Course Content

Academic Year	2019-2020	**Semester**	2
Course Coordinator	PROF HARIANTO RAHARDJO		
Course Code	CV2014		
Course Title	Geotechnical Engineering		
Pre-requisites	CV2013		
No of AUs	3		
Contact Hours	2 hours of lectures per week 1 hour of tutorial per week		
Proposal Date	September 2019		

Course Aims

This course aims to complete the fundamental principles of soil mechanics and extend your understanding of it to geotechnical engineering. It is the second series of three courses that will help you reinforce your understanding of soil mechanics principles and their applications to geotechnical design.

Course Learning Outcomes (Course LO)

By the end of this course, you (as a student) should be able to:

1. Describe the stress-strain behaviour of soil and use Mohr circle to analyse stresses acting on a soil element.
2. Determine the friction angle of soil and the typical soil behaviour in direct shear tests.
3. Explain the purposes of triaxial tests and the need to have different types of tests and to determine the shear strength parameters (c' and ϕ') using triaxial CD or CU tests, and explain the "ϕ=0" concept for the undrained shear strength of saturated clays.
4. Identify the 3 types of lateral earth pressures: at-rest, active, and passive and determine the limiting lateral earth pressure for each type; determine the lateral stresses induced on a retaining wall, plot the earth pressure distribution behind a retaining wall and calculate the thrust.
5. Identify and explain the assumptions, limitations and applications of Rankine's and Coulomb's earth pressure theories.
6. Calculate the vertical stress distribution in soil under: 1) Point load; 2) Strip area carrying uniform pressure; and 3) Rectangular area carrying uniform

pressure.

7. Identify and determine different types of slope failure and their mechanisms, such as: circular and non-circular rotational slips as well as translational slip and compound slip.
8. Calculate the factor of safety for fully saturated clay slopes under undrained conditions.
9. Describe the slope stability analyses based on method of slices (Fellenius, Bishop, Spencer) and their assumptions
10. Explain the fundamental principles of slope stabilization measures (buttress fills, retaining walls, soil nailing, horizontal drains, vegetative covers) to ensure the stability of the slopes
11. Study the limitations and applications of different instruments for slope monitoring with respect to deformations (inclinometers) and pore-water pressure changes (piezometers)
12. Explain the importance of compaction and soil improvement in earthwork construction and determine the suitability and applicability of different compaction methods and different types of soil improvement (temporary surcharge fills, vertical drains, in-situ densifications, soil reinforcement)

Course Content

S/N	Topic	Lecture Hrs	Tutorial Hrs
1	Soil as a Continuum	3	2
2	Shear Strength of Soil	7	2
3	Lateral Earth Pressure	3	1
4	Elastic Stress Distribution	1	1
5	Slope stability	6	2
6	Compaction	3	2
7	Soil Improvement	3	2
	Total:	26	12

Assessment (includes both continuous and summative assessment)

Component	**Course LO Tested**	**Related Programme SLO or**	**Weighting**	**Team/ Individual**	**Assessment rubrics**

		Graduate Attributes			
1. Final Examination	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	EAB SLOs (a), (b), (c), (d), (f), (g)	60%	Individual	Appendix 1
2. Continuous Assessment 1 (CA1): Quiz 1	1, 2, 3, 4, 5, 6	EAB SLOs (a), (b)	20%	Individual	Appendix 2
3. CA2: Quiz 2	7, 8, 9, 10, 11, 12	EAB SLOs (a), (b), (d), (g)	20%	Individual	Appendix 3
Total			100%		

* CEE SLOs = Student Learning Outcomes for Civil Engineering Programme (per BEng Civil Engineering Accreditation)

Related Programme LO or Graduate Attributes

a. **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems;

b. **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences;

c. **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

d. **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

f. **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g. **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.

Formative feedback

1. Feedback will be through the dissemination of your performance in quizzes as

well as review of the quiz questions in class.

2. Additional channel will be through individual consultation initiated by you on your particular learning needs.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lectures	Formal lectures on topics which cover fundamental of soil mechanics and selected topics of geotechnical engineering. The lectures will focus on the fundamentals of shear strength of soil and the application of shear strength concept to practical problems such as lateral earth pressure on retaining walls, slope stability and soil improvements. The application of these concepts will be illustrated through analysis and problem solving.
Tutorials	Reinforces concepts of lectures with example problems. To promote peer discussion and group interaction in problem solving.

Reading and References

Text

Knappett, J.A. and Craig, R.F., Craig's Soil Mechanics, 8th edition, Spon Press, 2012.

References

Holtz, R.D. Kovacs, W.D. and Sheahan, T.C., An Introduction to Geotechnical Engineering, 2nd edition, Pearson, 2011.

Coduto, D.P., *"Geotechnical Engineering, Principles and Practices"*, Prentice Hall, N. J., 1999.

Course Policies and Student Responsibilities

The standing university policy governing student responsibilities shall apply.

(1) General

Students are expected to attempt all assigned tutorials before the tutorial classes. Students are expected to take responsibility to follow up with lectures, course notes, and online materials. Students are expected to participate in all lectures, tutorials, quizzes and online exercises.

(2) Absenteeism

The quizzes make up a significant portion of your course grade. Absence from quizzes without a valid reason will affect your overall course grade. Valid reasons include falling sick

supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for quizzes.

If you miss a quiz, you must inform your course lecturer and coordinator via email. Students who miss quizzes with valid reasons will have to provide the CEE Undergraduate Office with medical certificates or excuse letter from the relevant bodies.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors AY2017/18

Instructor	Office Location	Phone	Email
Prof Harianto Rahardjo	N1-01b-36	67905246	chrahardjo@ntu.edu.sg
Prof Chu Jian	N1-B2-10a	67904563	cjchu@ntu.edu.sg

Planned Weekly Schedule

Two hours of lecture and one hour of tutorial.
The actual schedule will need to be adjusted to accommodate public holidays and official time off approved by University such as Union Day.

Week	Topic	Course LO	Readings/Activities
1	Review of Soil Mechanics	1	Lectures
2	Soil as a Continuum	1, 2	Tutorials and Lectures
3	Shear Strength of Soil 1	2, 3	Tutorials and Lectures
4	Shear Strength of Soil 2	2, 3	Tutorials and Lectures
5	Shear Strength of Soil 3 / Lateral Earth Pressure	3, 4	Tutorials and Lectures
6	Lateral Earth Pressure	4, 5	Tutorials and Lectures
7	Elastic Stress Distribution	6	Tutorials and Lectures
8	Slope Stability 1	7	Tutorials and Lectures

9	Slope Stability 2	8	Tutorials and Lectures
10	Slope Stability 3	9	Tutorials and Lectures
11	Compaction & Soil Improvement 1	10, 11	Tutorials and Lectures
12	Compaction & Soil Improvement 2	10, 11	Tutorials and Lectures
13	Compaction & Soil Improvement 3	12	Tutorials and Lectures

Appendix 1: Assessment Criteria for Final Examination

Performance Indicators	Weightage	Performance Level			
		Outstanding: 4	**Good: 3**	**Average, meet expectation : 2**	**Below expectations: 1**
Understand the shear strength principles of soil	20%	Able to understand and demonstrate the shear strength principles of soil in a systematic, clear and precise	Able to understand the shear strength principles of soil in a systematic manner.	Able to list the shear strength principles of soil	Unable to list the shear strength principles of soil
Apply knowledge to determine lateral earth pressure	20%	Able to apply appropriate knowledge in determining lateral earth pressure in a systematic, clear and precise manner.	Able to apply appropriate knowledge in determining lateral earth pressure in a systematic manner.	Able to apply basic knowledge in determining lateral earth pressure	Unable to apply basic knowledge in determining lateral earth pressure
Understand concept of elastic stress distribution	10%	· Able to comprehend and apply concept of elastic stress distribution	Able to comprehend concept of the elastic stress distribution	· Able to recall the basic concept of the elastic stress distribution	· Unable to recall the basic concept of the elastic stress distribution

Apply knowledge to analyse slope stability	20%	Able to apply appropriate knowledge in analysing slope stability in a systematic, clear and precise manner.	Able to apply appropriate knowledge in analysing slope stability in a systematic manner.	Able to apply basic knowledge in analysing slope stability	Unable to apply basic knowledge in analysing slope stability
Apply knowledge on soil compaction	20%	Able to apply appropriate knowledge in the calculation related to soil compaction in a systematic, clear and precise manner.	Able to apply appropriate knowledge in the calculation related to soil compaction in a systematic manner.	Able to apply basic knowledge in the calculation related to soil compaction	Unable to apply basic knowledge in the calculation related to soil compaction
Apply knowledge to determine soil improvement method	10%	Able to apply appropriate knowledge in determining the appropriate soil improvement method in a systematic, clear and precise manner.	Able to apply appropriate knowledge in determining the appropriate soil improvement method in a systematic manner.	Able to apply basic knowledge in determining the appropriate soil improvement method	Unable to apply basic knowledge in determining the appropriate soil improvement method

Appendix 2: Assessment Criteria for CA1(20%)

Criteria	**Standards**		
	Fail standard (< 4 marks)	**Pass standard (5-6 marks)**	**High standard (7-10 marks)**
Conceptual questions (LO 1, 2, 3)	Unable to show the understanding on the concept	Able to show some understanding on the concept	Fully understand the concept
Short Calculations (LO 2, 3)	Unable to show correct formula for question	Able to show use of correct formula for question but unable to obtain correct solution	Able to show use of correct formula and present correct solution for question

Appendix 3: Assessment Criteria for CA2(20%)

Criteria	Standards		
	Fail standard (< 4 marks)	**Pass standard (5-6 marks)**	**High standard (7-10 marks)**
Conceptual questions (LO 7, 8, 9, 10, 11)	Unable to show the understanding on the concept	Able to show some understanding on the concept	Fully understand the concept
Short Calculations (LO 7, 8, 9)	Unable to show correct formula for question	Able to show use of correct formula for question but unable to obtain correct solution	Able to show use of correct formula and present correct solution for question