Course guides
250812 - 250812 - Underground Excavations

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.
Degree: MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Optional subject).
Academic year: 2020  ECTS Credits: 5.0  Languages: Spanish, English

LECTURER
Coordinating lecturer: NURIA MERCE PINYOL PUIGMARTI
Others: ALESSANDRA DI MARIANO SIMONCINI, NURIA MERCE PINYOL PUIGMARTI, ANNA RAMON TARRAGONA

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
13308. To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
13309. To characterize the geological environment and its interaction with civil works.
13310. To interpret laboratory tests and field observations so as to identify the mechanisms responsible for soil response. To propose laboratory testing programmes.
13311. To formulate and implement Finite Element and Finite Differences numerical models with the objective to analyze the processes that govern ground response, to interpret field information and to predict soil response.
13312. To analyze, discriminate and integrate geological and geotechnical information in studies and projects.
13313. To apply the knowledge on soil and rock mechanics to the development of the study, design, construction and exploitation of foundations, excavations, embankments, tunnels and other constructions on or through the soils, regardless of their nature and state or the finality of the works under study. (Specific competence of the specializations in Geotechnical Engineering and Earthquake Engineering and Geophysics).
13314. To analyze, from the perspective of an expert, cases of failure in Geotechnical Engineering. To report the evidences, identify the mechanisms responsible for the failure and verify using back? analysis models. Eventually provide solutions to risk reduction. (Specific competence of the specialization in Geotechnical Engineering).
13322. To realize studies of land management and urban spaces, including construction of tunnels and other underground infrastructures. (Specific competence of the specialization in Geotechnical Engineering).
13326. To use, in a discriminate manner, commercial software for numerical calculations in order to design and eventually monitor geotechnical structures. (Specific competence of the specialization in Geotechnical Engineering).

Generical:
13300. To apply advanced knowledge in sciences and technology to the profesional or research practice.
13301. To lead, coordinate and develop integrated projects in Geo-Engineering.
13302. To identify and design solutions for geo-engineering problems within ethical, social and legislative frameworks.
13303. To evaluate the impact of Geo-engineering on environment, sustainable social development and the significance of working within reliable and conscious professional environment.
13304. To incorporate new technologies and advanced tools in Geo-engineering into profesional and research activities.
13305. To conceive Geo-engineering as a multi-disciplinary field that includes relevant aspects from geology, sismology, hydrogeology, geotechnical and earthquake engineering, geomechanics, physics of porous media, geophysics, geomatics, natural hazard, energy and climate interactions.
13306. To promote innovation for the development of methodology, analyses and solutions in Geo-engineering.
13307. To tackle and solve advanced mathematical problems in engineering from the drafting of the problem to the development of formulation and further implementation in computer programs. Particularly, to formulate, code and apply analytical and numerical advanced computational tools to project calculations in order to plan and manage them as well as to interpret results in the context of Geo-engineering and Mining engineering.
TEACHING METHODOLOGY

The course consists of 3 in-class hours in which theory and problem solving will be taught and case stories will be presented.

Students will apply the knowledge acquired by means of a report, which will consist in elaborating a preliminary draft of a tunnel in a real life environment. Typically the report should include the following aspects:

- Topographic and geological description of the site
- Structural description of the rock massif. Section of the tunnel and geomechanical classification. Estimate of the global strength parameters
- Analysis of the rock-bearing interaction. Determination of the characteristic curves. Linear and non-linear failure envelopes. Bearing curves
- Definition of bearing from the interaction analysis and the geomechanical classifications
- Analysis of the structural stability of the excavation
- Definition of the building procedure

Support materials, such as a detailed teaching plan, can be found in the virtual campus ATENEA: table of contents, activities scheduled and references.
LEARNING OBJECTIVES OF THE SUBJECT

To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
To characterize the geological environment and its interaction with civil works.
To interpret laboratory tests and field observations so as to identify the mechanisms responsible for soil response. To propose testing programmes.
To formulate and implement Finite Element and Finite Differences numerical models with the objective to analyze the processes that govern ground response, to interpret field information and to predict soil response.
To analyze, discriminate and integrate geological and geotechnical information in studies and projects.
To apply the knowledge on soil and rock mechanics to the development of the study, design, construction and exploitation of foundations, excavations, embankments, tunnels and other constructions on or through the soils, regardless of their nature and state or the finality of the works under study (Specific competence of the specialities in Geotechnical Engineering and Earthquake Engineering and Geophysics).
To analyze, from the perspective of an expert, cases of failure in Geotechnical Engineering. To report the evidences, identify the mechanisms responsible for the failure and verify using back-analysis models. Eventually provide solutions to risk reduction. (Specific competence of the specialization in Geotechnical Engineering).
To realize studies of land management and urban spaces, including construction of tunnels and other underground infrastructures. (Specific competence of the specialization in Geotechnical Engineering).
To use, in a discriminate manner, commercial software for numerical calculations in order to design and eventually monitor geotechnical structures. (Specific competence of the specialization in Geotechnical Engineering).

* To apply limit analysis concepts to the calculation of limit load in soils.
* To interpret the behavior of soils with regards to critical state mechanics.
* To interpret the behavior of compacted soils with regards to the mechanics of unsaturated soils.
* To suggest a geotechnical field survey campaign.
* To suggest a laboratory research program.
* To critically analyze laboratory and field test results and to obtain soil parameters.
* To calculate shallow and deep foundations.
* To calculate earth contention structures.
* To calculate tunnels in rocks and soils.
* To calculate preloading settlements.
* To use numerical models to calculate soil-structure interaction problems.
* To analyze fracture cases from the point of view of an expert.

- Soil as a continuum. Elasticity and plasticity. Excavation principles. Excavating equipment.
- Application of the finite element method to the analysis of excavation and retaining procedures.
- Study of real cases.

The course addresses the principles of stability, design and construction of underground excavations from a geotechnical perspective, that is applied principles of mechanics of soils and rocks. Construction issues are also addressed to provide more complete information, which is closely linked to details of fundamental type or even theoretical (in the case of the analysis of the movements induced tunnels built by shields in the concepts of soil loss are directly linked the construction and design of the machines) operations. The agenda refers initially (very relevant in the case of tunnels) and description of the rock mass general historical aspects. In the section of rock tunnels special attention is paid to the full development of elastoplastic solutions for various cases that combine different constitutive models. The course a

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Hours medium group</td>
<td>9,8</td>
<td>7.83</td>
</tr>
<tr>
<td>Hours small group</td>
<td>9,8</td>
<td>7.83</td>
</tr>
<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.80</td>
</tr>
<tr>
<td>Self study</td>
<td>80,0</td>
<td>63.95</td>
</tr>
<tr>
<td>Hours large group</td>
<td>19,5</td>
<td>15.59</td>
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</tbody>
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**CONTENTS**

### Excavations and tunnels. History of tunnelling

**Description:**
- Excavations and tunnels.
- History of tunnel construction

**Full-or-part-time:** 7h 11m
- Theory classes: 3h
- Self study : 4h 11m

### Rock tunnel

**Description:**
- State insitu stress.
- Stress state around the tunnel. Elastic solutions.
- Geomechanical classifications and its application to tunnel project
  - Plain deformation. Elastoplastic Mohr-Coulomb model. Hoek-Brown elastoplastic model.
- Curves support. Bolts. Circular linings and ribs

**Full-or-part-time:** 34h 48m
- Theory classes: 9h
- Practical classes: 5h 30m
- Self study : 20h 18m

### Tunnel in soils

**Description:**
- Application of theorems of plastic collapse. 2D and 3D solutions for circular tunnels. Solutions based numerical methods.
- German and Belgian traditional methods. Tunneling machines. Examples.
- Tunnels expansive soils. Case Studies

**Full-or-part-time:** 31h 12m
- Theory classes: 7h
- Practical classes: 6h
- Self study : 18h 12m

### Tunnel Project

**Description:**
- Project description of a tunnel. Desing and execution.

**Full-or-part-time:** 9h 36m
- Practical classes: 4h
- Self study : 5h 36m
Exam

**Full-or-part-time:** 10h 48m  
Laboratory classes: 4h 30m  
Self study : 6h 18m

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**GRADING SYSTEM**

The course will be evaluated taking the mean of the two tests taken during the course and the final report.

There will be two tests: one at mid-term (E1) and another one by the end of the term (E2).

Both tests will evaluate the knowledge of the students with regards to what has been taught by the time of the test is scheduled.

The result of the tests will be the maximum score of the second test plus the weighted mean of both tests (the first test will weight 40% and the second test will weight 60%).

Final test result = \(\max (0.4 \times \text{Result of E1} + 0.6 \times \text{Result of E2} \; ; \; \text{ResultE2})\)

The report will be evaluated independently and will be 20% of the final score. The final score of the course will be calculated as follows:

Final score = 0.8 * Final test result + 0.2 * Report score

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**EXAMINATION RULES.**

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

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**BIBLIOGRAPHY**

Basic: