

Western University
Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9702 – Geotechnical Earthquake Engineering

COURSE OUTLINE 2023-2024

DESCRIPTION

This course develops understanding of the concepts, theories and procedures of geotechnical earthquake engineering. The students will learn to analyze the ground response during earthquake, assess the liquefaction potential and seismic stability of slopes and retaining walls.

ENROLLMENT RESTRICTIONS

Enrollment in this course is restricted to graduate students in civil and environmental engineering, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

INSTRUCTOR CONTACT INFORMATION

Course instructor: Kareem Embaby, Ph.D., P.Eng.

Email address: Kembaby@uwo.ca

Office: TBD

Office hours: Weekly office hours (TBD) are held via zoom.

COURSE FORMAT

The course will be delivered in-person.

TOPICS

Topic #	Description	Learning Activities	Tentative timeline
1	Introduction		
Introduction	1.1. Seismology and earthquakes 1.2. Seismic waves 1.3. Size of earthquake 1.4. Ground motion parameters	<ul style="list-style-type: none">One Lecture (In-person)	Week 1
2	Wave Propagation		
Wave Propagation	2.1. One dimensional wave propagation 2.2. Multi-dimensional wave propagation 2.3. Surface and multi-layered soil wave systems	<ul style="list-style-type: none">One Lecture (In-person)	Weeks 2
3	Dynamic Soil Properties		
3.1. Field Tests	3.1.1. Seismic refraction 3.1.2. Continuous surface wave test 3.1.3. Spectral analysis of surface waves	<ul style="list-style-type: none">Two Lectures (In-person)	Weeks 3-4

Topic #	Description	Learning Activities	Tentative timeline
	3.1.4. Multichannel analysis of surface waves 3.1.5. Seismic downhole test (and SCPT) 3.1.6. Seismic cross-hole test (SCHT)		
3.2. Laboratory Tests	3.2.1. Resonant column test 3.2.2. Bender element test 3.2.3. Cyclic triaxial test 3.2.4. Shear box test		
3.3. Cyclic stress-strain behavior	3.3.1. Constitutive models 3.3.2. Equivalent linear analysis		
4	Ground Response Analysis		
Ground Response Analysis	4.1. Objectives of site response analysis 4.2. Types of site response analysis 4.2.1. One-dimensional analysis 4.2.2. Two-dimensional analysis 4.2.3. Dynamic finite element analysis 4.2.4. dynamic soil-structure interaction	<ul style="list-style-type: none"> Two Lectures (In-person) 	Weeks 5-6
	Reading Week (no lectures)		
5	Liquefaction		
5.1. Introduction	5.1.1. Liquefaction case histories 5.1.2. liquefaction process/factors 5.1.3. Effects on built environment	<ul style="list-style-type: none"> Two Lectures (In-person) 	Weeks 7-8
5.2. Liquefaction assessment	5.2.1. Cyclic stress approach 5.2.2. Cyclic strain approach 5.2.3. Liquefaction resistance		
5.3. Post liquefaction	5.3.1. Residual strength 5.3.2. Liquefaction settlement 5.3.3. Lateral spreading		
5.4. Mitigation	5.4.1. Foundation options 5.4.2. Ground improvement		
6	Seismic Slope Stability		
6.1. Introduction	6.1.1. Introduction 6.1.2. Basic Mechanism of seismic effects 6.1.3. Evaluation of seismic slope stability	<ul style="list-style-type: none"> Two Lectures (In-person) 	Weeks 9-10
6.2. Static Slope Stability	6.2.1. Limit equilibrium analysis 6.2.2. Stress-deformation analysis		
6.3. Seismic	6.3.1. Analysis of inertial instability 6.3.1.1. Pseudo static approach		

Topic #	Description	Learning Activities	Tentative timeline
Slope Stability	6.3.1.2. Homogeneous wedge approach 6.3.1.3. Newmark sliding block analysis 6.3.1.4. Probabilistic Newmark analysis 6.3.2. Analysis of weakening instability 6.3.2.1. Analysis of stability 6.3.2.2. Analysis of deformations 6.3.3. Finite element analysis stability		
7	Seismic Design of Retaining Walls		
7.1. Introduction	7.1.1. Dynamic response of retaining walls	<ul style="list-style-type: none"> Two Lectures (In-person) 	Weeks 11-12
7.2. Seismic Earth Pressure	7.2.1. Mononobe -Okabe Method 7.2.2. Effect of water on wall pressure 7.2.3. Seismic pressures on basement walls		
7.3. Seismic Displacement	7.3.1. Richard-Elms/deterministic method 7.3.2. Wu-Prakash/deterministic method 7.3.3. Whitman-Liao/statistical method		
7.4. Seismic Design	7.4.1. Design based on seismic pressures 7.4.2. Performance-based design 7.4.3. Design of mechanically stabilized earth (MSE) walls		

SPECIFIC LEARNING OUTCOMES

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	15%	<ul style="list-style-type: none"> Assignments Project 	<ul style="list-style-type: none"> Understanding of advanced concepts and theories Awareness of important current problems in the field of study Understanding of computational and/or empirical methodologies to solve related problems
Research & scholarship	20%	<ul style="list-style-type: none"> Assignments Project 	<ul style="list-style-type: none"> Ability to conduct critical evaluation of current advancements in the field of specialization Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	30%	<ul style="list-style-type: none"> Assignments Project 	<ul style="list-style-type: none"> Ability to apply knowledge in a rational way to analyze a particular problem Ability to use coherent approach to design a particular engineering system using existing design tools

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Professional capacity / autonomy	10%	<ul style="list-style-type: none"> • Assignments • Project 	<ul style="list-style-type: none"> • Awareness of academic integrity • Ability to implement established procedures and practices in the coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	15%	<ul style="list-style-type: none"> • Project 	<ul style="list-style-type: none"> • Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively
Awareness of limits of knowledge	10%	<ul style="list-style-type: none"> • Project 	<ul style="list-style-type: none"> • Awareness of the need of assumptions in complex scientific analyses and their consequences • Understanding of the difference between theoretical and empirical approaches • Ability to acknowledge analytical limitation due to complexity of practical problems

ASSESSMENTS

Assessment Type	Material Covered	Tentative Due Date	Weight
Homework Assignments (Five)	Topic 3 – 7		40%
Term tests (two)	Topics 3-4 and topics 5-7		20%
Participation in class activities			10%
Project 1: Design Project	Topic 3 – 7		20%
Project 2: Presentation			10%

Activities in which collaboration is permitted:

- Analysis/calculations of assignments and project

Activities in which students must work alone (collaboration is not permitted):

- Writing reports of assignments and projects

CHEATING, PLAGIARISM/ACADEMIC OFFENCES

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy,

specifically, the definition of what constitutes a Scholastic Offence at the following website: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

CONDUCT

Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

HEALTH/WELLNESS SERVICES

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at <http://www.health.uwo.ca/>.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Faculty of Engineering has a Student Wellness Counsellor. Information on how to schedule an appointment with the counsellor is available at: <https://www.eng.uwo.ca/undergraduate/academic-support-and-accommodations/Student-Wellness-Counselling.html>

Students who are in emotional/mental distress should refer to Mental Health@Western: <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

SICKNESS

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Students who are not able to meet certain academic responsibilities due to medical, compassionate or other legitimate reason(s), could request for academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at:

<https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.html>

ACCESSIBLE EDUCATION WESTERN (AEW)

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.