

Course guide

250520 - ENGSISM - Earthquake Engineering

Last modified: 07/10/2020

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: **Academic year:** 2020 **ECTS Credits:** 5.0
Languages: Spanish, English

LECTURER

Coordinating lecturer: MARCOS ARROYO ALVAREZ DE TOLEDO

Others: MARCOS ARROYO ALVAREZ DE TOLEDO, JOSE ORIOL CASELLES MAGALLON, ALFONSO RODRIGUEZ DONO, YEUDY FELIPE VARGAS ALZATE

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 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.

Transversal:

8560. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

8561. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

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.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	9,8	7.83
Hours small group	9,8	7.83
Guided activities	6,0	4.80
Self study	80,0	63.95
Hours large group	19,5	15.59

Total learning time: 125.1 h

CONTENTS

01 Introduction

Description:

Objectives of the course. Historical Introduction. Seismology, engineering seismology and Earthquake Engineering.

Specific objectives:

Definition of the parameters, terms and concepts specific to seismology and earthquake engineering.

Full-or-part-time: 2h 24m

Theory classes: 1h

Self study : 1h 24m



02 Elements of spectral analysis.

Description:

Spectral analysis I

Specific objectives:

Review of numerical analysis and mathematical aspects of signal processing oriented to the analysis seismograms and accelerograms.

Full-or-part-time: 4h 48m

Theory classes: 2h

Self study : 2h 48m

03 Analysis of accelerograms

Description:

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.

Specific objectives:

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.

Full-or-part-time: 7h 11m

Theory classes: 3h

Self study : 4h 11m

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.

Full-or-part-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. Methods for estimating the effects of soil: empirical and analytical. Analytical methods: calculation programs. Empirical methods: site reference and spectral ratios. The method of Nakamura. Case studies.

Specific objectives:

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

Full-or-part-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

Full-or-part-time: 4h 48m

Theory classes: 2h

Self study : 2h 48m

07 Advanced topics

Description:

Acceleration records: horizontal and vertical components. Different ways to define the horizontal seismic action. Influence of the orientation of the recorder. Orientation independent measures. Importance of the building orientation.

Incremental dynamic analysis. Real, synthetic and hybrid accelerograms. matching accelerograms to design spectra. Spectral matching.

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.

Full-or-part-time: 9h 36m

Theory classes: 4h

Self study : 5h 36m



08 Practices

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: velocigrames and desplacigrames
Analysis of accelerograms II: Response spectra
Calculation and comparison of response spectra and Fourier spectra.
Modal analysis of a building
Modify a given accelerogram so that its response spectrum matches 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.

Full-or-part-time: 45h 36m

Practical classes: 9h

Laboratory classes: 10h

Self study : 26h 36m

GRADING SYSTEM

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

EXAMINATION RULES.

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

BIBLIOGRAPHY

Basic:

- Lee, W.H.K. [et al.] (ed.). International handbook of earthquake and engineering seismology. Amsterdam: Academic, 2002-2003. ISBN 0124406521.
- Chopra, A.K. Dynamics of structures : theory and applications to earthquake engineering [on line]. 5th ed. Harlow: Pearson Education Limited, 2020 [Consultation: 08/02/2021]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?docID=5811586>. ISBN 9781292249209.

Complementary:

- Brigham, E.O. The fast Fourier transform and its applications. Englewood Cliffs, NJ: Prentice Hall, 1988. ISBN 0133075052.
- Sarria, A. Ingeniería sísmica. Bogotá: Ediciones Uniandes, 1990. ISBN 9789589057131.