250520 - ENGSISM - Earthquake Engineering

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2015
Degree: MASTER'S DEGREE IN GEOLOGICAL AND MINING ENGINEERING (Syllabus 2013). (Teaching unit Compulsory)
MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Teaching unit Optional)
MASTER'S DEGREE IN GEOTECHNICAL AND EARTHQUAKE ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 5  Teaching languages: Spanish

Teaching staff
Coordinator: LUIS GONZAGA PUJADES BENEIT
Others: JOSE ORIOL CASELLES MAGALLON, LUIS GONZAGA PUJADES BENEIT

Opening hours
Timetable: Thursday from 12 to 14 and by appointment.

Degree competences to which the subject contributes

Specific:
8211. The ability to address and solve advanced mathematical problems in engineering, from the scope and context of the problem to its statement and implementation in a computer program. In particular, the ability to formulate, program and apply advanced analytical and numerical calculation models to the design, planning and management of a project, as well as the ability to interpret the results obtained in the context of mining engineering.
8217. Ability to conduct land management studies, including the construction of tunnels and other underground infrastructures.
8241. Adequate knowledge of modelling, assessment and management of geological resources, including groundwater, mineral and thermal resources.

Teaching methodology
The course consists of 45 hours of class. 20 hours are devoted to lectures, 20 hours to exercises and practical problems, including analysis and processing of seismic signals in MatLab platform, and 5 hours to directed works. Students must complete a course work on accelerograms of a major earthquake. The work can be done on an individual or group format. Supporting materials are provided at the virtual campus ATENEA.

Learning objectives of the subject
Adequate knowledge of modeling, assessment and management of geological resources, including groundwater, mineral and thermal resources.

Ability to conduct land management studies, including the construction of tunnels and other underground infrastructures.

Ability to address and solve advanced mathematical engineering problems, from problem statement to formulation development and its implementation in a computer program. In particular, the ability to formulate, plan and implement advanced analytical models and numerical calculation, project planning and management, and the ability to interpret the results in the context of mining engineering.
Specialized knowledge on Geotechnics to be able to apply advanced techniques and methodologies. The aim is to deepen the knowledge on geotechnical engineering to design and build any geotechnical structure such as the design of stable slopes and tunnels, as well as to enhance the knowledge related to ground infrastructure engineering and earthquake engineering.

Geomechanics and Geotechnical Engineering, Design and Construction of geotechnical projects, slope stability, geotechnical engineering related to infrastructures, seismic engineering.

Introduce students in the fundamentals of Engineering Seismology and Earthquake Engineering, focusing on the definition of the seismic actions.

<table>
<thead>
<tr>
<th>Study load</th>
<th>125h</th>
<th>Theory classes:</th>
<th>19h 30m</th>
<th>15.60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time:</td>
<td></td>
<td>Practical classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<tr>
<td></td>
<td></td>
<td>Laboratory classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<td></td>
<td></td>
<td>Guided activities:</td>
<td>6h</td>
<td>4.80%</td>
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<tr>
<td></td>
<td></td>
<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
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</tbody>
</table>
### Content

<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01 Introduction</strong></td>
<td>2h 24m</td>
</tr>
<tr>
<td><em>Description:</em></td>
<td></td>
</tr>
<tr>
<td>Objectives of the course. Historical Introduction. Seismology, engineering seismology and Earthquake Engineering.</td>
<td></td>
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<tr>
<td><em>Specific objectives:</em></td>
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<tr>
<td>Definition of the parameters, terms and concepts specific to seismology and earthquake engineering.</td>
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<tr>
<td><strong>02 Elements of spectral analysis.</strong></td>
<td>4h 48m</td>
</tr>
<tr>
<td><em>Description:</em></td>
<td></td>
</tr>
<tr>
<td>Spectral analysis I</td>
<td></td>
</tr>
<tr>
<td><em>Specific objectives:</em></td>
<td></td>
</tr>
<tr>
<td>Review of numerical analysis and mathematical aspects of signal processing oriented to the analysis seismograms and accelerograms.</td>
<td></td>
</tr>
<tr>
<td><strong>03 Analysis of accelerograms</strong></td>
<td>7h 11m</td>
</tr>
<tr>
<td><em>Description:</em></td>
<td></td>
</tr>
<tr>
<td>Near field: effects of earthquakes on structures and soil effects. Practical cases. Time domain: acceleration, velocity and displacement. The baseline problem. Bracketed durations and peak ground acceleration, peak ground displacement and permanent displacements. Other parameters that quantify the severity of strong seismic actions. Fourier spectrum: amplitude and phase. Long period effects. Filtering. Baseline correction.</td>
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<tr>
<td><em>Specific objectives:</em></td>
<td></td>
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<tr>
<td>Knowing in practice the parameters that define the severity of an earthquake in a site. Understanding and analyzing the ground motion in the frequency domain. To detect and correct long period effects on the baseline.</td>
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</tbody>
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### 04 Response and response spectra

**Description:**
Response of a linear system with one degree of freedom. Acceleration, velocity and displacement responses.
Equació del moviment. Resposta d’acceleració, velocitat i desplaçament. Valors màxims. aproximació de petits esmorteïments.

**Specific objectives:**
Knowledge of the response of a single degree of freedom linear system. To understand, at qualitative and quantitative levels, the meaning of the response spectrum as the maximum response of a single degree of freedom damped linear system.

**Learning time:** 9h 36m  
Theory classes: 4h  
Self study: 5h 36m

### 05 Local effects

**Description:**
Introduction. Importance of local effects. Cases. Effects of surface topography, soil and subsurface geometry: amplification.

**Specific objectives:**
To introduce students to the assessment of the effects of seismic amplification due to the geology and / or topography.
To introduce students to the assessment of the effects of seismic amplification due to the geology and / or local topography.

**Learning time:** 9h 36m  
Theory classes: 4h  
Self study: 5h 36m

### 06 Design spectra

**Description:**
Smoothed response spectra. Definition of the seismic actions in seismic codes. The Spanish code NCSE-02. The Eurocode EC08.

**Specific objectives:**
To know how the seismic action is defined in seismic codes.

**Learning time:** 4h 48m  
Theory classes: 2h  
Self study: 2h 48m
<table>
<thead>
<tr>
<th><strong>07 Advanced topics</strong></th>
<th><strong>Learning time:</strong> 9h 36m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theory classes:</strong> 4h</td>
<td></td>
</tr>
<tr>
<td><strong>Self study:</strong> 5h 36m</td>
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**Description:**

**Specific objectives:**
To discuss and analyze the directionality effects on the definition of the seismic action and on the expected damage.
To know how to obtain accelerograms compatible with design spectra.
08 Practices

<table>
<thead>
<tr>
<th>Learning time: 45h 36m</th>
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<tbody>
<tr>
<td>Practical classes: 9h</td>
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<tr>
<td>Laboratory classes: 10h</td>
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<tr>
<td>Self study: 26h 36m</td>
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Description:
Spectral analysis of a seismogram. Amplitude and phase spectra.
Conditioning seismic signals in the time domain.
Interpolation and filtering.
Spectral intensity of Arias and Housner
Design spectra: EC8 and NCSE-02.
Orientations for the course work
Analysis of accelerograms I: velocigrams and displacigrams
Analysis of accelerograms II: Response spectra
Calculation and comparison of response spectra and Fourier spectra.
Modal analysis of a building
Modify a given accelerograms in such a way that its response spectrum is consistent with a given design spectrum.

Specific objectives:
Learning to analyze numerical series that define the acceleration data easily using Matlab programming.
Interpolating and filtering seismic signals.
Obtaining Arias and Housner intensities.
Design spectra: EC8 and NCSE-02.
Orientations for the course work
Integration of the accelerograms. The baseline problem.
Obtaining response spectra.
Verify that the undamped velocity response spectrum is comparable to the Fourier amplitude spectrum of the acceleration.
To understand the influence of the sensor orientation on the definition of the seismic actions. To understand the influence of the orientation of the building on the expected damage.

Learn to modify accelerograms in a way that its response spectrum is compatible with a certain design spectrum.

Qualification system

The course assessment takes into account the following: attendance; exercises; course work, written exam.

Regulations for carrying out activities

If not done any activity planned in the period, will be considered as a zero points score.
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Bibliography

**Basic:**


**Complementary:**
