MODULE DESCRIPTION FORM

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

CL507 and Ground Improvement and Reinforcement

Module Registrar: Dr Stewart Beattie	**Taught To (Course): MEng/MSc Civil Engineering**		
Other Lecturers Involved: **Owen Jones, Jim Shields (Both External)**	**Credit Weighting: 10**	**Semester: 2**	
Assumed Prerequisites: None	**Compulsory/ optional/ elective class**	**Academic Level: 5**	**Suitable for Exchange: Y**

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
18	6						20	56	100

Educational Aim

This module aims to provide comprehensive understanding of the principles, techniques and methods of analysis for ground improvement and soil reinforcement, piles and pile groups, and the application of these techniques for design in various ground conditions.

Learning Outcomes

On completion of the module the student is expected to be able to

LO1 Design single piles and pile groups in different ground conditions.

LO2 Identify the most appropriate treatment/improvement solution for various ground conditions and situations.

LO3 Design appropriate soil/rock reinforcement solutions.

LO4 Design reinforced earth walls

Syllabus

The module will teach the following:

Pile Foundations
Types of deep foundations, ultimate load capacity of pile foundations, Design of pile foundations and pile groups.

Specialist geotechnical techniques
Micro piling, ground anchoring, soil nailing

Ground Improvement
Techniques for ground improvement (mass replacement, preloading, vertical drains, deep mixing, dynamic compaction, deep vibro techniques, jet grouting, compaction grouting). Design methods for ground improvement.

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Soil Reinforcement
Principles of soil reinforcement, Types of reinforcement, properties and behaviour, Design of reinforced slopes and soil nailing, Design of reinforced earth retaining walls using the tie-back wedge method.

Grouting
Different grouting techniques, uses of the techniques, susceptibilities, constrains, applications.

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1
C1 Able to assess the suitability of piles and different pile types for a particular building design situation.
C2 Appreciate the construction problems which could arise from piling in different soil profiles.
C3 Able to design pile foundations and optimise the pile dimensions and spacing.
C4 Understand and apply the principles of Eurocode 7 to pile design.

LO2
C1 Understand the properties and behaviour of the various types of soil in relation to ground improvement.
C2 Able to design ground improvement by calculation.
C3 Able to optimise the design of sand drain and stone column systems using analytical methods.

LO3
C1 Understand the various options available to an engineer when reinforcing soil.
C2 Understand the behaviour of ground anchors and the fundamental design principles.

LO4
C1 Understand the properties and behaviour of the various types of soil reinforcement.
C2 Able to design reinforced earth retaining walls.
C3 Appreciate the influence of reinforcement type on the behaviour of reinforced earth retaining walls.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback
(within Assessment and Feedback Policy at: https://www.strath.ac.uk/staff/policies/academic/)

Please state briefly how these are incorporated in this module.

Feedback will be provided to students individually and as a group through the tutorial sessions, which will include worked examples.
The coursework and exam will require out of class learning and library study
The coursework will have a clear set of marking criteria and standards of performance.
Coursework feedback will be provided in relation to the specific marking criteria set out in the coursework.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

	Examinations				**Courseworks**		**Projects**	
	Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***
	1	May	2hrs	80%	1	20	None	
L/Outcomes	LO1, LO2, LO3, L04				LO3			

Indicate which learning outcomes (LO1, LO2 etc) are to be assessed by exam/coursework/project as required.

Coursework / Submissions deadlines (*academic weeks*):
Coursework: Ground Anchor Design, submission during week 5.

Resit Assessment Procedures:
2 hr examination in August diet

PLEASE NOTE:

Students must gain a summative mark of 50% to pass the module. Students who fail the module at the first attempt will be re-examined during the August diet. This re-examination will consist entirely of exam. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended **Highly recommended reading *For reference**

**Tomlinson, M J. and Woodward, Pile Design and Construction Practice, (6th ed), CRC Press, 2015.

**Knappet, J.A. and Craig, R.F. Craig's Soil Mechanics, 8th edition. Spon Press 2012.
**Soil Mechanics - Concepts and Application, 2nd edition by William Powrie. Spon Press 2004.
*Principles of Foundation Engineering, Braja Das, 2017

*BS EN 1997-1: 2004+A1: 2013 Eurocode 7: Geotechnical Design – Part 1: General Rules.
*NA+A1:2014 TO BS EN 1997-1:2004+A1: 2013 UK National Annex to Eurocode 7: Geotechnical design – Part 1: General rules
*BS 8006: Code of Practice for Strengthened/Reinforced Soils.
*Moseley, M.P. & Kirsch, K. Ground Improvement, 2nd Edition, Spon Press, 2004.
Various papers, articles and brochures made available on MyPlace.

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No

Session: 2021/22

Approved:

Course Director Signature:
Date of Last Modifications:

ASSESSMENT TIMETABLE

Module Code	CL507	Module Title	Ground Improvement and Reinforcement

Indicate in the tables below the Hand-Out (H), Submission (S) and Feedback (F) week number for each assignment (lab report/coursework/project etc) and the timing of each Exam (E), Class Test (CT) or Quiz (Q)

Coursework: Ground Anchor Design (20%) – design of a ground anchor system report.

Exam: Calculation by hand calculation and written essay style questions (80%).

Semester 2

Assessment type & title	LOs	Weight (%)	Individual or Group	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
Coursework: Ground anchor Design	LO3	20	Individual			(H)		(S)			(F)				
Exam															H/S

Appendix

Mapping Module Learning Outcomes to AHEP

Module Learning Outcome	**Engineering Council AHEP competencies: Knowledge, Understanding and Ability**
LO1 Design single piles and pile groups in different ground conditions.	Science and mathematics • A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems Design • Understand and evaluate business, customer and user needs, including considerations such as the wider engineering context, public perception and aesthetics • Investigate and define the problem, identifying any constraints including environmental and sustainability limitations; ethical, health, safety, security and risk issues; intellectual property; codes of practice and standards • Knowledge and understanding of the commercial, economic and social context of engineering processes
LO2 Identify the most appropriate treatment/improvement solution for various ground conditions and situations.	Economic, legal, social, ethical and environmental context • Understanding of engineering principles and the ability to apply them to undertake critical analysis of key engineering processes • Awareness of developing technologies related to own specialisation

	• Ability to use fundamental knowledge to investigate new and emerging technologies • Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal •
LO3 Design appropriate soil/rock reinforcement solutions.	Design • Understand and evaluate business, customer and user needs, including considerations such as the wider engineering context, public perception and aesthetics • Investigate and define the problem, identifying any constraints including environmental and sustainability limitations; ethical, health, safety, security and risk issues; intellectual property; codes of practice and standards • Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies • Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal • Plan and manage the design process, including cost drivers, and evaluate outcomes • Demonstrate wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations • Demonstrate the ability to generate an innovative design for products, systems, components or processes to fulfil new needs. Additional general skills • Apply their skills in problem solving, communication, working with others,

	information retrieval and the effective use of general IT facilities • A thorough understanding of current practice and its limitations, and some appreciation of likely new developments
LO4 Design reinforced earth walls	Engineering practice • Understanding of the use of technical literature and other information sources • Understanding of appropriate codes of practice and industry standards

Programme Threads

	Assessment Title		
Thread	**Primary**	**Secondary**	**Contributory**
Design	**Design calculation make up a large part of the coursework and assessment. Up-to-date codes and standards are used where applicable.**		
Health, Safety & Risk Assessment			**Covered extensively in lectures by industrialists – will be assessed some years depending on exam questions.**
Sustainability		**The students are asked to consider costs, material use and environmental impacts of the engineering methods covered in the course. These can be covered in the written parts of the exam questions.**	
Professionalism, Ethics, Diversity and Inclusion			
Application of Maths to solve engineering problems	**Vital to completing the course as a large part of the exam is hand calculation of complex geotechnical structures. Calculations are also required for the coursework.**		
Industrial Engagement & Site Visits	**Several lectures given by industry. Coursework and exam design in collaboration with industrial lecturers.**		
Digital Technologies	**Standard digital technologies used in course delivery.**		