Course guide
250232 - FORMARM - Reinforced Concrete

Last modified: 01/10/2023

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

Degree: BACHELOR'S DEGREE IN PUBLIC WORKS ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ALBERTO DE LA FUENTE ANTEQUERA, EVA MARIA OLLER IBARS

Others: ALBERTO DE LA FUENTE ANTEQUERA, EVA MARIA OLLER IBARS, DAVID VERGES COLL

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
3075. Knowledge of the bases and application of the behaviour of reinforced concrete and metal structures and the ability to conceive, design, construct and maintain this type of structures.
3079. Knowledge of the different types and basis for calculating prefabricated items and its application to the manufacturing processes
3080. Knowledge of the design, calculation, construction and maintenance of building works in regard to their structure, finishes, installations and equipment.
3087. Knowledge of and ability to design and dimension hydraulic works and facilities, energy systems and the harnessing of hydroelectric energy, and plan and manage surface and underground hydraulic resources
3091. Ability to construct, conserve, dimension and design roads and the items comprising basic road provision
3092. Ability to construct and conserve railway lines with knowledge of the application of the specific technical regulations, differentiating the characteristics of the rolling stock

Generical:
3105. Students will learn to identify, formulate and solve a range of engineering problems. They will be expected to show initiative in interpreting and solving specific civil engineering problems and to demonstrate creativity and decision-making skills. Finally, students will develop creative and systematic strategies for analysing and solving problems.
3106. Students will learn to assess the complexity of the problems examined in the different subject areas, identify the key elements of the problem statement, and select the appropriate strategy for solving it. Once they have chosen a strategy, they will apply it and, if the desired solution is not reached, determine whether modifications are required. Students will use a range of methods and tools to determine whether their solution is correct or, at the very least, appropriate to the problem in question. More generally, students will be encouraged to consider the importance of creativity in science and technology.
3107. Students will learn to identify, model and analyse problems from open situations, consider alternative strategies for solving them, select the most appropriate solution on the basis of reasoned criteria, and consider a range of methods for validating their results. More generally, students will learn to work confidently with complex systems and to identify the interactions between their components.
3111. Students will learn to plan, design, manage and maintain systems suitable for use in civil engineering. They will develop a systematic approach to the complete life-cycle of a civil engineering infrastructure, system or service, which includes drafting and finalising project plans, identifying the basic materials and technologies required, making decisions, managing the different project activities, performing measurements, calculations and assessments, ensuring compliance with specifications, regulations and compulsory standards, evaluating the social and environmental impact of the processes and techniques used, and conducting economic analyses of human and material resources.
3112. Students will develop an understanding of the different functions of engineering, the processes involved in the life-cycle of a construction project, process or service, and the importance of systematising the design process. They will learn to identify and interpret the stages in preparing a product design specification (PDS), draft and optimise specifications and planning documents, and apply a systematic design process to the implementation and operation phases. Students will learn to write progress reports for a design process, use a range of project management tools and prepare final reports, and will be expected to show an awareness of the basic economic concepts associated with the product, process or service in question.
3113. Students will learn to identify user requirements, to draft definitions and specifications of the product, process or service in question, including a product design specification (PDS) document, and to follow industry-standard design management models. Students will be expected to show advanced knowledge of the steps involved in the design, execution and operation phases and to use the knowledge and tools covered in each subject area to the design and execution of their own projects. Finally, students will assess the impact of national, European and international legislation applicable to engineering projects.

Transversal:
585. ENTREPRENEURSHIP AND INNOVATION - Level 1. Showing enterprise, acquiring basic knowledge about organizations and becoming familiar with the tools and techniques for generating ideas and managing organizations that make it possible to solve known problems and create opportunities.
586. ENTREPRENEURSHIP AND INNOVATION - Level 2. Taking initiatives that give rise to opportunities and to new products and solutions, doing so with a vision of process implementation and market understanding, and involving others in projects that have to be carried out.
589. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 2. Applying sustainability criteria and professional codes of conduct in the design and assessment of technological solutions.
594. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
584. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

The course consists on 4 hours of class per week during the second term.

The course is taught through theoretical classes that develope the program and some classes which deal with practical problems complementing or assessing the theoretical concepts, together with workshops for the development of the project. As possible, multimedia materials tought to facilitate the comprehension of the subject as well as educational software developed by the teachers will be used.

There might be a visit to a construction in progress or a precast plant, a internal steel workshops, concrete plants or others. However, this activity might be subjected to economic or availability conditions. If the visit is effecively carried out, it will be evaluated in the course exams.

Finally, the need for the active participation of students during the course development is emphazized.

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

Students will acquire a basic understanding of the behaviour of concrete structures and develop the capacity to conceive, design, build and maintain structures of this type.

Upon completion of the course, students will have acquired the ability to: 1. Define the actions and combinations of actions to be considered in the design of a concrete structure. Design and/or check the strength of sections under different kinds of stress, as well as the interaction of multiple stresses. 2. Determine the type of reinforcement, anchorage length and lap length required in the design of a framework. Design and/or check concrete structural elements in the presence of instability phenomena. 3. Design the most common types of concrete structures.

Mechanisms that enable structural concrete structures to withstand stress; Specific aspects related to the materials, design and construction of structures, such as durability strategy; Criteria for selecting the appropriate structural type, pre-design criteria, and methods for thoroughly checking and organising isostatic and hyperstatic structural concrete beams, as relates to adequate reinforcement and structural viability; Behaviour and cross sections of common types of concrete structures such as slabs, girders, beams, pillars and foundation elements

The aim of this course is to provide knowledge about the project, construction and maintenance of reinforced concrete (RC) structures. Upon completion of the course, students should understand the advantages and disadvantages of concrete and recognize its scope, understand the construction stages of RC structures, design RC structural elements using the limit states method and distribute the internal steel reinforcements at longitudinal and section level.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	10.00
Guided activities	6,0	4.00
Self study	84,0	56.00
Hours large group	30,0	20.00
Hours medium group	15,0	10.00

Total learning time: 150 h

CONTENTS

Introduction to reinforced concrete

Description:
Introduction to reinforced concrete

Full-or-part-time: 4h 48m
Theory classes: 2h
Self study : 2h 48m

Execution of RC structures

Description:
Execution of reinforced concrete

Full-or-part-time: 4h 48m
Theory classes: 2h
Self study : 2h 48m

Basis of design

Description:
Limit states
Structural safety
Loads
Loads. Exercise of load combinations
Workshop course work

Full-or-part-time: 19h 12m
Theory classes: 4h
Practical classes: 2h
Laboratory classes: 2h
Self study : 11h 12m

Durability

Description:
Durability
Durability. Exercise

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

Materials

Description:
Concrete and internal steel
Concrete. Exercise of concrete properties

Full-or-part-time: 12h
Theory classes: 1h
Practical classes: 1h
Laboratory classes: 3h
Self study : 7h

Ultimate limit state of normal stresses

Description:
Behaviour of reinforced concrete elements up to failure
Hypotheses of the bending with axial force limite state
Interaction diagram
Interaction diagram. Exercise
Ultimate limit state of bending
Ultimate limit state of bending. Exercise
Ultimate limit state of bending with axial force
Workshop course work
Bending with axial force ultimate limit state. Exercise

Full-or-part-time: 33h 36m
Theory classes: 8h
Practical classes: 4h
Laboratory classes: 2h
Self study : 19h 36m

Ultimate limit state of instability

Description:
Ultimate limit state of instability

Full-or-part-time: 2h 24m
Theory classes: 1h
Self study : 1h 24m

Ultimate limit state of shear stresses

Description:
Ultimate limit state of shear
Ultimate limit state of shear. Exercise
Workshop course work

Full-or-part-time: 24h
Theory classes: 7h
Practical classes: 1h
Laboratory classes: 2h
Self study : 14h

Ultimate limit state of anchorage

Description:
Ultimate limit state of anchorage
Internal steel distribution
Workshop course work

Full-or-part-time: 14h 23m
Practical classes: 4h
Laboratory classes: 2h
Self study : 8h 23m

Service limit state of cracking

Description:
Service limit state of cracking
Service limit state of cracking. Exercise

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

Service limit state of deformability

Description:
Service limit state of deformability
Service limit state of deformability. Practice

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

Structural elements

Description:
Structural elements
Workshop course work

Full-or-part-time: 12h
Theory classes: 1h
Laboratory classes: 4h
Self study : 7h

GRADING SYSTEM

The mark of the course is obtained from the marks of the exams and the practical exercice that should be submitted during the course.

There will be a minimum of two exams during the course.

There will be a work in groups of 3 people with different submissions. After the last deadline, there will be an interview in groups, which mark will be considered for the final mark of the course.

The final mark will be obtained as:

NF = 0,50 E + 0,40 T + 0,10·P
where:
E: mark of the partial exams. E = 0,40 P1 + 0,60 P2
T: mean of the work mark
P: participation in class activities
The minimum mark to pass the course will be 5,0. If students do not assist to an exam, do not submit the work project and do not participate in at least 60% of the class activities, their mark will be not presented (NP) and they will not be able to attend the re-evaluation test.

Criteria for re-evaluation qualification and eligibility: Students that failed the ordinary evaluation and have regularly attended all evaluation tests will have the opportunity of carrying out a re-evaluation test during the period specified in the academic calendar. Students who have already passed the test or were qualified as non-attending will not be admitted to the re-evaluation test. The maximum mark for the re-evaluation exam will be five over ten (5.0). The non-attendance of a student to the re-evaluation test, in the date specified will not grant access to further re-evaluation tests. Students unable to attend any of the continuous assessment tests due to certifiable force majeure will be ensured extraordinary evaluation periods.

These tests must be authorized by the corresponding Head of Studies, at the request of the professor responsible for the course, and will be carried out within the corresponding academic period.

BIBLIOGRAPHY

Basic:
- Ministerio de Transportes, Movilidad y Agenda Urbana. Código Estructural. Madrid: Ministerio de Transportes, Movilidad y Agenda Urbana. Secretaría General Técnica. Centro de Publicaciones, 2021. ISBN 9788449810596.
- Asociación Española de Normalización y Certificación. UNE-EN 1992-1-1: eurocódigo 2: proyecto de estructuras de hormigón: parte 1-1: reglas generales y reglas para edificación. Madrid: AENOR, 2016.
- Asociación Española de Normalización y Certificación. UNE-EN 1992-2: Eurocódigo 2: proyecto de estructuras de hormigón: parte 2: puentes de hormigón: cálculo y disposiciones constructivas. Madrid: AENOR, 2013.
- Marí, A.; Molins, C.; Bairán, J.M.; Oller, E. Formigó armat i pretensat: exercicis curts de bases de càlcul i estats límit, adaptat a la instrucció EHE-08 [on line]. 2a ed. Barcelona: Edicions UPC, 2009 [Consultation: 25/02/2021]. Available on: http://hdl.handle.net/2099.3/36837. ISBN 978-84-9880-390-7.
- Marí, A.; Aguado, A.; Agulló, L.; Martínez, F.; Cobo, D. Hormigón armado y pretensado: ejercicios [on line]. Barcelona: Edicions UPC, 1999 [Consultation: 08/03/2021]. Available on: http://hdl.handle.net/2099.3/36182. ISBN 84-8301-302-9.
- Murcia, J.; Aguado, A.; Marí, A.R. Hormigón armado y pretensado-I. Barcelona: Edicions UPC, 1997. ISBN 84-8301-030-5 (V.1).
- Park, R.; Paulay, T. Estructuras de concreto reforzado. México D.F.: Limusa, 1979. ISBN 9681801008.

Complementary:
- Murcia, J.; Aguado, A.; Marí, A.R. Hormigón armado y pretensado: vol. 2. Barcelona: Edicions UPC, 1993. ISBN 84-7653-357-8.
- Jiménez Montoya, P., García Meseguer, A., Morán, F., Arroyo, J.C.. Hormigón armado [on line]. 15a ed. Barcelona: Gustavo Gili, 2009 [Consultation: 08/03/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3209549. ISBN 9788425223075.
- Calavera, J. Proyecto y cálculo de estructuras de hormigón: en masa, armado y pretensado, de acuerdo con la nueva instrucción EHE-08: de acuerdo con el EUROCÓDIGO EC-2. 2a ed. Madrid: Intemac, 2008. ISBN 9788488764058.
- Leonhard, F. Estructuras de hormigón armado. 2a ed (v. 1, 2, 4); 3a ed (v. 3). Buenos Aires: El Ateneo, 1987-1996. ISBN 9500252422.
- Nilson, A.H. Diseño de estructuras de concreto. 12a ed. Santa Fe de Bogotá: McGraw Hill, 1999. ISBN 958600953X.
- Schokker, Andrea J. The sustainable concrete guide : strategies and Examples. 1. Farmington Hills, MI, USA: U.S. Green Concrete

Council, 2010. ISBN 9780870313622.