250820 - Numerical Models in Geotechnical Engineering

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: ALBERTO LEDESMA VILLALBA
Others: ANTONIO GENS SOLE, ALBERTO LEDESMA VILLALBA

Opening hours

Timetable: Class days before or after class. Agreed hours.

Degree competences to which the subject contributes

Specific:
13308. To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
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.
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.
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 conscionsous profesional environment.
13304. To incorporate new technologes 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.
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**Teaching methodology**

The course consists of 3 hours/week of classes in a small group. Approximately, 2 hours/week correspond to theoretical classes and the rest to practical classes involving examples developed on a computer.

Additional material is also provided on the website ATENEA, including the material used in the class as well.

**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.

- Soil constitutive models.
- Rock mechanics problems.
- Structure and use of a Finite Element program.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 19h 30m</th>
<th>15.60%</th>
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</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>9h 45m</td>
<td>7.80%</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<tr>
<td>Guided activities:</td>
<td>6h</td>
<td>4.80%</td>
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<tr>
<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
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</table>
### 250820 - Numerical Models in Geotechnical Engineering

#### Content

<table>
<thead>
<tr>
<th><strong>Introduction. The Finite Element Method.</strong></th>
<th><strong>Learning time:</strong> 14h 23m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 5h</td>
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<tr>
<td></td>
<td>Practical classes: 1h</td>
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<tr>
<td></td>
<td>Self study: 8h 23m</td>
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</tbody>
</table>

**Description:**
- Brief presentation of the subject and the numerical methods in the context of Geotechnical Engineering.
- Reminder of the basics of the Finite Element Method.
- Examples of application of the finite element method to problems of elasticity in 2 dimensions.

**Specific objectives:**
- Presentation about the subject.
- Remember the concepts of Finite Element Method in general.
- Illustrate the theory of finite element method with simple examples.

<table>
<thead>
<tr>
<th><strong>Constitutive equations. Elastic and Elasto-plastic models.</strong></th>
<th><strong>Learning time:</strong> 21h 36m</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 8h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 12h 36m</td>
</tr>
</tbody>
</table>

**Description:**
- Description of critical state models.
- Description of other typical models in Geotechnics. The elastic - perfect plastic Mohr-Coulomb model. Hardening and softening. Visco-elastic and visco-plastic models.
- Examples of application of constitutive equations.

**Specific objectives:**
- Role of constitutive equations in numerical analysis. Description of elastic model and its variants.
- Understanding the fundamental features of the critical state models and its ability to simulate the mechanical behavior of the soil.
- Understanding other families of constitutive models from the basic models of plasticity.
- Illustration theoretical aspects described in the subject.
### Fluid-solid interaction. Formulation of Biot

**Learning time:** 21h 36m  
Theory classes: 7h  
Practical classes: 2h  
Self study: 12h 36m

**Description:**  

**Specific objectives:**  
Understand the concept of H-M coupled formulation of the problem and the particular case of the u-p formulation. Understanding a particular case of application of the u-p formulation. See the application of the u-p formulation to seismic engineering problems in the context of Geotechnics. Illustrating the u-p formulation in complex real problems.

### Boundary value problems in Geotechnical Engineering

**Learning time:** 14h 23m  
Theory classes: 6h  
Self study: 8h 23m

**Description:**  
Specific aspects of geotechnical problems: initial stresses, effective stresses and dissipation of water pressure. Specific aspects to be considered in problems of construction and excavation

**Specific objectives:**  
Understanding some specific aspects of Geotechnical Engineering in the field of simulation of real problems by finite elements. Understand the specific aspects to be considered in geotechnical problems when solving via finite elements.

### Application examples

**Learning time:** 16h 48m  
Practical classes: 7h  
Self study: 9h 48m

**Description:**  
Illustration of the concepts explained in various problems

**Specific objectives:**  
Understand the application of numerical methods in real cases of Geotechnical Engineering.
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Assessment

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

Qualification system

Final exam of the subject at the end of the semester. Additional examination after at least a week for students who do not pass the initial exam.

Regulations for carrying out activities

Exams consist of several short questions to answer in the sheets provided. Books, class-notes, etc. are not allowed. Typical duration: 2 hours.

Bibliography

Basic:


Others resources: