



## Course guide

### 250830 - 250830 - Sismology

**Last modified:** 25/01/2024

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

**Degree:** MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Optional subject).

**Academic year:** 2023    **ECTS Credits:** 5.0    **Languages:** Spanish

#### LECTURER

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**Coordinating lecturer:** YEUDY FELIPE VARGAS ALZATE

**Others:** JOSE ORIOL CASELLES MAGALLON, LUIS GONZAGA PUJADES BENEIT, YEUDY FELIPE VARGAS ALZATE

#### TEACHING METHODOLOGY

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The course consists of 45 hours. 27 hours are devoted to theoretical lectures and 12 hours to problems and practices. 6 hours are set apart for other activities. The student must perform four practical exercises. Support materials are provided through the virtual campus of ATENEA.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

## LEARNING OBJECTIVES OF THE SUBJECT

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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 analyze, discriminate and integrate geological and geotechnical information in studies and projects.

To apply the knowledge on soil and rock mechanics to the development of the study, design, construction and exploitation of foundations, excavations, embankments, tunnels and other constructions on or through the soils, regardless of their nature and state or the finality of the works under study (Specific competence of the specialties in Geotechnical Engineering and Earthquake Engineering and Geophysics).

To assess seismic risks. To plan and dimension risk reduction measures. (Specific competence of the specialization in Earthquake Engineering and Geophysics).

To identify all types of structures and materials. To design, plan, implement and maintain structures and buildings in civil works. (Specific competence of the specialization in Earthquake Engineering and Geophysics).

To analyze the structures, by applying advanced methods, design software and structural calculations, from the knowledge and understanding of the forces and their application to the structural typologies used of civil engineering. To perform structural integrity assessment. (Specific competence of the specialization in Earthquake Engineering and Geophysics).

To perform studies of seismic hazard. (Specific competence of the specialization in Earthquake Engineering and Geophysics).

\* To understand, speaking of advanced use, the theoretical and practical concepts in seismology.

\* To know and be able to deal with the different seismic wave recording procedures at a global, regional and local level, as well as the tools used in the near and far field and the instrumentation of buildings and structures.

\* To know the risk assessment methods and techniques and to be able to develop studies applied to seismic risk.

\* To know and apply soil surveying techniques using non-destructive geophysical tools and techniques.

\* To have a global vision on how to address the main problems falling to seismology for engineering and earthquake engineering.

- The seismic phenomenon: causes and effects.

- Principal waves and seismic phases.

- Mechanism of earthquakes.

- Size of earthquakes: magnitude and intensity.

- Empirical formulas.

To introduce students to the concepts, methods and applications of seismology, with special emphasis on those aspects related to engineering seismology and earthquake engineering.

## STUDY LOAD

Type	Hours	Percentage
Hours large group	25,5	20.38
Hours small group	9,8	7.83
Self study	80,0	63.95
Hours medium group	9,8	7.83

**Total learning time:** 125.1 h



## CONTENTS

### 01 Introduction

**Description:**

Historical aspects. Seismology in the world. Associations and scientific institutions. Seismological observatories. Seismological Service institutions in Spain, in Catalonia and in the world.

**Specific objectives:**

To know seismology in the history and in the world.

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

Theory classes: 2h

Self study : 2h 48m

### 02 The seismic phenomenon

**Description:**

Plate tectonics. Global, regional and local tectonics. Importance of local and regional tectonics. Compressive, distensive and tear regimes. Regional and local stress tensors.

Historic earthquakes. The Lisbon 1755 earthquake. Duality of the study of earthquakes.: science and engineering, seismology and earthquake engineering.

**Specific objectives:**

Understanding the causes of earthquakes in different tectonic environments.

Know the main characteristics of earthquakes and their effects.

**Full-or-part-time:** 10h 48m

Theory classes: 4h 30m

Self study : 6h 18m

### 03 Seismic phases

**Description:**

Equation of motion. Infinite, semi-infinite and stratified media. Internal waves and surface waves.

Main seismic phases observed in the Earth. Internal waves: near, far and shadow zone earthquakes near, far and shaded area.

Reflected and refracted waves. Phases of deep earthquakes. Surface Rayleigh and Love waves. Other seismic waves. Anatomy of seismograms.

Geometry of the arrival of internal waves: SV, SH, SVV, SVH, PV, PH, angles of incidence of the P wave, azimuth, angle of polarization of the wave S.

To determine an epicenter with data from a single station, using the polarities and amplitudes of the P wave, arrivals of P and S waves and travel time tables of internal waves. Three approaches are suggested: graphic, velocity models and seismological tables. Determine the geographical coordinates of the epicenter and origin time. Discuss the problem of determining the depth of the earthquake.

Detailed analysis of the ground motion caused by a Rayleigh surface wave. Determine the station-epicenter azimuth.

**Specific objectives:**

To know the main waves propagating in continuous infinite, semi-infinite and stratified media..

To know the main seismic phases observed on Earth.

To study the geometry of the arrival of the internal waves P and S.

Learn how to make a determination epicentral.

Characterize the ground motion caused by seismic shocks.

**Full-or-part-time:** 20h 24m

Theory classes: 5h 30m

Practical classes: 3h

Self study : 11h 54m



#### 04 The size of earthquakes

**Description:**

Concept of macro-seismic intensity. Main scales. The MM'56 and the EMS'98 scales.

Seismic magnitude, seismic moment and energy. Magnitude of internal and surface waves. Standard formulas. Local magnitude formulas. Empirical equations and formulas.

Determine the magnitude of an earthquake from a Rayleigh wave. Using empirical formulas for estimating the other parameters that define the size of the earthquake: intensity, magnitude of internal waves, seismic moment and energy.

**Specific objectives:**

To know the macro-seismic quantification of the size of earthquakes.

To know, at an applied level, the main parameters used to determine the size of earthquakes.

To learn to estimate the magnitude of an earthquake and other parameters associated with it.

**Full-or-part-time:** 21h 36m

Theory classes: 5h

Practical classes: 2h

Laboratory classes: 2h

Self study : 12h 36m

#### 05 Seismic and macroseismic attenuation

**Description:**

Isoseismal zones. Variation of intensity with distance. Laws attenuation laws. Applications to seismic hazard analysis.

Other instrumental parameters of the maximum ground motion. Spectral parameters: response spectra. Empirical relationships.

Main attenuation laws. Relationship with the seismic hazard.

**Specific objectives:**

To learn about macro-seismic attenuation laws.

To know about attenuation laws of other instrumental parameters.

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

Theory classes: 4h

Self study : 5h 36m

#### 06 The mechanism of earthquakes

**Description:**

Historical Introduction to the mechanism of earthquakes. The elastic rebound. Parameters of the causing fault: azimuth, dip and slip. Conjugate faults. Normal, reverse and shear faults.

The inverse problem. simplified models: simple pair of forces, double pair without moment. Radiative models for P and S waves. P waves based mechanism: azimuth, emergence angle and polarity. The focal sphere. Stereo-graphic projections. Conjugate plans. Graphical representation. Multiple mechanisms. Linking tectonics and focal mechanism. Advanced methods of full waveform inversion. Focal mechanism catalogs.

Determine a mechanism from the first P wave arrivals.

**Specific objectives:**

To know and to understand the fundamentals of the mechanism of the source of earthquakes.

Learn estimate focal mechanisms from the polarities of the arrivals of the waves P.

To learn how to determine a focal mechanism and associated parameters.

**Full-or-part-time:** 19h 12m

Theory classes: 4h 30m

Laboratory classes: 3h 30m

Self study : 11h 12m



## 07 Other topics.

### Description:

Parameters of interest in earthquake engineering. Response and response spectra. Seismic hazard and risk. Seismic damage. Earthquake-resistant design. Realization and discussion of problems.

### Specific objectives:

To introduce students to earthquake engineering. Realization and discussion of selected problems

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

Theory classes: 1h 30m

Laboratory classes: 1h 30m

Self study : 4h 11m

## GRADING SYSTEM

The course evaluation is based on the assessment of the problems and practices carried out by the students but it also takes into account the attendance and an exam. The final grade is a weighted average of the marks of the continuous assessment of problems and practices and of the grade of the exam.

## EXAMINATION RULES.

If not done any of the scheduled activities, it will be considered as a zero score.

## BIBLIOGRAPHY

### Basic:

- Aki, K.; Richards, P.G. Quantitative seismology. 2nd ed. Sausalito: University Science Books, 2002. ISBN 0935702962.
- Lee, W.H.K [et al.] (eds.). International handbook of earthquake and engineering seismology: Part A (2002): Part B (2003).. Amsterdam [etc.]: Academic Press, 2002-2003. ISBN 0124406521 (PART A) ; 0124406580 (PART B)..

### Complementary:

- Udías, A.; Buforn, E. Principles of seismology. 2nd ed. Cambridge: Cambridge University Press, 2018. ISBN 9781107138698.
- Shearer, P.M. Introduction to seismology. 2nd ed. Cambridge: Cambridge University Press, 2009. ISBN 9780521708425.
- Payo, G. Introducción al análisis de sismogramas. Madrid: Instituto Geográfico Nacional, 1986. ISBN 8450540097.
- Kulhánek O. Anatomy of seismograms. Amsterdam: Elsevier, 1990. ISBN 0444883754.