

## 250141 - ESTACER - Steel Structures

Coordinating unit:	250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit:	751 - DECA - Department of Civil and Environmental Engineering
Academic year:	2018
Degree:	BACHELOR'S DEGREE IN CIVIL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory) BACHELOR'S DEGREE IN CIVIL ENGINEERING (Syllabus 2017). (Teaching unit Compulsory)
ECTS credits:	6
Teaching languages:	Catalan, Spanish, English

### Teaching staff

Coordinator:	ROLANDO ANTONIO CHACÓN FLORES
Others:	ROLANDO ANTONIO CHACÓN FLORES, ENRIQUE MIRAMBELL ARRIZABALAGA, ESTHER REAL SALADRIGAS, DAVID VERGES COLL

### Opening hours

Timetable:	To be agreed
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### Degree competences to which the subject contributes

#### Specific:

- 3024. Ability to apply knowledge of construction materials to structural systems. Knowledge of the relation between the structure of materials and the mechanical properties resulting from them.
- 3031. Students will acquire a basic awareness of the behaviour of reinforced concrete and metal structures and the capacity to conceive, design, build and maintain these types of structures.
- 3032. Students will acquire the ability to select the most appropriate methods for calculating and dimensioning structural (reinforced and prestressed) concrete structures and metal structures to which European regulations apply.
- 3037. Knowledge of the different types and basis for calculating prefabricated items and its application to the manufacturing processes.
- 3038. Knowledge of the design, calculation, construction and maintenance of building works in regard to their structure, finishes, installations and equipment.

#### Generical:

- 3104. 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.
- 3110. 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

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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 of 4 hours per week of classroom sessions in the classroom for 15 weeks (60 hours total). It involved approximately 33 hours lectures, classes of problems 15 hours, 5 hours laboratory practice tests and evaluation 5 hours.

Not all the material included in the program is taught in class: these focus on those aspects of greatest importance and difficulty, leaving the rest for the students to work with the help of personal notes and additional documentation provided.

It uses material support through the virtual campus ATENEA: content, programming and evaluation activities directed learning and literature.

### Learning objectives of the subject

Students will acquire a basic understanding of the behaviour of metal 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 metal structure. 2. Design and/or check the strength of sections under different kinds of stress, as well as the interaction of multiple stresses. 3. Design and/or check metal structural elements under flexural torsional buckling and lateral torsional buckling. 4. Design and/or check the most common types of bolted

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and welded joints used in metal construction. 5. Design the most common types of structures used in metal construction (slab girders and tie-beams, trussed beams, light truss beams, lattice girders and roof purlins), taking into account the serviceability limit states and ultimate limit states

Production of steel for the manufacture of bars and plates used in construction; Common types of structures in metal construction; Stress-deformation behaviour of metal structures under sectional stresses (axial force, shear force, bending moment and torsion), taking into account the possible interaction and behaviour of the elements in the presence of instability phenomena: basic equations and design formulas (flexural-torsional buckling and lateral-torsional buckling); Behaviour of bolted and welded joints in metal structures

### Study load

Total learning time: 150h	Theory classes:	33h	22.00%
	Practical classes:	15h	10.00%
	Laboratory classes:	12h	8.00%
	Guided activities:	6h	4.00%
	Self study:	84h	56.00%

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### Content

<p>Item 1: Introduction to steel structures</p>	<p>Learning time: 2h 24m Theory classes: 1h Self study : 1h 24m</p>
<p>Description: Introduction to steel structures</p>	
<p>Item 2: The steel material</p>	<p>Learning time: 7h 11m Theory classes: 2h Practical classes: 1h Self study : 4h 11m</p>
<p>Description: 2.1 Characteristics of steels 2.2 Types of steel 2.3 Steel Products 2.4 Handbooks: PerfilCelsa 2.5 Steel Production 2.6 Failure criteria Exercises</p>	
<p>Item 3: Basis of design</p>	<p>Learning time: 7h 11m Theory classes: 2h Practical classes: 1h Self study : 4h 11m</p>
<p>Description: 3.1 General. 3.2 Limit states design: Ultimate limit states and serviceability limit states. 3.3 Durability. 3.4 Actions. Combination of actions. 3.5 Steel material. Partial factor for material.  Exercises</p>	

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<p>Item 4: Serviceability limit states. Deflections</p>	<p>Learning time: 4h 48m Theory classes: 1h Practical classes: 1h Self study : 2h 48m</p>
<p>Description: 4.1 Limits of deflections for buildings 4.2 Limits of deflections for bridges</p> <p>Exercises</p>	
<p>Item 5: Ultimate limit state of resistance of cross sections</p>	<p>Learning time: 21h 36m Theory classes: 6h Practical classes: 2h Laboratory classes: 1h Self study : 12h 36m</p>
<p>Description: 5.1 General 5.1.1 Elastic verification 5.1.2 Cross section properties 5.1.3 Shear lag effects 5.2 Classification of cross sections 5.3 Tension 5.4 Compression 5.5 Bending 5.6 Shear 5.7 Bending-shear interaction 5.8 Bending-axial force interaction 5.9 Bending-shear-axial force interaction</p> <p>Exercises Laboratory</p>	

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<p>Item 6: Design of structural elements subjected to bending</p>	<p>Learning time: 16h 48m</p> <p>Theory classes: 4h Practical classes: 2h Laboratory classes: 1h Self study : 9h 48m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>6.1 Elastic global analysis</li> <li>6.2 Plastic global analysis</li> <li>6.3 Structural types <ul style="list-style-type: none"> <li>6.3.1 Beams and girders</li> <li>6.3.2 Trusses and cellular beams</li> </ul> </li> </ul> <p>Exercises Laboratory</p>	
<p>Item 7: Structural elements subjected to torsion</p>	<p>Learning time: 16h 48m</p> <p>Theory classes: 4h Practical classes: 2h Laboratory classes: 1h Self study : 9h 48m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>7.1 General</li> <li>7.2 Uniform torsion</li> <li>7.3 Warping torsion</li> <li>7.4 Non-uniform torsion</li> <li>7.5 Design of structural elements subjected to torsion</li> <li>7.6 Shear-torsion interaction</li> <li>7.7 Bending-torsion interaction</li> </ul> <p>Exercises Laboratory</p>	
<p>Assessment 1</p>	<p>Learning time: 4h 48m</p> <p>Laboratory classes: 2h Self study : 2h 48m</p>

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<p>Item 8: Ultimate limit state of instability. Buckling</p>	<p>Learning time: 33h 36m Theory classes: 9h Practical classes: 4h Laboratory classes: 1h Self study : 19h 36m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>8.1 Elastic compression members. Elastic critical force for flexural buckling</li> <li>8.2 Real compression members</li> <li>8.3 Design buckling curves</li> <li>8.4 Design of simply supported elements subjected to compression</li> <li>8.5 Design of compression elements. Effective length <ul style="list-style-type: none"> <li>8.5.1 Simple elements</li> <li>8.5.2 Frames</li> <li>8.5.3 Triangulated structures</li> </ul> </li> <li>8.5.4 Compressed elements under variable axial force</li> <li>8.5.5 Torsional buckling and torsional-flexural buckling</li> <li>8.6 Lateral-torsional buckling <ul style="list-style-type: none"> <li>8.6.1 Elastic critical moment for lateral-torsional buckling</li> <li>8.6.2 Design of flexural elements against lateral buckling</li> </ul> </li> <li>8.7 Design of elements subjected to compression and bending. <ul style="list-style-type: none"> <li>8.7.1 Simplified method</li> <li>8.7.2 General method</li> </ul> </li> </ul> <p>Exercises Laboratory</p>	

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<p>Item 9: Joints</p>	<p>Learning time: 21h 36m</p> <p>Theory classes: 6h Practical classes: 2h Laboratory classes: 1h Self study : 12h 36m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>9.1 Introduction <ul style="list-style-type: none"> <li>9.1.1 General considerations</li> <li>9.1.2 Applied forces and moments</li> <li>9.1.3 Classification of joints by strength and stiffness. Moment-rotation diagram.</li> </ul> </li> <li>9.2 Bolted joints <ul style="list-style-type: none"> <li>9.2.1 Bolt classes</li> <li>9.2.2 Categories of bolted connections</li> <li>9.2.3 Positioning of holes for bolts</li> <li>9.2.4 Preloaded bolts</li> <li>9.2.5 Design resistance of bolted connections</li> <li>9.2.6 Distribution of forces between fasteners</li> <li>9.2.7 Types of bolted joints. Calculation</li> </ul> </li> <li>9.3 Welded joints <ul style="list-style-type: none"> <li>9.3.1 General</li> <li>9.3.2 Types of joints and welds</li> <li>9.3.3 Geometry and dimensions for fillet welds and butt welds</li> <li>9.3.4 Design resistance of fillet welds and butt welds</li> <li>9.3.5 Distribution of forces</li> <li>9.3.6 Types of welded joints. Calculation</li> </ul> </li> </ul> <p>Exercises Laboratory</p>	
<p>Assessment 2</p>	<p>Learning time: 7h 11m</p> <p>Laboratory classes: 3h Self study : 4h 11m</p>



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### Qualification system

A series of exams will be performed throughout the course. In addition, the students must develop 6 hours of guided activities (AD). All evaluations contribute to the final marks. The final marks consist of the contributing part from the exams and the contributing part of the guided activities,

On the one hand, the exams are based upon theoretical questions concerning important concepts that arise throughout the course and upon exercises in which these concepts are applied. The exams include all the worked material up to date. On the other hand, the guided activities are based upon case-studies in which both practical and theoretical concepts of the design of steel structures are involved.

The exams are weighted in the following fashion:  $A = 0.4 \cdot A1 + 0.6 \cdot A2$  The final mark of the course (NF) is obtained as follows:  $NF = 0.75 \cdot A + 0.25 \cdot AD$

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.

### Regulations for carrying out activities

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:

Comisión Permanente de Estructuras de Acero. Título EAE : instrucción de acero estructural: con comentarios de los miembros de la Comisión Permanente de Estructuras de Acero. 2a ed. Madrid: Ministerio de Fomento. Secretaría General Técnica, 2011. ISBN 9788449809040.

Ministerio de Fomento. Dirección General de la Vivienda, la Arquitectura y el Urbanismo. Documento básico SE-A: seguridad estructural, acero. Madrid, 2008.

CEN. UNE-EN 1993-1-1:2008/AC: Eurocódigo 3: proyecto de estructuras de acero: Parte 1-1: Reglas generales y reglas para edificios. Madrid: AENOR, 2010.

Trahair, N.S.; Bradford, M.A.; Nethercot, D.A.; Gardner, L. The behaviour and design of steel structures to EC3. 4th ed. London ; New York: Taylor & Francis, 2008. ISBN 978-0-415-41866-9.

Simoes da Silva, L.; Simoes, R.; Gervasio, H. Eurocode 3: design of steel structures : part 1-1: general rules and rules for buildings. Brussels: ECCS- European Convention for Constructional Steelwork, 2010. ISBN 978-92-9147-098-3.