Syllabus for ACE060 - Deep Foundations

7,5 Credits
Grading: TH – Five, Four, Three, Not passed
Education cycle: Second-cycle
Major Subject: Civil and Environmental Engineering
Department: 20 – ARCHITECTURE AND CIVIL ENGINEERING
Teaching language: English
The course is open for exchange students

Examiner
Jelke Dijkstra

Teachers
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and others

Course specific prerequisites
Geotechnics (BOM355) or equivalent undergraduate basic soil mechanics course covering the following topics: effective stress, settlements, slope stability and earth pressure calculations.

Good basic knowledge of the subject of Applied Mechanics with applications within the area of deformations and strength of materials as well as evaluating stability of simple structures**.**

Aim
The aim of the course is equipping future Civil and Structural Engineers with up-to-date knowledge on techniques and methods of analyses needed for the geotechnical design of infrastructure and buildings. The focus is on construction in a densely populated urban environment, where the lack of space and environmental effects are a major concern. The techniques and methods are applied in practice as part of a design project that deals with the construction of an underground structure in an urban setting.

Learning outcomes (after completion of the course the student should be able to)

After completion of the course the following learning outcomes should be accomplished:

- Knowledge
    - Describe the principles, benefits and limitations of various foundation & retaining wall types and in-situ instrumentation and monitoring concepts.
- Comprehension
    - Distinguish the difference and select between undrained and drained analysis in the context of ultimate and serviceability limit state design
    - Appreciate the limitations of various analytical and numerical design methods for geotechnical structures.
    - To comprehend the role of the soil and the structure in the analyses of soil-structure interaction in context of retaining walls and foundations.
- Application
    - To calculate bearing capacity and settlements of shallow and deep foundations.
    - To calculate earth pressures (at rest, active, passive) for drained (long-term) and undrained (short-term) conditions.
    - To calculate stability of earth retaining structures.
- Analysis
    - To analyse stress paths in the soil adjacent to foundation elements.
    - To analyse the strength as a function of initial state and load path.
    - To predict stability and consolidation & creep settlements of foundations.
    - To analyse soil-structure interaction problems.
- Synthesis:
    - To integrate theoretical knowledge with engineering judgement to solve real-world problems, such as dimensioning of retaining walls and the response of shallow and deep foundations.
    - Comparison of predicted and expected soil response, e.g. comparing results of advanced numerical methods against monitoring data or hand calculations.

Organisation

As a Master's level course, the course relies on an active participation by the students. Lectures are supported by *tutorials* and *project work* (groups of max. 4 students) that integrates the various aspects of learning in a real geotechnical context.

All documents related to the tutorials (exercises, worked solutions) and project work (document, groups, hand in) will be available in Canvas. Hand in of tutorials and project work is on Canvas.

Refer to the separate document on the project requirements in Canvas.

Content

The course content in a nutshell (relevant topics for design project in bold)

- **Revisit basic concepts (mainly on lecture slides)**
- **Deep excavations (Swedish guidelines, Kempfert book & slides)**
- Shallow foundations (lecture slides)
- **Deep foundations (Fleming book & slides)**
- Ground improvement (lecture slides)
- Tunnelling in soft soils (lecture slides)
- Geotechnical monitoring (lecture slides)

Literature

Fleming, K. Weltman, A. Randolph, A. & Elson, A., (2008). *Piling Engineering, 3rd edition*, Taylor & Francis, ISBN 9780415266468, (e-book)
Kempfert, H-G. & Gebreselassie, (2006). *Excavations and foundations in soft soils*. Springer, (e-book)

Lecture slides and any additional material will be published on the course home page.

Complementary literature

ICE Manual of Geotechnical Engineering, Volume 2: Geotechnical design, construction and verification. ICE Publishing 2012. (e-book)
LimitStateGeo and Plaxis manuals

Examination

The project represents 40% of the final grade and 3.5 credits.
Written examination of 4 hours that contributes 60% to the final grade and 4 credits. This will cover all aspects of the course, hence can include some of the topics addressed by the course work (related to excavations and piles).
Mandatory tutorials are marked fail/pass.

Detailed course content

- Introduction
    - Geotechnical design
    - Limit states
    - Observational Method
    - Principles of design and stress paths related to deep foundations and earth retaining walls
    - Earth pressures revisited- dependency of earth pressures on mobilised displacements
- Deep Excavations
    - Types of retaining walls (gravity, reinforced concrete, embedded walls), supports (props, anchors) and walling techniques (Berlin wall, sheet pile, contiguous and secant piles, diaphragm walls), including installation effects
    - Dewatering (wells & recharge wells)
    - Design of single and multi-propped embedded walls
    - Bottom heave and stability, methods for mitigating bottom heave (cross walls, deep mixing etc.)
    - Environmental impact
    - Construction sequence (top down, bottom up)
- Shallow foundations
    - Analytical methods
    - VHM design
- Deep Foundations
    - Pile types
    - Pile installation
    - Axially loaded piles (compression, tension)
    - Laterally loaded piles
    - Group effects
    - Cyclic and dynamic loads
    - Pile load tests (static, statnamic and dynamic)
- Tunneling in soft soils
    - Cut and cover
    - TBM
    - Settlement through
    - Compensation grouting
- Monitoring
    - Design concepts
    - Displacements (structure and soil)
    - (Excess) pore pressures in the soil
    - Measuring (contact) stress
    - Distributed sensing (strain and temperature)

Course schedule and detailed lecture topics – NOTE THAT courses/tutorials are in person with an additional zoom link that is distributed via Canvas

Datum	Time	L/E/T	Location	Who	Topic
Week 1					
Tue 22/3	13.15-15.00	Lec	SB-H7	JD	Introduction, geotech design
-"-	15.15-17.00	Lec	SB-H7	JD	Limit states
Thu 24/3	13.15-15.00	Lec	SB-H7	JD	Earth pressures
-"-	15.15-17.00	Tut	L400/L408	JD	Tut 1: Earth pressures (no hand in)
Fri 25/3	13.15-15.00	Lec	SB-H7	JD	Stress paths and undrained strength **Introduction to the project**
			Canvas		Form project groups for tutorials and design project
Week 2					
Tue 29/3	13.15-15.00	Lec	SB-H7	MaK	Design of retaining walls -part 1 Single-prop
-"-	15.15-17.00	Tut	L400/L408	MaK/JT/JD	Tut 2: Single prop analysis
Thu 31/3	13.15-15.00	Lec	SB-H7	MaK	Design of retaining walls -part 2 Multi-prop
-"-	15.15-17.00	Tut	L400/L408	MaK/JT/JD	Tut 2: Single prop analysis
Fri 1/4	13.15-15.00	Lec	SB-H7	JD	Flow around excavations Introduction to project
					Design project A:

					Read project description and start implementing calculation framework for design of wall
Week 3					
Tue 5/4	13.15-15.00	Lec	SB-H7	JD	Deep foundations: pile types and installation
	15.15-17.00	Tut	Zoom	MaK/JT/JD/HT	Tut 3: Multi-prop analysis
Wed 6/4	23.59		Canvas		**Hand in tutorial 2: Single-prop**
Thu 7/4	13.15-15.00	Lec	SB-H7	JD	ULS axially loaded piles
	15.15-17.00	Tut	L300/308	MaK/JT/JD/HT	Tut 3: Multi-prop analysis
Fri 8/4	13.15-15.00	Lec	SB-H7	JD	SLS axially loaded piles
Week 4					
Wed 20/4	23.59		Canvas		**Hand in tutorial 3: Multi-prop**
Thu 21/4	13.15-15.00	Lec	SB-H7	JD	Laterally loaded piles
-"-	15.15-17.00	Tut	SB-D042	JD/HT/JT	Tut 4: Axially loaded piles
Fri 22/4	13.15-15.00	Lec	SB-H7	JD	Structural design of piles
					Design project: geotechnical calculations for retaining wall
Week 5					
Tue 26/4	13.15-15.00	Lec	SB-H7	JD/	Pile groups
-"-	15.15-17.00	Tut	L200/L400	JD/JT/HT	Tut 4: Axially loaded piles
~~Thu 28/4~~	~~13.15-15.00~~	~~Lec~~	~~SB-H7~~	~~JD~~	~~No lecture~~

-”-	15.15-17.00	Tut	SB-H7	MaK/ JT/HT	Project consultation
~~Fri 29/4~~	~~13.15-15.00~~	~~Lec~~	~~SB-H7~~	~~JD~~	~~No lecture~~
					Hand in tutorial 4: Axial piles
Week 6					
Tue 3/5	13.15-15.00	Lec	SB-H7	JD	Pile load tests
	15.15-17.00	Tut	L400/L408	JD	Tut 5: Laterally loaded piles
Thu 5/5	13.15-15.00	Lec	SB-H7	JD	Shallow foundations
-”-	15.15-17.00	Tut	L400/L408	JD/HT/JT	Tut 5: Laterally loaded piles
Fri 6/5	13.15-15.00	Lec	SB-H7	JD	Introduction to pile project
Week 7					
Tue 10/5	13.15-15.00	Lec	SB-H7	JD	Shallow foundations
-”-	15.15-17.00	Tut	L400/L408	JD/JT/HT	Tut: 6 Shallow foundations
Wed 11/5	23.59		Canvas		**Hand in tutorial 5: Lateral piles**
Thu 12/5	13.15-15.00	Lec	SB-H7	JD	Introduction to pile project
-”-	15.15-17.00	Tut	L400/L408	JT/HT/JD	Project consultation
Fri 13/5	13.15-15.00	Lec	SB-H7	JD	Project consultation
-”-	23:59		Canvas		**Hand in of project part A on retaining wall 13 May 2022**
Week 8					

Tue 17/5	13.15-15.00	Lec	SB-H7	JD	Monitoring
-”-	15.15-17.00	Tut	L400/L408	JD/HT/JT	Project consultation
Thu 19/5	13.15-15.00	Lec	SB-H7	JT	Case study monitoring
-”-	15.15-17.00	Tut	L400/L408	JD/HT/JT	Project consultation
					Design project B: Piles, vertical equilibrium of final structure
Week 9					
Tue 24/5	13.15-15.00	Lec	SB-H7		Revision
-”-	15.15-17.00	Tut	Zoom	JD//HT/JT	Consultation design project
					Hand in of project part B on piles 3 June 2022