



National University of Engineering (UNI)

School of Civil Engineering

Syllabus 2027-I

1. COURSE

CE3G1. Soil Dynamics (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE3G1. Soil Dynamics
2.2 Semester	: 8 th Semester.
2.3 Credits	: 3
2.4 Hours	: 3 HT;
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. (7 th Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Soil Dynamics is an advanced elective of the Geotechnical Engineering track that extends the static shear-strength and deformation framework developed in Soil Mechanics II into the time-varying loading regime relevant to earthquakes and vibrating machinery. The course begins with the theoretical foundations of single-degree-of-freedom dynamic systems and one-dimensional wave propagation through soil deposits, then develops the tools needed to characterize seismicity, process strong-motion signals, and determine the dynamic properties of soils from laboratory and field testing. This foundation supports the analysis of seismic site response and the seismic stability of slopes, retaining structures, and foundations, and is applied to two design problems of markedly different scale: the design of foundations for vibrating machinery under steady-state dynamic loads, and the assessment, mitigation, and post-earthquake analysis of soil liquefaction, including the residual strength of liquefied soils. As a specialization elective following Soil Mechanics I and II, the course prepares students to perform the seismic geotechnical analyses required in professional practice in a seismically active country.

5. GOALS

- Formulate single-degree-of-freedom dynamic models and one-dimensional wave-propagation equations to characterize how seismic waves travel through soil deposits.
- Characterize regional seismicity, classify earthquakes by their expected consequences, and process strong-motion signals for use in geotechnical seismic analysis.
- Determine the dynamic properties of soils from laboratory and field testing for use in seismic response and liquefaction analyses.
- Perform seismic site response analysis to estimate ground motion amplification and design ground motions.
- Analyze the seismic stability of slopes, retaining structures, and foundations using pseudo-static and performance-based methods.
- Design foundations for vibrating machinery considering dynamic soil-foundation stiffness, resonance avoidance, and permissible vibration amplitudes.
- Evaluate liquefaction susceptibility and triggering, assess its effects on structures and infrastructure, and select mitigation measures including ground improvement.
- Evaluate the residual strength of liquefied soils and perform post-earthquake stability 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: Geotechnical Earthquake Engineering (42 hours)	
Competences Expected: ABET-1,ABET-2,ABET-6	
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 : [Kramer1996], [Das1983SoilDynamics], [Prakash1981]	

Unit 2: Slope Stability Analysis and Stabilization (6 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 : [DuncanWright2014]	

Unit 3: 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 : [Koerner2012], [Das2019]	

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