Master of Science (Geotechnical Engineering)

Description of Modules

Core Modules

CE4257- Linear Finite Element Methods
Workload: 3-0-0-1-6
This module equips students with the fundamentals of finite element principles to enable them to understand the behaviour of various finite elements and to be able to select appropriate elements to solve physical and engineering problems with emphasis on structural and geotechnical engineering applications. It covers weak formulation, element shape function, isoparametric concepts, 1-D, 2-D, 3-D and axisymmetric elements, field problems, modeling and practical considerations, special elements and related topics. The module is targeted at undergraduate and graduate students involved in research or application of the finite element method in civil engineering problems.

CE5108- Earth Retaining Structures
Workload: 3-0-0-1-6
This module teaches students the behaviour and basic design principles of a wide range of earth retaining systems. Students will learn to understand the fundamental behaviour of earth retaining structures and apply the methods of limit state and other design concepts to the design of rigid and flexible retaining walls, cellular cofferdams and deep supported excavations. Through lectures and case studies, the course covers the application of limit state design concepts to rigid and flexible retaining walls, cellular cofferdams and deep supported excavations, including earth pressure theories, failure mechanisms, ultimate load and serviceability limit states. This module enables students to acquire the knowledge and practical skills through the lectures, case studies and projects.

CE6101- Geotechnical Constitutive Modelling
Workload: 3-0-0-1-6
This module introduces students to the various aspects of soil behaviour and their modeling using some of the more commonly used constitutive models. The course is divided into a few major segments. The first covers basic concepts of stress, strain, effective stress, stress and strain paths. The second covers mathematical elasticity using the generalized Hooke’s Law and its prediction of soil behaviour. The third part covers basic concepts of plasticity and shear-induced plasticity as is encapsulated in the Mohr-Coulomb criterion. The fourth part covers critical state soil mechanics, stress-dilatancy, leading eventually to simple volumetric hardening plasticity models such as the original and the modified Cam Clay models. The last part deals with real soil behaviour and the idealizations made by these constitutive models.

\[1\] Workload Components: A-B-C-D-E
A: no. of lecture hours per week; B: no. of tutorial hours per week; C: no. of lab hours per week; D: no. of hours for projects, assignments, fieldworks etc per week; E: no. of hours for preparatory work by a student per week.
CE5111- Underground Construction Project
Workload: 0-2-0-8-0
The objective of this module is to integrate the various concepts and components of temporary earth retaining structure, underground construction and major geotechnical works design which have been covered in the other modules into a properly executed geotechnical analysis and design project. As such, the student will be advised to take it only either in the last 2 semester. The requirements of the project will include interpretation of site investigation data, derivation of design parameters, use of computer or finite element software for the wall and ground movement as well as drawdown and implications for adjacent structures, design of wall, strutting and waling systems, and proposal of an appropriate ground instrumentation programme. Student will be given a maximum of 2 semesters to complete their projects. At the end of the projects, students will be required to submit a report of their findings and give an oral presentation, which will be graded.

CE5112- Excavation Support Systems
Workload: 3-0-0-2-5
This module teaches students the essential methodology for the design of the structural components of a wide range of earth retaining systems. These components include the various types of retaining walls, walers, struts, kingposts and connection details. It will also cover the design of temporary working platforms which are often required in deep excavations, as well as methods of jointing and splicing to allow incorporation of instrumentation. The course will cover both steel and reinforced concrete retaining walls, such as sheet pile, soldier piles, timber lagging, contiguous bored piles and diaphragm walls. The course enables students to acquire the knowledge and practical skills through the lectures, case studies and projects.

CE5113- Geotechnical Investigation & Monitoring
Workload: 3-0-0-1-6
This module teaches students the essential concepts and methodology for the planning, design and implementation of site investigation and ground instrumentation programmes. The course will be broadly divided into two parts. The first part covers various aspects of site investigation such as the planning, design, density of bore holes, sampling technology and disturbance, in-situ and laboratory testing and geophysical methods. The second part covers various aspects of ground instrumentation such as monitoring of ground movement, drawdown, excess pore pressures, strut forces, wall deflection and observational methods. This module enables students to acquire the knowledge and practical skills through the lectures, case studies and projects.

CE6102- Geotechnical Analysis
Workload: 3-0-0-1-6
This module is an advanced analysis module which follows up on the concepts from CE4257 and CE6101. The objective is to equip students with advanced concepts of finite difference and finite element analysis which are needed for the solution of geotechnical problems. The module will cover finite difference concept and formulation, non-linear analysis techniques, elasto-plastic formulation with a tangent stiffness approach, solution techniques, large strain analysis, seepage analysis, flow-deformation coupled analysis, solution accuracy and reliability.
Elective Modules

CE5101 - Seepage and Consolidation of Soils
Workload: 3-0-0-1-6
This is an advanced module in flow through a two-phase medium (possibly compressible). The topics that are covered include steady state seepage, dewatering systems for excavations, transient seepage, basic contaminant transport processes, measurement of hydraulic transport parameters, 1-D to 3-D consolidation analysis, and methods of accelerating consolidation. Students are taught Darcy’s Law, continuity equation, coupling between effective stress and pore pressure, and various transport mechanism. The goals of the module are analysis of seepage problems, analysis of consolidation problems, design methods to accelerate consolidation and an appreciation of ideas and concepts concerning transport of contaminants.

CE5104 - Underground space
Workload: 3-0-0-1-6
This is an advanced module on analysis and design of tunnels. The topics covered include bored tunnelling methods, construction of caverns, New Austrian Tunnelling Method, jack tunnelling, stability of underground openings, ground movement prediction due to tunnels, effects of ground movements on buildings and structures, instrumentation and monitoring, and stresses on lining. The creation of underground structures to form subways, underpasses, metro stations and other uses is an increasing requirement in major urban areas worldwide. Students are taught the various methods of construction for creating underground space.

CE5105 - Analytical and Numerical Methods in Foundation Engineering
Workload: 3-0-0-1-6
This module introduces students to soil models and methods of analysing such models. The central idea is to convey to the students the need to develop simplified conceptual model to better understand foundation analysis. The students will be exposed to a variety of models and both analytical and numerical approaches. Specific ideas concerning beams and rafts on Winkler soil will be discussed, and then extended to problems such piles and piles-groups, considering both linear and nonlinear soil behaviour. Dynamic loads on piles will also be introduced, and both steady-state and transient responses examined. Pile driving analysis by the wave equation will also be covered. Simulation of deep excavations: sheet pile walls; diaphragm walls; struts; ground anchors. Case studies are used to illustrate the application of the above techniques. The course enables students to acquire the knowledge and practical skills through the course, assignments and a mini-project.

CE5106 - Ground improvement
Workload: 3-0-0-1-6
This is an advanced module on ground improvement techniques as well as its design, construction and monitoring in geotechnical engineering. Topics covered include ground improvement principles and design considerations, techniques of improving granular soils, techniques of improving cohesive soils and peaty soils, field controls and monitoring, field evaluation, specification, performance evaluation and acceptance criteria, and case study. Student are taught the basic principles of various ground improvement techniques, and how to select the most appropriate ground improvement techniques to be used in specific circumstances. Specific learning objectives include understanding the principles and design of vibro-flotation
method, dynamic compaction, dynamic replacement with mixing, vertical drains with preloading, chemical stabilization and grouting. Field construction control and instrumentation as well as monitoring techniques will be discussed but this will be limited to their use in ground improvement works. Instead, emphasis on cement and lime stabilization will be enhanced.

CE5107 - Pile foundation
Workload: 3-0-0-1-6
This module introduces students to the advanced principles and concepts on the analysis and design of pile foundations. Its objective is to enable students to develop an appreciation of the behaviour of complex pile foundations under various loading and boundary conditions and ability to apply principles of geomechanics to the advanced design of pile foundations in civil engineering. Students will also learn how to appreciate and appraise complex pile foundation problems under various loading and boundary conditions. The topics covered include bearing capacity and settlement; laterally loaded piles; piles subject to ground movement; piles in difficult ground; foundations for marine structures; construction related problems; pile driving analysis and dynamic testing; static pile tests. The course enables students to acquire the knowledge and practical skills through the course project assignments and case studies in the practice of advanced pile design.

CE6002 - Analysis of Civil Engineering Experiments
Workload: 3-0-0-1-6
This module is designed for graduate coursework and research students in the Department of Civil Engineering. It introduces students the nature of civil engineering experiments and characteristics of data gathered. Fundamental methods to conduct in-laboratory and field experiments to verify civil engineering models will be covered. Included in this module is also the procedure to construct empirical, deterministic and stochastic civil engineering models based on experimental measurements. Examples are drawn from the various fields in civil engineering discipline, including structure, geotechnical, hydraulics, environmental and transportation engineering.

CE6003 - Numerical Methods in Engineering Mechanics
Workload: 3-0-0-1-6
This module introduces the basic principles of engineering mechanics modelling problems and the required numerical tools for analysis and design of engineering problems. Students will learn to understand the fundamental of finite element methods, finite difference methods, and boundary element methods in general. Related topics on numerical methods for civil engineering applications, such as linear equation solvers, eigenvalue solvers, numerical integration, solution of nonlinear problem and convergence and stability problems of numerical algorithms will be discussed.