CVEN4202

Advanced Topics in Geotechnical Engineering

Term 2, 2023

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Asal Bidarmaghz	a.bidarmaghz@unsw.edu.au	Email to make an appointment	Civil Engineering Building (H20) Level 5, Room CE502	+61430755 050

Lecturers

Name	Email	Availability	Location	Phone
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School Contact Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Course Details

Units of Credit 6

Summary of the Course

Topic 1: *Understand the concept and applications of ground energy systems. To gain insights into designs and evaluations of these systems via hand calculations and computational modelling.*

Topic 2: *Understand the basic principles of critical state soil mechanics and soil plasticity,and use elastic-plastic constitutive models to simulate soil stress-strain behaviour.*

Course Aims

This course will be delivered in two parts. Part one (weeks 1-5) is focused on ground energy and ground source heat pump systems, common design parameters and approaches and available analytical solutions to understand the concept of geothermal systems. To better understand the physics and governing equations involved in ground energy systems the interactions between the systems and the surrounding ground, the educational finite element software COMSOL will be used to computationally model different cases of ground energy systems.

The second part of the course (weeks 7-10) is mainly on understanding the basic principles of critical state soil mechanics and soil plasticity, and use elastic-plastic constitutive models to simulate soil stress-strain behaviour. To use elastic-plastic soil models, to solve geotechnical engineering problems.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Understand the concept and applications of ground energy systems. To gain insights into designs and evaluations of these systems via hand calculations and computational modelling.	PE1.1, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2
2. Understand the basic principles of critical state soil mechanics and soil plasticity,and use elastic-plastic constitutive models to simulate soil stress-strain behaviour.	PE1.1, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2
3. Using finite element method to solve geo-energy problems, including geothermal energy systems and their interaction with the ground.	PE1.1, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2

Teaching Strategies

Private Study

- Review lecture material and textbook
- Do set problems and assignments
- Join Moodle discussions of problems
- Reflect on class problems and assignments
- Download materials from Moodle
- Keep up with notices and find out marks via

	Moodle
Lectures	• Find out what you must learn • See methods that are not in the textbook • Follow worked examples • Hear announcements on course changes • Ask questions • Be guided by Demonstrators/Lecturers • Practice solving set problems
Workshops	• Ask questions • Demonstrate your knowledge and skills • Demonstrate higher understanding and problem solving
Assessments	• Hands-on work, to set studies in the context
Laboratory Work	

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Multiple-choice quiz covering the first three weeks of the course	5%	17/06/2023 11:59 PM	1, 2, 3
2. Shallow geothermal systems design and optimisation - using FE modelling	45%	Week 9	1, 2, 3
3. Modelling soil stress-strain behaviour	50%	11/08/2023 11:59 PM	1, 2, 3

Assessment 1: Multiple-choice quiz covering the first three weeks of the course

Due date: 17/06/2023 11:59 PM

Marks to be out before the census date.

Assessment 2: Shallow geothermal systems design and optimisation - using FE modelling

Due date: Week 9

Individual assignment for which the students will design a shallow geothermal system for specific space and thermal load using COMSOL Multiphysics (in an optimised and efficient manner).

Assessment 3: Modelling soil stress-strain behaviour

Due date: 11/08/2023 11:59 PM

Assignment 3 is an individual assignment for which the students will model the stress-strain behaviour of soils.

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Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 29 May - 2 June	Lecture	30/05/2023 Introduction to shallow geothermal systems (Science and Engineering G02) (no workshop for this week)
Week 2: 5 June - 9 June	Lecture	06/06/2023 Common design approaches for shallow geothermal systems - analytical methods (Science and Engineering G02) 08/06/2023 Common design approaches for shallow geothermal systems - analytical methods (Newton 307)
Week 3: 12 June - 16 June	Lecture	13/06/2023 Heat and mass transfer mechanisms in the context of shallow geothermal systems - analytical solutions (Science and Engineering G02) 15/06/2023 Heat and mass transfer mechanisms in the context of shallow geothermal systems - analytical solutions (Newton 307)
Week 4: 19 June - 23 June	Lecture	20/06/2023 Introduction to finite element package COMSOL Multiphysics (General heat and mass transfer modelling and analysis, FEM – computer lab, level 2 22/06/2023 Introduction to finite element package COMSOL Multiphysics (General heat and mass transfer modelling and analysis, FEM – computer lab, level 6
Week 5: 26 June - 30 June	Lecture	27/06/2023 Introduction to finite element package COMSOL Multiphysics (General heat and mass transfer modelling and analysis, FEM – computer lab, level 2 29/07/2023 Introduction to finite element

		package COMSOL Multiphysics (General heat and mass transfer modelling and analysis, FEM – computer lab, level 6
Week 7: 10 July - 14 July	Laboratory	11/07/2023 Soil elasticity and yielding. Modelling the elastic-plastic behaviour of soils and critical state soil mechanics (Science and Engineering G02) 13/07/2023 Soil elasticity and yielding. Modelling the elastic-plastic behaviour of soils and critical state soil mechanics (Newton 307)
Week 8: 17 July - 21 July	Lecture	18/07/2023 Constitutive models, solving differential equations as an initial value problem and simulating the stress-strain behaviour of soils (Science and Engineering G02) 20/07/2023 Constitutive models, solving differential equations as an initial value problem and simulating the stress-strain behaviour of soils (Newton 307)
Week 9: 24 July - 28 July	Blended	25/07/2023 The Mohr-Coulomb, Cam-clay and Bounding surface plasticity constitutive models (Science and Engineering G02) 27/07/2023 The Mohr-Coulomb, Cam-clay and Bounding surface plasticity constitutive models (Newton 307)
	Assessment	Shallow geothermal systems design and optimisation - using FE modelling
Week 10: 31 July - 4 August	Blended	01/08/2023 Maple demonstration (Computer lab level 2) 03/08/2023 Maple demonstration (Computer lab level 6)
Stuvac: 7 August - 11 August	Assessment	Modelling soil stress-strain behaviour

Resources

Recommended Resources

Part 1:

1. Banks, D. “An Introduction to Thermogeology”, Wiley and Backwell, 2012.
2. Al-Khoury, R. “Computational Modelling of Shallow Geothermal Systems”, CRC Press.
3. IGSHPA, “Ground Source Heat Pump Residential and Light Commercial Design and Installation Guide”, Oklahoma State University.
4. Laloui, L., Di Donna, A., “ Energy Geo-structures – Innovation in Underground Engineering”, Wiley, 2013.
5. Laloui, L. & Loria, A. F. R., “Analysis and Design of Energy Geostructures: Theoretical Essentials and Practical Application”, Academic Press, 2019.

Part 2:

No textbook is prescribed although the first four books listed below are very good investments for any geotechnical engineer.

1. Muir Wood, D. “Soil Behaviour and Critical State Soil Mechanics”, Cambridge University Press, 1992.
2. Muir Wood, D. “Geotechnical modelling”, Spon Press, 2004.
3. Puzrin, A.M., Alonso, E.E. and Pinyol, N.M. “Geomechanics of failures”. Springer. 2010.
4. Alonso, E.E., Pinyol, N.M. and Puzrin, A.M. “Geomechanics of failures: Advanced Topics”. Springer. 2010.
5. Lambe and R.V. Whitman, "Soil mechanics", John Wiley & Sons, 1969.
6. Atkinson and P.L. Bransby, "The mechanics of soils: An introduction to critical state soil mechanics", McGraw-Hill, 1978.
7. Holtz, Kovacs and Sheahan, "An introduction to geotechnical engineering", Pearson, 2011.
8. Reddy J.N. An Introduction to the Finite Element Method, 3rd ed., McGraw-Hill, New York, 2006.
9. Potts D.M., Zdravkovic L. Finite Element Analysis in Geotechnical Engineering - Theory, Thomas Telford Publishing, London, 2001.
10. Potts D.M., Zdravkovic L. Finite Element Analysis in Geotechnical Engineering - Application, Thomas Telford Publishing, London, 2001.

Laboratory Workshop Information

In total three weeks of the course (weeks 4, 5 and 10) will be held in the computer lab working with a FE software COMSOL and Maple, both of which accesible via MyAccess in computer labs on level 2 and 6.

Submission of Assessment Tasks

Please refer to the Moodle page of the course for further guidance on assessment submission.

UNSW has a standard late submission penalty of:

- 5% per day, for all assessments where a penalty applies, capped at five days (120 hours), after which a student cannot submit an assessment, and no permitted variation.

Academic Honesty and Plagiarism

Beware! An assignment that includes plagiarised material will receive a 0 fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the use of another person's work or ideas as if they were your own. When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:

https://student.unsw.edu.au/plagiarism

Academic Information

Final Examinations:

Final Exams in T2 2023 will be held on campus between Friday 11th and Thursday 24th August (inclusive), and Supplementary Exams between Monday 4th and Friday 8th September (inclusive). You are required to be available on these dates. Please do not to make any personal or travel arrangements during this period.

For students enrolled in the distance offering of a postgraduate course, and who reside further than 100km from UNSW Kensington campus, will be contacted regarding sitting an external exam. The school's External Exam Policy can be found on the Intranet.

ACADEMIC ADVICE

- Key Staff to Contact for Academic Advice (log in with your zID and password): https://intranet.civeng.unsw.edu.au/key-staff-to-contact-during-your-studies-at-unsw
- Key UNSW Dates - eg. Census Date, exam dates, last day to drop a course without academic/financial liability etc.
- CVEN Student Intranet (log in with your zID and password): https://intranet.civeng.unsw.edu.au/student-intranet
- Student Life at CVEN, including Student Societies: https://www.unsw.edu.au/engineering/civil-and-environmental-engineering/student-life
- Special Consideration: https://student.unsw.edu.au/special-consideration
- General and Program-Specific Questions: The Nucleus: Student Hub
- Book an Academic Advising session: https://unswengacademicadvising.as.me/schedule.php

Disclaimer

This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Mike Gal.

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	✓
PE2.3 Application of systematic engineering synthesis and design processes	
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in professional and lay domains	
PE3.3 Creative, innovative and pro-active demeanour	
PE3.4 Professional use and management of information	
PE3.5 Orderly management of self, and professional conduct	
PE3.6 Effective team membership and team leadership	