Course guides
250835 - 250835 - Static and Dynamic Structural Analysis

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

LECTURER

Coordinating lecturer: MARCOS ARROYO ALVAREZ DE TOLEDO

Others: MARCOS ARROYO ALVAREZ DE TOLEDO, JOSE RAMON GONZALEZ DRIGO

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
13308. To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
13312. To analyze, discriminate and integrate geological and geotechnical information in studies and projects.
13317. To dimension civil structures in the presence of seismic forces. To dimension corrective solutions. (Specific competence of the specialization in Earthquake Engineering and Geophysics).
13318. To assess seismic risks. To plan and dimension risk reduction measures. (Specific competence of the specialization in Earthquake Engineering and Geophysics).
13324. 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).
13325. 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).

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 3 hours per week of classroom activity (large size group).

The 3 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 the basic and advanced knowledge on linear or non-linear structural analysis.
* To know and be able to deal with the different types of structures significant in earthquake engineering.
* To know the methods and techniques for active and passive vibration control in buildings.
* To know and apply advanced techniques on the use of especial and composed materials.
* To have a global vision on howto address the main problems regarding the dinamic response of buildings and structures.
* To know and apply the main regulation on seismoresistant design and construction.

- Matrix analysis of structures.
- Plastic Analysis of structure and plate theory.
- Systems of one degree of freedom.
- Systems of n degrees of freedom.
- Seismic response and design of multi-levels buildings.
- Computational programs and structural analysis.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Statics of structures

Description:
INTRODUCTION TO THE STRUCTURAL ANALYSIS Introduction. Concept of structure in mechanical engineering. Classification of structures. Boundary conditions. Supports and links. Balance and compatibility. Linearity and superposition principle. static indeterminacy. Hiperestatismo degree. Kinematic indeterminacy. Traslacionalidad degree. Symmetrical balance and support structures. Movements and deformations taxes. isostatic and statically indeterminate structures. Classification analysis methods. Uniqueness of solutions. ACTIONS STRUCTURES Introduction. Actions in buildings. Types of actions. Loading assumptions. METHODS OF THE MATRIX ANALYSIS OF STRUCTURES Introduction. fundamental principles. geometric definition of the structure. Reference systems (global and local). acting loads and loading conditions. matrix form of elastic equations. Concepts of rigidity and flexibility of a piece midplane. Coordinate transformation. Stresses and displacements in local coordinates. a piece elastic equations midplane in global coordinates. RIGIDITY METHOD Introduction. Reticulated structures midplane. Assembly of the stiffness matrix of the structure. Boundary conditions. Calculation of displacement. Calculation of reactions. Calculating forces end parts. Joints. Examples. BARCODE TYPE OF STRUCTURES Introduction. Slatted planes. Spatial reticulated structures. Articulated flat structures. Articulated space structures.

Specific objectives:
Acquire knowledge, ability and competence for structural design of simple structural systems and for handling numerical calculation codes oriented linear and nonlinear calculation of conventional structures

Full-or-part-time: 19h 12m
Theory classes: 8h
Self study : 11h 12m

Plastic calculation of structures

Description:
PLASTIC ANALYSIS dimensional bar structures Plasticity. Moment resistant plastic. Structures subjected to tension rods. Porticoes and dominant bending beams forming plastic hinges.

Specific objectives:
Acquire knowledge, ability and competence for structural design of simple structural systems and for handling numerical calculation codes oriented linear and nonlinear calculation of conventional structures

Full-or-part-time: 7h 11m
Theory classes: 3h
Self study : 4h 11m

Plate theory

Description:
THEORY OF PLATES Introduction. Basic plate bending theory. Analytical solutions: rectangular and circular plates. Kirchhoff method and energy methods. Finite difference approximation. FLAT SURFACE STRUCTURES. APPLICATIONS Forjados reticular. Plates on ad hoc support. Virtual porticoes. Screens: Calculation Hypothesis. Assimilation porticoed structures. Wall Walls: Determination of limit load and failure mechanisms. STRUCTURES SURFACE CURVES. General Theory sheets and membranes Reed. Sheets revolution. Applications: spherical and cylindrical tanks. Approximate methods of calculation.

Specific objectives:
Acquire knowledge, ability and competence for structural design of simple structural systems and for handling numerical calculation codes oriented linear and nonlinear calculation of conventional structures

Full-or-part-time: 7h 11m
Theory classes: 3h
Self study : 4h 11m

estrcuturas dynamic calculation. systems one degree of freedom

Description:
ELEMENTS SYSTEMS Seismological a degree of freedom analysis of free vibrations harmonic excitations Response Response Response periodic excitations excitations Response Impulsive general dynamic excitations. Superimposition methods. Resolution methods step by step generalized nonlinear response Coordinates Response spectra

Specific objectives:
Acquire knowledge, ability and competence for the design and management of numerical calculation codes for solving linear and nonlinear problems in the field of earthquake engineering and structural dynamics.

Full-or-part-time: 19h 12m
Theory classes: 8h
Self study : 11h 12m

estrcuturas dynamic calculation. systems N degrees of freedom

Description:
STRUCTURES N degrees of freedom. SHEAR BUILDING matrix formulation of the equations of motion for shear buildings Free Vibrations Vibrations in buildings shear shear forced into buildings. Damping modal superposition method in buildings Reduction shear dynamic arrays multigrade SYSTEMS DISCREET OF FREEDOM dynamic analysis of beams and plane frames analysis response time. Stepper methods modeled DISTRIBUTED PROPERTIES dynamic characteristic analysis systems Discretization of continuous systems
Structure project

Specific objectives:
Acquire knowledge, ability and competence for the design and management of numerical calculation codes for solving linear and nonlinear problems in the field of earthquake engineering and structural dynamics

Full-or-part-time: 40h 48m
Theory classes: 9h
Laboratory classes: 8h
Self study : 23h 48m

GRADING SYSTEM

The mark of the course is obtained from the ratings of continuous assessment and their corresponding laboratories and/or classroom computers.

Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom).

The teachings of the laboratory grade is the average in such activities.

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application exercises.

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:
- Blanco, E.; Cervera, M.; Suárez, B. Análisis matricial de estructuras [on line]. Barcelona: CIMNE, Centro Internacional de Métodos Numéricos en Ingeniería, 2015 [Consultation: 05/03/2021]. Available on: http://cervera.rmee.upc.edu/libros/Analisis%20Matricial%20Estructuras.pdf. ISBN 9788494424458.
- Ghali, A; Neville, A.M. Structural analysis : a unified classical and matrix approach. Boca Raton: CRC Press, Taylor and Francis Group, 2017. ISBN 9781498725064.
- Szilard, R.. Theories and applications of plate analysis: classical numerical and engineering methods. New Jersey: John Wiley and sons, 2003. ISBN 9780471429890.
- 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.
- Humar, J.L. Dynamics of structures. 3rd ed. Boca Raton: CRC Press, Taylor & Francis Croup, 2012. ISBN 9780415620864.
- Paz, M. Structural dynamics, theory and computation [on line]. 4th ed. Cham: Springer International Publishing, 2019 [Consultation: 11/11/2020]. Available on: https://doi.org/10.1007/978-3-319-94743-3. ISBN 9783319947433.