## BASIC DETAILS:

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| **Subject:** | ESTRUCTURAS III | | |
| **Id.:** | 30214 | | |
| **Programme:** | GRADUADO EN ARQUITECTURA. PLAN 2009 (BOE 21/03/2015) | | |
| **Module:** | TECNICO | | |
| **Subject type:** | OBLIGATORIA | | |
| **Year:** | 3 | **Teaching period:** | Primer Cuatrimestre |
| **Credits:** | 3 | **Total hours:** | 75 |
| **Classroom activities:** | 34 | **Individual study:** | 41 |
| **Main teaching language:** | Inglés | **Secondary teaching language:** | Castellano |
| **Lecturer:** | BERTOL GROS, ANA (T) | **Email:** | abertol@usj.es |

## PRESENTATION:

This course is about reinforced concrete structures.

Reinforced concrete is the most used building material for building structures. Its virtue is its ability to be moulded, so that it takes up the shapes required for every structural form. It is also very durable and fire resistant. Concrete can be used for all standard buildings both single storey and multi-storey and for containment and retaining structures and bridges.

The course will take students from initial basic concepts, that will allow them to make quick and easy pre-dimension; to the full calculation of a reinforced concrete structure, considering ultimate limit states and serviceability limit states. At the end of the course the student will be able to produce full detailed reinforced concrete projects.

This course will follow the rules stablished in the Spanish Building Code (CTE) and the Structural Concrete Norms (EHE-08).

## PROFESSIONAL COMPETENCES ACQUIRED IN THE SUBJECT:

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| **General programme competences** | G02 | Ability to resolve problems and make decisions throughout their lifetime and choose professional and educational pathways independently. |
| | G03 | Ability for autonomous learning and self-criticism. |
| | G04 | Ability to transfer the knowledge acquired in practical work and skills to the field of work. |
| | G05 | Demonstrate creativity, independence of thought, autonomy. |
| | G06 | Demonstrate critical and analytical ability to conventional approaches of the discipline. |
| | G07 | Demonstrate capacity for innovation, creativity and initiative. |
| **Specific programme competences** | E03 | Knowledge applied to: Numeracy, analytical and differential geometry and algebraic methods. |
| | E04 | Ability to conceive, calculate, design, integrate into buildings and urban units and execute: Building structures (T); Interior division systems, carpentry, stairways and other finished work (T); Locking systems, roof and other structural work (T); Foundation Solutions (T); Supply facilities, water treatment and disposal, heating and air conditioning (T). |
| | E05 | Ability to: Apply technical and construction standards; Maintain building structures, foundation and civil works; Conserve the finished work; Evaluate the project. |
| **Regulated profession competences** | P06 | Ability to understand the architectural profession and its role in society, in particular by developing projects that take social factors into account. |
| | P07 | Knowledge of methods of investigation and preparation of construction projects. |
| | P08 | Understand the problems of the structural design, construction and engineering associated with building projects. |
| | P09 | Adequate knowledge of physical problems and the different technologies and of the function of buildings so as to provide them with internal conditions of comfort and protection against the climate conditions. |
| | P10 | Design capacity to meet the requirements of building users within the limits imposed by budget factors and building regulations. |
| | P11 | Adequate knowledge of the industries, organisations, regulations and procedures involved in translating design concepts into buildings and integrating plans into planning. |
| **Learning outcomes** | R01 | Elaborar el proyecto de ejecución de una estructura de edificación de Hormigón Armado |
| | R02 | Comprender y resolver cuestiones de carácter estructural relativas a la estabilidad de las |

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| | | construcciones arquitectónicas con referencia a los Estados Límite de Servicio y Último |
| | R03 | Llevar a cabo el estudio pormenorizado de resolución estructural y puesta constructiva de distintas tipologías de forjados empleados en edificación |
| | R04 | Diseñar, predimensionar, calcular y realizar el armado de una estructura de edificación de hormigón armado, analizando los resultados obtenidos y teniendo en cuenta el cumplimiento de la normativa vigente |
| | R05 | Aplicar los conocimientos necesarios de los programas informáticos de cálculo de estructuras de hormigón armado, para contrastar con el empleo de los mismos los resultados obtenidos manualmente |
| | R06 | Analizar, comprender y resolver problemas referidos a sistemas de cimentación superficial |
| | R07 | Analizar, comprender y resolver problemas referidos a sistemas de cimentación profunda |

**PRE-REQUISITES:**

It is advisory that every student that enrols in this course has basic knowledge about mechanics of materials taught in “Estructuras I” and structural analysis taught in “Estructuras II”. It is also advisory that students have some upper intermediate level of English.

It will be supposed that every student remembers some basic math skills, including basic algebra and trigonometry, as well as some basic calculus topics (such as differentiation, simple integration, and how to find maximum and minimum values of functions). The student should be proficiency in geometry and trigonometry. Being familiar with the cartesian coordinate system and its terminology as well as knowing the basic rules governing sines, cosines and tangents of angles is invaluable as you work mechanics of materials problems.

**SUBJECT PROGRAMME:**

Observations:

The course will begin with some basic concepts about reinforced concrete structures. The materials and their properties, quick tools to design RC structures, and basic knowledge to understand the global concepts of the course.

Afterwards, the course will teach about structural calculations, following the ultimate limit state method. The student will learn to design and verify reinforced concrete beams and pillars, as well as draw the detailed section considering the spacing requisites stablished in the codes. Some basic concepts about design following the serviceability limit states will also be taught.

The course will conclude with some theory and exercises about foundation calculations. Students will learn to design both, shallow and deep foundations.

**Subject contents:**

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| **1 - Introduction** |
| 1.1 - Reinforced concrete history |
| 1.2 - Regulations and units of measurement |
| **2 - Basic concepts** |
| 2.1 - Useful tips |
| 2.2 - Quick calculations |
| 2.3 - Understanding RC structures |
| **3 - Reinforced concrete** |
| 3.1 - Concrete |
| 3.1.1 - Components |
| 3.1.2 - Properties |
| 3.2 - Corrugated steel |
| 3.2.1 - Reinforcing bars |
| 3.2.2 - Properties |
| 3.3 - Durability |
| 3.4 - Shrinkage and creep |

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| 3.5 - Mechanical properties |
| **4 - Calculation process** |
| 4.1 - Limit State Method |
| 4.2 - Building loads CTE-DB-SE-AE |
| 4.3 - Deformation domains |
| 4.4 - Calculation formulas |
| **5 - Structural excitations** |
| 5.1 - Concrete characteristic strength |
| 5.2 - Steel characteristic strength |
| **6 - Calculation under normal stresses** |
| 6.1 - Calculation hypothesis |
| 6.2 - Practical calculations |
| 6.2.1 - Axial stress |
| 6.2.2 - Simple bending stress |
| 6.2.3 - Compressive bending stress |
| 6.3 - Sections design and verification |
| **7 - Calculation under tangential stresses** |
| 7.1 - Calculation hypothesis |
| 7.2 - Practical calculations |
| 7.2.1 - Shear stress |
| 7.2.2 - Torsion stress |
| 7.3 - Sections design and verification |
| **8 - Reinforced concrete detailing** |
| 8.1 - Linear elastic analysis with limited redistribution |
| 8.2 - Rebar arrangement |
| 8.2.1 - Rebar anchorage |
| 8.2.2 - Splice length |
| **9 - Reinforced concrete structures construction** |
| 9.1 - Structural project documentation |
| 9.2 - Building process |
| **10 - Serviceability Limit State** |
| 10.1 - General design criteria |
| 10.2 - Crack control |
| 10.3 - Deflection control |
| **11 - Foundations** |
| 11.1 - Geothecnical evaluation |
| 11.2 - Shallow foundation design |
| 11.2.1 - Under compression stress |
| 11.2.2 - Under compressive bending stress |
| 11.3 - Deep foundation design |
| **12 - Reinforced concrete structures calculation** |

Subject planning could be modified due unforeseen circumstances (group performance, availability of resources, changes to academic calendar etc.) and should not, therefore, be considered to be definitive.

## TEACHING AND LEARNING METHODOLOGIES AND ACTIVITIES:

### Teaching and learning methodologies and activities applied:

To achieve the course competencies established in this guide, the activities are planned as follows:

There will be several **theory sessions** where the teacher will transmit the new information through oral and written exposition, conveniently using ICT as auxiliary means. The theory sessions will mainly be taught online, via Microsoft TEAMS. The exposition will be oriented to the course development; the new concepts will be structured in a coherent and logical way. The basic ideas and philosophy of the subject will be explained, avoiding extensive demonstrations that conspire against the understanding of the fundamental ideas of physics - which does not mean that mathematical demonstrations are less

important. If circumstances require it, other theory activities not contemplated in the initial programming may be adopted. During the expositions questions or problematic situations may be asked. There will be some small practical activities. The teacher will solve any possible doubt or incomplete information, guiding and motivating students to search for answers, generating debates and creating an active class environment.

There will be **practical sessions** related to the previous theory ones. The practical sessions will mainly be taught in the classroom, giving way to a more social interaction with the students to solve any practical doubt using the blackboard. Students must prepare the practical activities prior to the realization of the session and study every concept needed to solve exercises. There will be some **small written tests** to check the evaluating competences are being met.

After every theory session, to prepare for the following practical session, there will be some, mostly **individual, coursework** that each student must complete before the beginning of the next session. For this, the student must study each new concept and practice solving exercises on their own.

There will also be a **course project** that will be developed in an autonomous way. The project will evaluate every concept of the course and will be done **individually**. Each student will work on their project with the obligation to bring material to work in class, as well as doubts or questions that have arisen during the autonomous work to be able to solve them together in class. Students will be able to ask the professor their doubts in person during tutoring hours or via email.

To conclude with the course project, there will be a last task to be carried out in **groups**. And will evaluate the capacity of the students to explain a structural project to their classmates as well as building an actual reinforced concrete structural model.

**Student work load:**

| Teaching mode | Teaching methods | Estimated hours |
|---|---|---|
| **Classroom activities** | Master classes | 15 |
| | Practical exercises | 6 |
| | Practical work, exercises, problem-solving etc. | 7 |
| | Debates | 3 |
| | Coursework presentations | 1 |
| | Films, videos, documentaries etc. | 2 |
| **Individual study** | Tutorials | 3 |
| | Individual study | 15 |
| | Individual coursework preparation | 6 |
| | Group cousework preparation | 4 |
| | Project work | 7 |
| | Research work | 4 |
| | Recommended reading | 2 |
| | **Total hours:** | 75 |

**ASSESSMENT SCHEME:**

**Calculation of final mark:**

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| Written tests: | 15 | % |
| Individual coursework: | 25 | % |
| Group coursework: | 10 | % |
| Final exam: | 20 | % |
| Course project: | 30 | % |
| **TOTAL** | 100 | % |

*Las observaciones específicas sobre el sistema de evaluación serán comunicadas por escrito a los alumnos al inicio de la materia.

## BIBLIOGRAPHY AND DOCUMENTATION:

### Basic bibliography:


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| Ministerio de Fomento. Código Técnico de la edificación (CTE) Seguridad estructural. 2006, Madrid. |
| Ministerio de Fomento. Instrucción de hormigón estructural (EHE-08). 2008, Madrid. |
| P. BHATT, T.J.MACGINLEY, B.S.CHOO. Reinforced concrete, design theory and examples. 3rd Edition. 2006, USA. |
| M.Y.H.BANGASH. Structural details in concrete. 1992, Hong Kong. |
| MONTOYA, Jiménez. Hormigón armado, 16º Edición basada en la EHE-08. 2018, Madrid. |


### Recommended bibliography:


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| Ministerio de Fomento. Guía de aplicación de la Instrucción de Hormigón Estructural (EHE-08) |
| AN/ UNE-EN 1992-1-1 Eurocode 2: Design of concrete structures. |
| CALAVERA, José. Proyecto y cálculo de estructuras de hormigón armado (tomos I y II). Madrid |


### Recommended websites:

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| Estructurando | http://estructurando.net/ |
| Civil geeks | https://civilgeeks.com/ |