Course guides
250839 - 250839 - Statistics Applied to Civil and Earthquake Engineering

Last modified: 07/10/2020

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 753 - TA - Department of Architectural Technology.

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

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

LECTURER

Coordinating lecturer: FRANCISCO LOPEZ ALMANSA

Others: FRANCISCO LOPEZ ALMANSA

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Generical:
13300. To apply advanced knowledge in sciences and technology to the profesional or research practice.
13301. To lead, coordinate and develop integrated projects in Geo-Engineering.
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 consciensous profesional environment.
13304. To incorporate new techncologies 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.

TEACHING METHODOLOGY

The course consists of 2,4 hours per week of classroom activity (large size group).

The 2,4 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

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.

LEARNING OBJECTIVES OF THE SUBJECT

To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
To analyze, discriminate and integrate geological and geotechnical information in studies and projects.
To dimension civil structures in the presence of seismic forces. To dimension corrective solutions. (Specific competence of the specialization in 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 have basic and advanced knowledge on the linear or non-linear structural calculation.
* To know and be able to treat different types of structures of interest in earthquake engineering.
* To know the active and passive vibration control methods and techniques in buildings.
* To know and apply advanced techniques of using special and composed materials.
* To have a global vision of how to deal with the main problems regarding the dynamic response of builidngs and structures.
* To know and apply the main seismoresistant design and construction regulations.

- Probability concepts.
- Statistical inference.
- Random, real and multidimensional processes.
- Gaussian processes.
- Stationarity and ergodicity.
- Process operations.
- Random response of linear and nonlinear systems.
- Systems with stationary and non-stationary response.
- First incursion and fatigue failure.
- Monte Carlo method .
- Statistical linearization.
- Applications.

Present an overview of the applications of statistics in civil and earthquake engineering.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Probability

Description:
Conditional probability. Independence of events
Probability. Exercises

Specific objectives:
Review of probability theory

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

Random variables

Description:
Discrete and continuous variables. Real and multidimensional variables. Moments. Variance and covariance.
Exercises
Normal, log-normal distribution of Gumbel and Poisson. Applications to civil and seismic engineering. Operations with random variables. Characteristic function.
Random Variables Exercises (2)
Sequences of random variables. Law of large numbers. Central limit theorem. Statistical inference.
Exercises of random variables (3)

Full-or-part-time: 21h 36m
Theory classes: 6h
Practical classes: 3h
Self study : 12h 36m

Random processes

Description:
Real and multidimensional processes. Gaussian processes. Stationary and ergodicity.
Random processes exercises (1)
Spectral decomposition of processes. Process operations. Derivation and integration of processes.
Exercises
Markov processes. Distribution of extremes. Normal and Poisson processes.
Exercises

Full-or-part-time: 21h 36m
Theory classes: 6h
Practical classes: 3h
Self study : 12h 36m

Random vibrations

Description:
Random response of linear and nonlinear systems. Time and frequency domain analysis. Systems of one and several degrees of freedom.
Random vibrations exercises (1)
Modal analysis. Ruptures due to first incursion and fatigue. Systems with stationary and non-stationary response.
Random Vibration Exercises (2)
Monte Carlo method. Statistical linearization. Applications.
Random Vibration Exercises (3)

Full-or-part-time: 21h 36m
Theory classes: 6h
Practical classes: 3h
Self study : 12h 36m

Operational modal analysis

Description:
Time domain identification. AR and Poly-reference (PR) models. ARMA models.
Identification of Stochastic Subspaces (SSI). Frequency domain identification. Frequency domain decomposition (FDD). Applications

Full-or-part-time: 21h 36m
Theory classes: 6h
Practical classes: 3h
Self study : 12h 36m

GRADING SYSTEM

The mark is obtained from exercises solved by students outside the school hours

EXAMINATION RULES.

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

BIBLIOGRAPHY

Basic:
- Brincker, R.; Ventura, C.E. Introduction to operational modal analysis [on line]. West Sussex: John Wiley & Sons, 2015 [Consultation: 17/03/2021]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118535141. ISBN 9781118535141.
- Papoulis, A.; Pillai, S.U. Probability, random variables, and stochastic processes. 4th ed. Boston: McGraw-Hill, 2002. ISBN 0073660116.
- Roberts, J.B.; Spanos, P.D. Random vibration and statistical linearization. Mineola: Dover, 2003. ISBN 0486432408.
- Lin, Y.K. Probabilistic theory of structural dynamics. Repr. with corr. Huntington: Robert E. Krieger, 1976. ISBN 0882753770.
- Nowak, A.S.; Collins, K.R. Reliability of structures. 2nd ed. Boca Raton: CRC Press/Taylor & Francis Group, 2013. ISBN 9780415675758.

Complementary:
- Ash, R.B. Basic probability theory. New York: John Wiley, 1970. ISBN 0471034509.
- Ash, R.B. Real analysis and probability. New York: Academic Press, 1972. ISBN 0120652013.
- Bratley, P.; Fox, B.L.; Schrage, L.E. A guide to simulation. 2nd ed. New York: Springer-Verlag, 1987. ISBN 0387964673.
- DeGroot, M.H.; Schervish, M.J. Probability and statistics. 4th ed. Harlow: Pearson Education Limited, 2014. ISBN 9781292025049.
- Feller, W. Introducción a la teoría de probabilidades y sus aplicaciones. México: Limusa, 1973-1978. ISBN 9681807219.

- Lutes, L.D.; Sarkani, S. Stochastic analysis of structural and mechanical vibrations. Upper Saddle River: Prentice Hall, 1997. ISBN 0134905334.
- Nigam, N.C. Introduction to random vibrations. Cambridge: MIT Press, 1983. ISBN 0262140357.
- Rohatgi, V.K. An introduction to probability theory and mathematical statistics. New York: John Wiley and Sons, 1976. ISBN 0471731358.
- Sólnes, J. Stochastic processes and random vibrations: theory and practice. Chichester: John Wiley & Sons, 1997. ISBN 0471971928.
- Soong, T.T.; Grigoriu, M. Random vibration of mechanical and structural systems. Englewood Cliffs, New Jersey: PTR Prentice Hall, 1993. ISBN 0137523610.
- Rainieri, C.; Fabbrocino, G. Operational modal analysis of civil engineering structures: an introduction and guide for applications [on line]. New York, NY: Springer, 2014 [Consultation: 19/01/2021]. Available on: http://dx.doi.org/10.1007/978-1-4939-0767-0. ISBN 9781493907670.
- Lutes, L.D.; Sarkani, S. Random vibrations : analysis of structural and mechanical systems [on line]. Amsterdam: Elsevier, 2004 [Consultation: 24/03/2021]. Available on: https://www.sciencedirect.com/science/book/9780750677653. ISBN 0750677651.
- Schneider, J.; Vrouwenvelder, T. Introduction to safety and reliability of structures. 3rd. rev. ext. ed. Zürich: International Association for Bridge ans Structural Engineering, 2017. ISBN 9783857481512.