

Western University - Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 4424b – Earth Structures Engineering
Course Outline 2023/24

Introduction:

This course has been developed to provide knowledge and understanding of the geotechnical, geological, and hydrological principles involved in the solution of earth structures engineering problems. Based on their knowledge of soil mechanics and geology, students will be introduced to the analysis, design and construction of slopes, dams and other structures made from soil and rocks.

The topics covered in this course include:

- Geotechnical site investigation
- Embankments and tunnels in soft ground
- Slopes, excavations and cuttings
- Earth dams

By the end of this course, students will be able to analyze laboratory and field tests data, to identify the appropriate analytical and design approaches for a range of earth structures, to recognize the complexities of construction materials, construction techniques and quality control, and to understand the methods available for the remediation and monitoring of geotechnical structures. Design problems and assignments will enable students to improve their problem-solving and communication skills, whilst working individually and in groups. Through studying and analyzing the outcomes of engineering cases, students will also be exposed to the complex and multidisciplinary challenges facing civil engineers. Where relevant, the students will use industry standard software packages in their designs.

Calendar Copy:

This course is intended to be a comprehensive introduction to the design of slopes, dams and other structures made from soil and rock materials. The material will cover the theory and analysis of a range of geotechnical problems involving natural slopes, cuttings, embankments, dams and waste facilities.

Pre-requisites: CEE3322a/b.

Anti-requisites: None.

Note: It is the **student's responsibility** to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the student's responsibility to ensure that they have not taken a course listed as an Anti-requisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Anti-requisite conditions.

Contact Hours:

- 3 lecture hours/week (Mon and Tue).

Lectures will be delivered in class.

- 2 tutorial/design/case hours/week (Wed).

Tutorial/design/case sessions will be delivered in class. Tutorials are optional, but students seeking assistance with weekly assignments or clarification on lecture material are strongly encouraged to attend. The three design sessions and two case studies are mandatory.

Contingency plan for an in-person class pivoting to 100% online learning

In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, affected course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online as determined by the course instructor.

Instructor:

Dr. Tim Newson, SEB 3084, tnewson2@uwo.ca

Office hours: *To be discussed in class.*

Admin Support: Sandra McKay (smckay@uwo.ca), SEB 3005.

Teaching Assistants:

Pablo Barbieri - pbarbie2@uwo.ca

Behnoush Sedighian - bhonarva@uwo.ca

Burak Ozturk - bozturk2@uwo.ca

Textbook:

Prepared class notes should be brought to each class and may be downloaded from the course website (OWL).

Other References:

The following books form a useful additional source of reference materials:

- Mitchell, R. (1983). *Earth Structures Engineering*. Springer (ISBN 9789401160018). p. 266.
- Clayton, C., Matthews, M. and Simons, N. (1995). *Site Investigation*. Wiley-Blackwell (ISBN 9780632029082). p. 592.
- Whitlow, R. (2000). *Basic Soil Mechanics*. Pearson International (ISBN 9780582381094). p. 592.
- Almeida, M. and Marques, M. (2013). *Design and Performance of Embankments on Very Soft Soils*. CRC Press (ISBN 9781138076938). p. 228.
- Atkinson, J. (2007). *The Mechanics of Soils and Foundations*. CRC Press (ISBN 9780415362566). p. 480.
- Fell, R., MacGregor, P., Stapledon, D., Bell, G. and Foster, M. (2015). *Geotechnical Engineering of Dams*. CRC Press (ISBN 9781138749344). p. 1382.

Laboratory:

None.

Units:

SI units will be used in teaching, assignments, design project, tutorials, cases and final exam.

Specific Learning Objectives [GA Indicator – **bold** denotes evaluated indicator]:

- 1) Geotechnical Site Investigation. At the end of this section and after completion of the Design Project the student should be able to:
 - a) correctly use relevant terminology and understand the purpose of geotechnical site investigations [KB4]
 - b) understand the planning of site investigations, identify the various phases of the investigation process and understand the relationships between the key components of each phase [**I1**]
 - c) understand the links between the site materials, the proposed structure, the sampling process and the geotechnical testing for the best design outcomes [D1]
 - d) understand and interpret advanced *in-situ* geotechnical site investigation tests (shear vane, cone penetrometer, pressuremeter and plate load test)
 - e) describe the various geophysical tests available and their ability to characterize soil volumes [KB4].
- 2) Embankments and Tunnels in Soft Ground. At the end of this section and after completion of the Design Project the student should be able to:
 - a) describe the different forms and methods of embankment and tunnel construction [KB4]
 - b) understand the stress changes that occur in the surrounding ground due to their construction and the influence of water in their design [KB4]
 - c) analyze the stability, settlement and consolidation of embankments [PA1, PA2, D1, D4]
 - d) analyze surface ground movements due to tunnel construction [PA1, PA2]
 - e) describe remedial and ground improvement techniques for embankment construction [D4]
 - f) describe the use of staged construction, monitoring and the observational method for embankments [KB4].
- 3) Slopes, Excavations and Cuttings. At the end of this section the student should be able to:
 - a) describe the key slope failure mechanisms for natural and man-made slopes and excavations [KB4]
 - b) analyze the stability of sloping earth surfaces using both analytical and graphical methods [**ET1, ET2**]
 - c) understand the effects of crest loadings, dynamic loadings, submergence and drawdown processes on the stability of slopes [KB4]
 - d) recommend appropriate factors of safety and construction procedures for various different scenarios [PA2]
 - e) analyze the stability of excavations and cuttings using analytical and graphical methods [**I3, ET2**]
 - f) describe appropriate remediation and monitoring methods for unstable slopes and excavations [D4].
- 4) Earth Dams. At the end of this section the student should be able to:
 - a) describe the different types of earth dam structure [KB4]
 - b) understand the major design considerations used in the construction of earth dams (including core and filter design) [D2]
 - c) describe foundation treatments available for the most efficient dam designs [KB4]

- d) analyze the stability, settlement/distortion and seepage behaviour of large earth dams and structures [ET1, ET2]
- e) describe the risks associated with rapid drawdown and earthquakes for dams [KB4]
- f) understand the construction of earth dams, their monitoring, performance and maintenance [PA2].

The instructor may expand or revise material presented in the course as appropriate.

General Learning Objectives:

E=Evaluate, T=Teach, I=Introduce; (I) = Introduction, (D) = Developing, (A) = Advanced level

Knowledge Base	T	Engineering Tools	E	Impact on Society	
Problem Analysis	T	Teamwork	T	Ethics and Equity	
Investigation	E(A)	Communication	I	Economics and Project Management	
Design	T	Professionalism	I	Life-Long Learning	I

Evaluation:

The final course mark will be determined as follows:

Design assignments	15%
Case studies	15%
Design project	30%
Final examination	40%
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Total	100%

1. The mark for the *design project* shall be multiplied by the number of group members and the product allocated to the members in proportion to each member's contribution to the work. At the end of the course, group members must individually recommend (in the appropriate form), a suitable allocation to be used. A summary of the work done by each member (with reference to the three design project reports) must be attached to the final report submission.
2. Criteria for the various coursework submissions are described below.
3. The penalty for late submission of coursework shall be 10% per day; thus, if any submission is more than 5 days late it cannot receive a passing grade.
4. Students must pass the *final examination* to pass this course. Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less.
5. Students who have failed this course previously must repeat all components of the course. No special permissions will be granted enabling a student to retain design project, assignment or test marks from previous years. Previously completed assignments and design project reports cannot be resubmitted.

1. Examination:

A three-hour closed book final examination will be held during the regular examination period. Only approved programmable calculators are permitted in the final exam. Students should consult the list of approved calculators outside the Departmental Office. To get approval to use a calculator not on the list you must consult with Dr. Newson at least three weeks prior to the quiz/exam where you wish to use the calculator.

2. Design assignments:

Two *individual* design calculation assignments will be completed during the course. Each assignment must

be submitted prior to the due date to OWL. Late assignments will be assessed a penalty of 10% per day, to a maximum of 3 days, after which they will receive a mark of zero.

3. Case studies:

Two *group* case assignments will be completed during the course. This requires written analysis of the case material prior to the class. The cases will be presented by practicing engineers who are experts in geotechnical engineering. Each assignment must be turned in to OWL by the group at the beginning of the case class. Group membership will be assigned by the instructor. Late assignments will be assessed a penalty of 10% per day, to a maximum of 3 days, after which they will receive a mark of zero.

4. Design Project:

The design project is a major component of the coursework. Students will tackle a design problem in groups that will be assigned by the instructor. The design project involves a site that has previously been considered for construction of a geotechnical structure. This assignment is in three parts: 1) *Planning and costing a suitable site investigation*, 2) *Interpreting the available site investigation and in-situ/laboratory data, and conducting an analysis on an embankment, slope or dam*, 3) *Producing an alternative design and interpretive geotechnical report with recommendations*. The submission should be sufficiently detailed such that it could be presented to a client for review and approval of the project. Your submission should clearly indicate the name of the individual who undertook prime responsibility for each aspect of the work and the name of the individual who reviewed that aspect of the work. All hand calculations are to be on squared paper and must be organized and presented in a neat, clear and professional manner. All pages of calculations must have the date, initials of the originator and initials of the checking engineer. All calculations are to be checked. All drawings are to be of professional quality with the name of originator and checking individual shown.

5. Use of English:

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Accommodation and Accessibility:

Accommodation Policies

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at:

[https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Accommodation_disabilities.pdf).

Conduct

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Please turn off your cell phone before coming to a class, tutorial, quiz or exam. On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: <http://www.uwo.ca/univsec/board/code.pdf>

Sickness and Other Problems

If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below.

Academic Consideration for Absences

Students should immediately consult with the instructor if they have any problems that could affect their performance in the course. The student should seek advice from the instructor regarding how best to deal with the problem. Failure to notify the instructor (or as soon as possible thereafter) will have a negative effect on any appeal. Please visit for information on how to submit a request for Academic Consideration:

<https://www.eng.uwo.ca/undergraduate/academic-consideration-for-absences.html>

The mechanism employed to handle the absence (e.g., an extension, make-up opportunity, or reweighting) will be decided by the instructor and will be applied on case-by-case basis.

Absences from Final Examinations

If you miss the Final Exam, please contact Western Engineering Undergraduate Services as soon as possible. They will assess your eligibility to write the Special Examination. You may also be eligible to write the Special Exam if you are in a “Multiple Exam Situation” (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period). If a student fails to write a scheduled Special Examination, the date of the next Special Examination (if granted) normally will be the scheduled date for the final exam the next time this course is offered. The maximum course load for that term will be reduced by the credit of the course(s) for which the final examination has been deferred. See the Academic Calendar for details (under [Special Examinations](#)).

Masking Guidelines

Students may be expected to wear triple layer, non-medical, paper masks at all times in the classroom as per University policy and public health directives. Students who are unable to wear a mask must seek formal accommodation through Western Accessible Education, and present medical documentation. Students are not permitted to eat or drink while in class to ensure masks stay in place. Students will be able to eat and drink outside of the classroom during scheduled breaks. *Students unwilling to wear a mask as stipulated by Western policy and public health directives will be referred to the Dean, and such actions will be considered a violation of the student Code of Conduct.*

Academic Policies

The website for Registrar Services is <http://www.registrar.uwo.ca>.

In accordance with policy,

https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf

the centrally administered e-mail account provided to students will be considered the individual’s official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at their official university address is attended to in a timely manner.

Scholastic offences are taken seriously, and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

Support Services:

Please visit the Western Engineering Undergraduate Services webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: <https://www.eng.uwo.ca/undergraduate/index.html>

Students who are in emotional/mental distress should refer to Mental Health@Western (<https://uwo.ca/health/>) for a complete list of options about how to obtain help.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts at

https://www.uwo.ca/health/student_support/survivor_support/get-help.html.

To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at:

http://academicsupport.uwo.ca/accessible_education/index.html

if you have any questions regarding accommodations.

Learning-skills counsellors at the Student Development Centre (<https://learning.uwo.ca>) are ready to help you improve your learning skills. They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Additional student-run support services are offered by the USC, <https://westernusc.ca/services/>.

Consultation:

Students are encouraged to discuss problems with their teaching assistant and/or the instructor in tutorial sessions. Office hours (online) will be arranged for the students to meet with the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the instructor.

Course breakdown:

Engineering Science = 50% = 23 AU's; Engineering Design= 50% = 23 AU's.

The attached document “INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED” is part of this course outline.