250819 - Soil Behaviour and Advanced Modelling

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2019
Degree: MASTER’S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: Spanish, English

Teaching staff
Coordinator: JEAN VAUNAT
Others: JEAN VAUNAT

Opening hours
Timetable: Out-of-room meetings are scheduled by agreement with the teacher

Degree competences to which the subject contributes

Specific:
13308. To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
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.
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).

Generical:
13300. To apply advanced knowledge in sciences and technology to the professional or research practice.
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 professional and research activities.
13305. To conceive Geo-engineering as a multi-disciplinary field that includes relevant aspects from geology, seismology, 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.
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Teaching methodology

The course consists of 3 hours per week of classroom activity.

During the course, 20 hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

15 hours are devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

Support material is provided using the virtual campus ATENEA: detailed teaching plan, content, learning advance plan, evaluation activities and literature.

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 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 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 advanced concepts in continuum media and material mechanics to soils and rocks.
* To use advanced behaviour laws to model the stress-deformation response of soils and rocks.
* To differentiate the response of laboratory reconstituted soils from that of natural soils.
* To correctly interpret the response of the latter.
* To use laws of behaviour that include the effect of environmental variables.
* To use in a discriminated manner calculation software to model geotechnical engineering problems.

- Laboratory soil testing. Controlling variables.
- Irreversible deformations within the limit envelope. Cyclic strain accumulation. Nested plasticity.
- Inclusion of environmental variables.
## Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Theory classes:</th>
<th>19h 30m</th>
<th>15.60%</th>
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<tbody>
<tr>
<td></td>
<td>Practical classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<tr>
<td></td>
<td>Laboratory classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<td></td>
<td>Guided activities:</td>
<td>6h</td>
<td>4.80%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
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<table>
<thead>
<tr>
<th><strong>Content</strong></th>
<th><strong>Learning time:</strong> 7h 11m</th>
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<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Theory classes: 3h</td>
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<tr>
<td></td>
<td>Self study: 4h 11m</td>
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</tbody>
</table>

**Description:**
Presentation of the course, teaching methodology, type of evaluation, self-presentation by students. Introduction about the content of the course: brief description of the typical responses of soils considered - clays and silts reconstituted in the laboratory, clays and natural silts, clay rocks, sands, cemented sands, sandstones - definition of the concept of micro-structure. Presentation the literature.

**Specific objectives:**
Recognize the difference between the behavior of natural and reconstituted soils. Acquire the concept of soil micro-structure. Be aware of the logistic aspects of the course (learning advance schedule, evaluation activities, ...).

<table>
<thead>
<tr>
<th><strong>Laboratory tests and modeling frameworks</strong></th>
<th><strong>Learning time:</strong> 14h 23m</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
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<tr>
<td></td>
<td>Practical classes: 2h</td>
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<tr>
<td></td>
<td>Self study: 8h 23m</td>
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</tbody>
</table>

**Description:**
Define the concept of deformation, stress and effective stress. Brief presentation of the theories of elasticity, plasticity and visco-plasticity. Formulation of the one-dimensional theory of perfect and hardening plasticity. One-dimensional Illustration of the concepts of loss of existence and uniqueness in material response. Presentation of conventional and unconventional tests available in the laboratory to study the response of soils. Implementation of a driver for the integration of an elastic model under triaxial conditions. Simulation of synthetic tests.

**Specific objectives:**
Handle the variables controlling the mechanical behavior of soil. Know available frameworks to model the behavior of soils. Handle more particularly the framework of elastoplasticity. Choosing the most appropriate laboratory tests to study the response of soils under given conditions. Interpret the experimental response. Acquire concepts to develop a driver for the integration of mechanical laws under mixed stress-strain control. Formulate an elastic model. Apply it to common stress paths in Geotechnics.
## Mechanical behavior of soils

**Learning time:** 48h  
- Theory classes: 7h  
- Practical classes: 13h  
- Self study: 28h

**Description:**  
Presentation of Mohr-Coulomb shear failure criterion. Formulation of an elastoplastic model based on this criterion. Description of solutions to the problem of the shape of the failure criterion in the deviatoric plane. Discussion on the dilatant aspect of the model. Brief presentation of applications of this type of model in Geotechnics.  
Development of an elastoplastic model based on shear strength criterion  
Remoulded soil behavior and modeling the phenomenon of dilatancy / contractancia  
Development of a model critical condition  
Behavior of natural soils and modeling of the phenomenon of destructuración  
Behavior within the limit envelope and modeling of the progressive appearance of plastic deformations  
Development of an elastoplastic model with softening by degradation

## Soil behavior under environmental actions

**Learning time:** 19h 12m  
- Theory classes: 8h  
- Self study: 11h 12m

**Description:**  
Modelling unsaturated soil behavior  
Modeling of the thermal load response  
Introduction to modeling the response of soils under chemical changes  
Introduction to the modeling of microstructural changes

## Final evaluation

**Learning time:** 4h 48m  
- Laboratory classes: 2h  
- Self study: 2h 48m

## Qualification system

Course mark is computed from the ratings obtained during continuous evaluation activities and evaluation tests.  
Continuous evaluation consists in several additive and training activities carried out during the year in and out of the classroom. They are realized individually or in group.  
Evaluation tests consist of questions on concepts associated with knowledge/understanding learning objectives, completed by several application exercises.
Regulations for carrying out activities

Any continuous evaluation activity not presented in the scheduled period will be granted with a null mark.

Bibliography

Basic:

