization of foundation and borrow materials that supports that design. Rather than introducing new content, the workshop revisits and applies, at a professional level of integration, the knowledge units developed throughout the specialization's preceding courses.

5. GOALS

- Plan and interpret geotechnical site investigation programs and apply shear strength and stress distribution principles to characterize project sites.
- Analyze slope stability and design landslide mitigation and stabilization measures.
- Evaluate seismic hazards and liquefaction potential and design mitigation measures for geotechnical earthquake engineering problems.
- Design shallow and deep foundations and earth retaining systems for representative structures.
- Select and design ground improvement and geosynthetic solutions for problematic ground conditions.
- Select an embankment dam typology and apply geotechnical characterization and design methods to size an earth or rockfill dam.

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: Site Investigation and In-Situ Testing (9 hours)	
Competences Expected: ABET-6	
Topics	Learning Outcomes
• Investigation planning and scope determination • Boring methods and subsurface exploration techniques • Sampling methods for disturbed and undisturbed samples • Standard Penetration Test and correlations • Laboratory testing program and test selection • Cone Penetration Test and piezocone testing • Vane shear test and pressuremeter testing • Geophysical methods including seismic and resistivity surveys • Groundwater monitoring and piezometer installation • Report preparation and geotechnical data presentation • In-situ permeability (Lugeon/packer) testing for foundation grouting and seepage assessment • Borrow area investigation for embankment fill material quantity and quality	• Develop appropriate site investigation programs based on project requirements [Assessment] • Select appropriate boring and exploration methods for different soil conditions [Familiarity] • Specify sampling techniques to obtain quality samples for testing [Usage] • Interpret SPT data and apply empirical correlations for design parameters [Assessment] • Design laboratory testing programs for geotechnical projects [Usage] • Analyze CPT and piezocone data for soil profiling and parameter evaluation [Assessment] • Apply vane shear and pressuremeter tests for soft clay characterization [Usage] • Utilize geophysical methods to complement traditional investigation techniques [Assessment] • Monitor groundwater conditions and interpret piezometric data [Usage] • Prepare comprehensive geotechnical investigation reports [Assessment] • Perform packer (Lugeon) testing and interpret results for foundation grouting curtain design [Usage] • Characterize borrow areas for embankment fill material quantity and quality [Assessment]
Readings : [Das19]	

Unit 2: Shear Strength and Consolidation (6 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Shear strength of soils and Mohr-Coulomb failure criterion • Direct shear and triaxial testing methods • Drained and undrained shear strength behavior • Consolidation theory and settlement analysis • Time-rate of consolidation and degree of consolidation • Stress distribution in soil masses using elastic theory • Critical state soil mechanics concepts • Residual shear strength and sensitivity of clays • Secondary compression and creep behavior • Anisotropy and stress path effects on soil behavior	• Apply Mohr-Coulomb criterion to determine shear strength parameters [Familiarity] • Interpret direct shear and triaxial test results [Assessment] • Distinguish between drained and undrained loading conditions [Usage] • Calculate consolidation settlement using one-dimensional theory [Assessment] • Predict time-rate of settlement for consolidating soils [Usage] • Compute stress distribution beneath loaded areas using Boussinesq theory [Assessment] • Explain critical state concepts and their application to soil behavior [Familiarity] • Evaluate residual strength and sensitivity for slope stability problems [Assessment] • Estimate secondary compression for highly plastic soils [Usage] • Analyze the effects of stress paths and anisotropy on soil response [Familiarity]
Readings : [Das19]	

Unit 3: Slope Stability Analysis and Stabilization (12 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	Learning Outcomes
• Infinite slope analysis for simple geometries • Method of slices and limit equilibrium analysis • Circular and non-circular failure surfaces • Factor of safety determination and acceptance criteria • Stability charts and simplified methods • Landslide types and failure mechanisms • Seismic slope stability and pseudo-static analysis • Stabilization methods including drainage and reinforcement • Monitoring systems and early warning for unstable slopes • Probabilistic slope stability analysis	• Perform infinite slope stability analysis for uniform slopes [Assessment] • Apply method of slices to analyze slope stability [Usage] • Analyze slopes with circular and non-circular failure surfaces [Assessment] • Calculate factors of safety and interpret results [Usage] • Use stability charts for rapid slope evaluation [Assessment] • Identify landslide types and their characteristic features [Familiarity] • Evaluate seismic stability using pseudo-static methods [Usage] • Design slope stabilization measures for specific failure modes [Assessment] • Implement monitoring systems for potentially unstable slopes [Usage] • Conduct probabilistic stability analysis considering parameter uncertainty [Assessment]
Readings : [DWB14]	

Unit 4: Geotechnical Earthquake Engineering (15 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	Learning Outcomes
• Single-degree-of-freedom dynamic systems and one-dimensional wave propagation through soil deposits • Site response and ground motion amplification • Seismic hazard analysis and design ground motions • Liquefaction susceptibility and triggering mechanisms • Cyclic stress ratio and liquefaction evaluation procedures • Effects of liquefaction on structures and infrastructure • Dynamic soil properties and laboratory testing • Design of foundations for vibrating machinery under dynamic loading • Ground improvement methods for liquefaction mitigation • Lateral spreading and flow failures • Seismically induced settlement and bearing capacity • Performance-based design for geotechnical earthquake engineering	• Formulate single-degree-of-freedom models and one-dimensional wave-propagation equations to characterize seismic wave transmission through soil deposits [Usage] • Explain site response effects and ground motion characteristics [Familiarity] • Determine design ground motions for geotechnical seismic analysis [Assessment] • Evaluate liquefaction susceptibility using field investigation data [Usage] • Calculate cyclic stress ratios and assess liquefaction potential [Assessment] • Assess the consequences of liquefaction on foundations and structures [Familiarity] • Characterize dynamic soil properties from laboratory and field tests [Usage] • Proportion machine foundations considering dynamic soil-foundation stiffness, resonance avoidance, and permissible vibration amplitudes [Assessment] • Select and design ground improvement methods to mitigate liquefaction [Assessment] • Predict lateral spreading displacements and flow failure potential [Usage] • Analyze seismically induced settlement and reduced bearing capacity [Assessment] • Implement performance-based approaches for seismic geotechnical design [Assessment]
Readings : [Kra96], [Das19]	

Unit 5: Bearing Capacity and Design (9 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Bearing capacity theory and failure mechanisms • Ultimate bearing capacity equations for various conditions • Settlement analysis using elastic and consolidation methods • Isolated spread footing design • Combined footings and strap footings • Allowable bearing pressure and factor of safety selection • Mat foundation analysis and design • Eccentric and inclined loading effects • Soil-structure interaction effects • Differential settlement and tolerable limits • Continuous (strip) footing design for basement and foundation walls	• Explain bearing capacity failure mechanisms in shallow foundations [Familiarity] • Calculate ultimate bearing capacity using Terzaghi and Meyerhof equations [Assessment] • Predict total and differential settlements for shallow foundations [Usage] • Design isolated spread footings for gravity loads [Assessment] • Proportion combined and strap footings for column arrangements [Usage] • Determine allowable bearing pressures based on strength and settlement criteria [Assessment] • Analyze mat foundations using conventional and finite element methods [Assessment] • Evaluate bearing capacity under eccentric and inclined loading [Usage] • Consider soil-structure interaction in foundation design [Familiarity] • Assess differential settlement and apply tolerable settlement criteria [Assessment] • Design continuous strip footings for basement and foundation walls [Usage]
Readings : [Cod01], [Das19]	

Unit 6: Ground Improvement Techniques (6 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Compaction methods including dynamic and vibratory techniques • Stone columns and vibro-replacement methods • Preloading and vertical drains for soft ground treatment • Deep mixing and jet grouting techniques • Chemical stabilization and grouting methods	• Select appropriate ground improvement methods for specific soil conditions [Familiarity] • Design stone column systems for settlement reduction [Assessment] • Calculate consolidation time reduction using vertical drains [Usage] • Identify geosynthetic types and their engineering applications [Familiarity] • Proportion reinforcement for mechanically stabilized earth structures [Assessment]
Readings : [Koe12], [Das19]	

Unit 7: Deep Foundations (5 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Pile types and installation methods • Axial capacity of single piles in cohesive and cohesionless soils • Lateral load capacity and p-y method • Pile group behavior and group efficiency • Drilled shaft design and construction considerations • Negative skin friction and downdrag forces	• Select appropriate pile types based on soil conditions and loading [Familiarity] • Calculate axial capacity of piles using static methods [Assessment] • Analyze laterally loaded piles using p-y curves [Usage] • Evaluate pile group capacity and settlement [Assessment] • Design drilled shaft foundations including shaft diameter and reinforcement [Usage] • Interpret pile load test results and verify design assumptions [Assessment]
Readings : [Cod01], [Das19]	

Unit 8: Earth Retaining Systems (4 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Earth pressure theory including active and passive pressures • Retaining wall types and selection criteria • Load testing methods including static and dynamic tests • Anchored walls and tied-back systems • Mechanically stabilized earth walls and reinforced soil systems • Basement and foundation wall design considering top-of-wall restraint conditions • Counterfort and buttressed retaining wall design	• Apply lateral earth pressure theories for retaining wall design [Assessment] • Design gravity and cantilever retaining walls [Usage] • Design anchored wall systems including ground anchor capacity [Assessment] • Proportion mechanically stabilized earth walls and select reinforcement [Usage] • Design basement and foundation walls considering top restraint, surcharge, and hydrostatic loads [Assessment] • Design counterfort retaining walls including stem, heel, toe, and counterfort elements [Usage]
Readings : [Das19], [Cod01]	

Unit 9: Earth Dams (4 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Definition, function, and role of earth dams within water resources infrastructure • Typology of embankment dams: homogeneous and zoned earthfill/rockfill dams, and selection criteria • Dam zoning: core, shell, filters, drains, and transition zones • Site selection factors and reservoir/dam-site feasibility considerations	• Explain the function of earth dams and their role within water resources infrastructure [Familiarity] • Classify embankment dams by type and select an appropriate typology for given site and material conditions [Assessment] • Describe the zoning of an earth dam and the function of each zone (core, shell, filters, drains) [Familiarity] • Evaluate site selection factors governing dam type and location choice [Usage]
Readings : [Fel+15], [US 87]	

Unit 10: Geotechnical Characterization for Earth Dams (5 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Foundation geotechnical characterization: rock and soil foundation conditions for embankment dams • Characterization of borrow materials for core, shell, and filter zones • Compaction and shear strength properties of compacted fill materials • Permeability characterization of foundation and embankment materials • Dispersive soil identification and erodibility assessment for core materials	• Characterize foundation soil and rock conditions relevant to embankment dam design [Assessment] • Evaluate borrow material sources for suitability as core, shell, or filter material [Usage] • Determine compaction and shear strength properties of compacted embankment materials [Assessment] • Assess dispersive soil potential and erodibility of candidate core materials [Usage]
Readings : [Fel+15], [US 87]	

Unit 11: Geotechnical Design of Embankment Dams (9 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	Learning Outcomes
• Seepage analysis through the embankment and foundation using flow nets and numerical methods • Seepage control measures: core design, cutoff walls, and grout curtains • Filter and drain design criteria to prevent internal erosion and piping • Slope stability analysis of upstream and downstream dam faces under static and rapid drawdown conditions • Seismic design considerations and deformation analysis for embankment dams • Freeboard determination and settlement/camber allowance in embankment design	• Analyze seepage through the embankment and foundation using flow nets or numerical seepage models [Assessment] • Design seepage control measures including impervious cores, cutoff walls, and grout curtains [Usage] • Design filter and drain zones according to piping and internal erosion criteria [Assessment] • Evaluate slope stability of dam faces under steady-state seepage, rapid drawdown, and end-of-construction conditions [Usage] • Incorporate seismic loading and deformation analysis into embankment dam design [Assessment] • Determine freeboard and settlement allowances for embankment design [Usage]
Readings : [Fel+15], [She+63], [US 03]	

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

- [She+63] James L. Sherard et al. *Earth and Earth-Rock Dams: Engineering Problems of Design and Construction*. John Wiley & Sons, 1963.
- [US 87] U.S. Bureau of Reclamation. *Design of Small Dams*. Tech. rep. U.S. Government Printing Office, 1987.
- [Kra96] Steven L. Kramer. *Geotechnical Earthquake Engineering*. Prentice Hall, 1996.
- [Cod01] Donald P. Coduto. *Foundation Design: Principles and Practices*. 2nd. Prentice Hall, 2001.
- [US 03] U.S. Army Corps of Engineers. *Engineering and Design: Slope Stability*. Tech. rep. EM 1110-2-1902. U.S. Army Corps of Engineers, 2003.
- [Koe12] Robert M. Koerner. *Designing with Geosynthetics*. 6th. Xlibris Corporation, 2012.
- [DWB14] J. Michael Duncan, Stephen G. Wright, and Thomas L. Brandon. *Soil Strength and Slope Stability*. 2nd. John Wiley & Sons, 2014.
- [Fel+15] Robin Fell et al. *Geotechnical Engineering of Dams*. 2nd. CRC Press, 2015.
- [Das19] Braja M. Das. *Principles of Geotechnical Engineering*. 9th. Cengage Learning, 2019.