250806 - Groundwaves Generation and Propagation

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 Compulsory)
ECTS credits: 5
Teaching languages: Spanish, English

Teaching staff

Coordinator: ALBERTO LEDESMA VILLALBA
Others: JOSE ORIOL CASELLES MAGALLON, ALBERTO LEDESMA VILLALBA, ANTONIO LLORET MORANCHO

Opening hours

Timetable: After hours of class and appointments with the professors of the subject.

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.

Generical:
13300. To apply advanced knowledge in sciences and technology to the professional or research practice.
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.

Teaching methodology

The course consists of 3 hours per week of classroom activity. That includes theory classes and solving of practical problems, according to the programme.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Some laboratory sessions are also planned: tests on soil dynamic properties and geophysical equipments.
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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 laboratory 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 apply the theoretical concepts of flow and transportation on porous media.
* To characterize soils.
* To apply the theoretical concepts of deformation and flow in soils.
* To characterize rock massifs and their discontinuities.
* To apply the concepts of mechanical stability and flow in cracks.
* To apply the theoretical problems of elastic and electromagnetic wave propagation in soils and rocks.
* To interpret and process wave signals.

- Introduction to wave propagation in a continuum Time and frequency responses. Lineal and non-lineal systems.
- Elastic waves in soils. Material behaviour under dynamic loads. Laboratory tests to determine dynamic properties.
- Analysis of soil dynamic response. Analysis in total and effective stress.
- Analysis of a real case.
- Basic concepts of soil-structure interaction.

Generation and propagation of electromagnetic waves in the soil.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Theory classes: 19h 30m</th>
<th>15.60%</th>
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</thead>
<tbody>
<tr>
<td>Practical classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<tr>
<td>Laboratory classes:</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>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 7h 11m</th>
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</table>
| Waves in the ground | Theory classes: 3h  
Self study: 4h 11m |

**Description:**
Description of the generation of seismic waves in the ground. Earthquakes.

**Specific objectives:**
Understanding the origin of the seismic waves and types of waves.

<table>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 14h 23m</th>
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</thead>
</table>
| Tools for wave analysis | Theory classes: 4h  
Practical classes: 2h  
Self study: 8h 23m |

**Description:**
Introduction to wave analysis tools based on the Fourier transform. Exercises about the subject.

**Specific objectives:**
Understanding the spectral representation of a seismic signal. To help understanding the concepts and practicing the tools explained the subject.

<table>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 16h 48m</th>
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</thead>
</table>
| Resonance. Wave propagation | Theory classes: 4h  
Practical classes: 2h  
Laboratory classes: 1h  
Self study: 9h 48m |

**Description:**
Presentation of the wave equation and associated aspects, such as resonance and conservation of energy flow. Application examples. Introduction to the application of wave propagation in soil and rock characterization.

**Specific objectives:**
Understanding resonance phenomenon and the wave equation in a continuous medium. To illustrate the concepts with examples of application. Brief description of survey techniques based on the principle of wave propagation in the ground.
## Introduction to Soil Dynamics

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>9h 36m</th>
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</thead>
<tbody>
<tr>
<td><strong>Theory classes:</strong></td>
<td>4h</td>
</tr>
<tr>
<td><strong>Self study:</strong></td>
<td>5h 36m</td>
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</table>

**Description:**
Introduction to soil dynamics. Dynamic behavior of soils in the laboratory and in the field.

**Specific objectives:**
Understanding the behavior of the ground when receiving a seismic wave.

## Soil Liquefaction

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>12h</th>
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</thead>
<tbody>
<tr>
<td><strong>Theory classes:</strong></td>
<td>3h</td>
</tr>
<tr>
<td><strong>Laboratory classes:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Self study:</strong></td>
<td>7h</td>
</tr>
</tbody>
</table>

**Description:**
Introducing the concept of soil liquefaction. Study in the laboratory and determining the risk of liquefaction in the field. Visit to the Geotechnical Laboratory. Presentation of Soil Dynamics equipments.

**Specific objectives:**
Understanding the concept of soil liquefaction due to a seismic signal and to learn the tools available for their study.
To know the equipments available to study the dynamic properties of soils.

## Dynamic response of the soil

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<th><strong>Learning time:</strong></th>
<th>14h 23m</th>
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<tbody>
<tr>
<td><strong>Theory classes:</strong></td>
<td>4h</td>
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<tr>
<td><strong>Practical classes:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Self study:</strong></td>
<td>8h 23m</td>
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**Description:**
Introducing methodologies for the analysis of wave propagation at local level in a soil deposit.
Application examples

**Specific objectives:**
Understanding the different methodologies available for analyzing the response of the ground locally.
Examples to illustrate the concepts of the subject
Applications in Geotechnical Engineering

**Description:**
Present some applications of the concepts worked in the field of Geotechnical Engineering (geotechnical works, soil-structure interaction) and Geological Engineering (slopes), etc.

**Specific objectives:**
Illustration of the concepts presented in the course.

Evaluation

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

Qualification system

The mark of the course is obtained from a final exam. This exam consists of several questions and/or short exercises that must be answered without using any support material.

There are guided activities that are marked and may increase the final mark up to 1 point.

Regulations for carrying out activities

Failure to perform any assessment activity in the scheduled period will result in a mark of zero in that activity.
Bibliography

Basic:


Complementary:

