Course Content

Academic Year	2019/20	**Semester**	2
Course Coordinator	Asst/P Yi Yaolin		
Course Code	CV4111		
Course Title	Ground Engineering		
Pre-requisites	CV2013 Engineering Geology & Soil Mechanics, CV2014 Geotechnical Engineering and CV3013 Foundation Engineering		
No of AUs	3		
Contact Hours	*26 hours Lecture & 13 hours Tutorials*		
Proposal Date	*20 August 2019*		

Course Aims

Ground engineering, including ground improvement and slope stability, is commonly encountered in civil engineering projects. This course aims to acquaint you with the principles of engineering ground improvement and the methods of slope stability analysis and slope stabilization.

Course Learning Outcomes (Course LO)

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

1. Explain the purpose and principles of ground improvement
2. Evaluate and select ground improvement methods
3. Analyse the slope stability incorporating the unsaturated soil mechanics principles
4. Select and design the appropriate slope stabilization systems for specific site based on applicable standards
5. Evaluate slope stability appropriate to specific site and engineering conditions.
6. Apply analytical and computer skills learnt which are useful in slope analysis and beyond.

Course Content

S/N	Topic	Lecture Hrs	Tutorial Hrs
1	Principles of ground improvement and shallow surface compaction	3	1
2	Deep densification and deep replacement	4	2
3	Preloading and vertical drains	2	1
4	Chemical stabilization	2	1
5	Shear strength of saturated and unsaturated soils	2	1
6	Case studies of residual soil slopes	1	1
7	Slope monitoring and slope stabilization	2	1
8	Slope cover and drainage systems and soil reinforcement	2	1
9	Limit equilibrium method of slope stability analysis	2	1
10	Iterative slope stability analysis using computer	4	2

11	Analysis of reinforced embankments over soft clay	2	1
	Total:	26	13

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme SLO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
1. Final Examination	1, 2, 3, 4, 5 & 6	EAB SLOs (a), (b)	60%	Individual	
2. Continuous Assessment 1 (CA1): Quiz 1	1, 2	EAB SLOs (a), (b)	20%	Individual	Appendix 1
3. CA2: Quiz 2	3, 4, 5, 6	EAB SLOs (a), (b)	20%	Individual	Appendix 2
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 civil engineering specialisation to the solution of complex civil engineering problems.

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

c) **Design/development of Solutions**: Design solutions for complex civil engineering problems and design system components or processes 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 methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex civil engineering activities with an understanding of the limitations.

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 the need for the sustainable development.

h) **Ethics**: Apply ethical principles and commit to professional and moral responsibilities in the civil engineering practice.

i) **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

j) **Communication**: Communicate effectively on complex civil engineering activities with the engineering community and with society at large, be able to comprehend and write effective reports and design documentation, and make effective presentations.

k) **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to work, as a member and leader in a multidisciplinary team.

l) **Life-long Learning**: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological evolution.

Formative feedback

1. Feedback will be through the dissemination of the student's performance in quizzes as well as review of the quiz questions in class.
2. We encourage you to initiate an individual consultation sessions on your particular learning needs.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Provide materials to you and guidance in scope for reading of texts and references
Tutorials	Reinforce materials covered in lectures and further explain concepts, process and design philosophy in ground engineering.
CA1 & CA2	Provide feedback to you on your understanding of the course

Reading and References

Text

Jie Han. (2015). Principles and Practices of Ground Improvement, John Wiley.
CV4111 Course Notes on Slope Stability.
Fredlund, D.G. and H. Rahardjo (1993) "Soil Mechanics for Unsaturated Soils". John Wiley & Sons, Inc., New York, 517 pages (ISBN 0-471-85008-X).

Reference

Kirsch, K. and Bell, A. (2013) Ground Improvement, 3rd Edition, CRC Press.
Bo, M.W., Chu, J., Low, B.K., and Choa, V. (2003). Soil Improvement: Prefabricated Vertical Drain Techniques, by Thomson Learning, Thomson Asia Pte Ltd.
Cornforth, D. (2005). Landslides in practice: investigation, analysis, and remedial/preventive options in soils, John Wiley.

Course Policies and Student Responsibilities

(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 me 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

Instructor	Office Location	Phone	Email
Asst/P Yi Yaolin	Rm N1-1c-94	6790 6309	yiyaolin@ntu.edu.sg
Prof. Harianto Rahardjo	Rm N1-1b-36	6790 5246	chrahardjo@ntu.edu.sg
A/P Low Bak Kong	Rm N1-1b-40	6790 5270	cbklow@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Overview and principles of ground improvement	1, 2	Reading texts and references,
2	Shallow surface compaction	1, 2	Reading texts and references, Tutorial 1
3	Deep densification: dynamic compaction and vibro-compaction	1, 2	Reading texts and references, Tutorial 2
4	Deep replacement	1, 2	Reading texts and references, Tutorial 3
5	Preloading and vertical drains	1, 2	Reading texts and references, Tutorial 4
6	Chemical stabilization; Shear strength of saturated and unsaturated soils.	1, 2, 3	Reading texts and references, Tutorial 5
7	Slope stability analyses under rainfall loading; Case studies of residual soil slopes.	3, 4	Reading texts and references, Tutorial 6
8	Slope monitoring; Slope stabilization.	3, 4	Reading texts and references, Tutorial 7
9	Slope cover and drainage systems; Soil reinforcement.	3, 4	Reading texts and references, Tutorial 8
10	The $\phi_u = 0$ method of slope analysis. Ordinary method of slices. Bishop's simplified method and implementation.	5, 6	Reading texts and references, Tutorial 9
11	Stability of embankments on soft ground. Total versus effective stress analysis. Search for critical slip surface.	5, 6	Reading texts and references, Tutorial 10
12	Reformulated Spencer method, and implementation.	5, 6	Reading texts and references, Tutorial 11
13	Wedge method of analysis. Comparative review of different limit equilibrium methods of stability analysis.	5, 6	Reading texts and references, Tutorial 12

Appendix 2: Assessment Criteria for CA1(20%)

Criteria	Standards		
	Fail standard (< 4 marks)	**Pass standard (5-6 marks)**	**High standard (7-10 marks)**
MCQs (LO 1 & 2)	Getting 1 or 2 MCQs correct	Getting 2-3 MCQs correct	Getting 3-5 MCQs correct
Short Calculations (LO 1 & 2)	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 3 & 4)	Unable to show the understanding on the concept	Able to show some understanding on the concept	Fully understand the concept
Short Calculations (LO 3 & 4)	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