Mixed and Composite Structures (250475)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012) MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012) MÀSTER UNIVERSITARI EN ENGINYERIA ESTRUCTURAL I DE LA CONSTRUCCIÓ (pla 2015) PARS: ENGINYER/A DE CAMINS, CANALS I PORTS (pla 2022)
Course	2024/25

Main teaching language at each group

- Group 10ES1 Spanish (Q1)

Faculty

Responsible Faculty: Enrique Mirambell Arrizabalaga
Faculty: Itsaso Arrayago Luquin, Diego Cobo Del Arco, Enrique Mirambell Arrizabalaga

Objectives of Education

Specialization subject in which knowledge on specific competences is intensified.

Knowledge and skills at specialization level that permit the development and application of techniques and methodologies at advanced level.

Contents of specialization at master level related to research or innovation in the field of engineering.

Competencies

Especific

Knowledge of all kinds of structures and materials and the ability to design, execute and maintain structures and buildings for civil works.
Knowledge of and competence in the application of advanced structural design and calculations for structural analysis, based on knowledge and understanding of forces and their application to civil engineering structures. The ability to assess structural integrity.

Transversal

ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	25.5 h	56.67 %
	Medium group	9.75 h	21.67 %
	Laboratory classes	9.75 h	21.67 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Overview

Introduction to the subject. Concept of structure and composite construction. Presentation of the agenda. Evaluation method. Bibliography. Advantages and disadvantages of building in steel and concrete. Advantages and characteristics of composite construction. Possibilities in design and construction: construction process relevance.
Materiales: Structural steel, steel reinforcement, concrete

Structural behavior. Time dependent effects

Qualitative structural behavior of composite structures. Differential equation of the interaction. Full interaction: Method of the reduced cross-section. Longitudinal shear force. Transverse reinforcement of the concrete slab. Effective width: Statement of the effective width according to EC3 and EC4. Time dependent effects: Shrinkage: Structural effects in isostatic and indeterminate structures. Analysis considering cracking: Non-linearity of the problem. Creep: The nature of the phenomenon. Approaching the problem with the ageing coefficient. The method j. Analysis of continuous composite beams considering creep. Thermal effects in composite structures and composite bridges. Design temperature distributions. Generalized deformations.
Calculation of a composite structure subjected to a differential action type as shrinkage.

The prestressed composite structures.

The prestressed composite structures: Prestressed pre-connection and post-connection. Instantaneous and delayed study. Efforts flush of localized nature.
Resolution of exercise for determining the ultimate moment of a section subjected to bending mixed positive and negative, considering linear elastic and plastic theory.

Ultimate limit states. Bending and shear

Ultimate limit states. Classification of composite sections. Ultimate strength of the cross sections of a composite beam. Ultimate bending moment: Bases. Plastic bending moment of a section with total connection. Plastic bending moment of a section with partial connection. Ultimate bending moments response in classes 1, 2, 3 and 4 to positive and negative bending. Resistance of the composite section to shear in sections class 1 and 2. Bending-shear interaction.
Exercise

Serviceability limit states. Deformability and cracking

Serviceability limit states: General. Limit state deformations: effects of the construction process, the shear lag, incomplete interaction of shrinkage and creep, cracking of concrete and structural steel lamination. Limit state of cracking: Approach to EN 1992-1-1 and Instruction EHE. Simplified method of EN 1994-1-1. Resolution of exercise of verification of the limit state of cracking in an intermediate support cross-section of a continuous composite beam.

Construction process

Construction process. Influence of the construction process. Influence of preloads. Sequences isostatic concrete beams. Influence of the construction process in continuous composite beams: Sequences of concretecast and bearing systems. Metal piece fully assembled or not, before executing the concrete slab.
Resolution of an exercise related to the construction process of a steel-concrete composite structures

Connection in composite structures

Connectors. Connection concept. Vs. total connection. partial connection. Justification for the partial connection. Vs ductile connectors. rigid connectors. Strain capacity of the connectors. Connections tested with push tests. Flush effort calculation: Beams with past efforts and calculated according to elastic theory under plastic theory. Total and partial connection connection with connectors dúctiles.Capacidad resistant ductile or last of the connectors: Pin connectors. Other types of connectors. Distribution connectors along the element. Limitations. Construction layout. Transverse reinforcement in the connection area.
Resolution of exercise related to the design of connection in composite beam

Composite columns

Composite columns. Overview. Structural types. General and simplified method. Assumptions for the simplified method. Resistance of the cross-section. Flexure-compression strength in straight sections. NM interaction diagram. Influence of shear. Resistance to instability of pillars under biaxial bending in the general case. Influence of second-order effects. Study of the area of load introduction area. Shear at the intreface and connection in the steel-concrete interface.
Resolution of exercise of the verification of a composite column under axial load and biaxial bending

Composite bridges

Composite bridges. Introduction. About composite bridges. Common types of cross sections. Design conditions of composite bridges. Presentation of structural types of composite bridges. Some aspects of their calculation.

Composite slabs with profiled sheet

Composite slabs with profiled sheet. Introduction. Behaviour of the composite slab. Basis of calculation. Structural analysis. Checking sections. Checking the serviceability limit states.
Resolution of exercise of composite slab with profiled sheet

Composite structures with different types of concrete

Time dependent effects. Longitudinal shear force. Shear-friction model.
Exercise

Evaluation

Activities

Activity 1

Design of a composite bridge subjected to thermal action-homogeneous distribution with discontinuity-

Dedication

1h 30m

Activity 2

Determination of ultimate strength in bending failure of a composite section, when the reinforcing steel is increased

Dedication

1h 30m

Activity 3

Calculation of deflections in a composite beam, considering the construction process and the effect of cracking.

Dedication

1h 30m

Activity 4

Resolution of concrete-concrete composite structure

Dedication

1h 30m

Teaching Methodology

The course consists of 3 hours per week of classroom activity during 13 weeks.

In the theoretical lectures, 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.

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.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

The mark of the course is obtained from the continuous assessment.

It consists of five activities and a final exam.

The final mark (F) is obtained from the exam mark (E) and the activities directed (AD)

F = 0.7E+0.3AD

The maximum score assigned to each activity will be the same.

Test Rules

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

Office Hours

The consultations will take place on appointment.

Bibliography

Basic

- Comisión Permanente del Hormigón. EHE-08: Instrucción de Hormigón Estructural: con comentarios de los miembros de la Comisión Permanente del Hormigón. 5a ed. Madrid: Ministerio de Fomento, Centro de Publicaciones, 2011.
- Espanya. Comisión Permanente de Estructuras de Acero. EAE: instrucción de acero estructural: con comentarios de los miembros de la Comisión Permanente de Estructuras de Acero. Madrid: Ministerio de Fomento, Secretaría General Técnica, 2011. ISBN 9788449809040.
- Comité Européen de Normalisation (CEN). Eurocode 2: design of concrete structures: ENV 1992. Brussels: European Comittee for standardization, 1995.
- Comité Européen de Normalisation (CEN). Eurocódigo 4:proyecto de estructuras mixtas de hormigón y acero: parte 1-1: Reglas generales y reglas para edificación: parte 2: puentes. Laussanne: AENOR, 1996.
- Dirección General de Carreteras. Recomendaciones para el proyecto de puentes mixtos para carretereras: RPX-95. Madrid: Ministerio de Fomento. Secretaría de Estado de Infraestructuras y Transportes. Dirección General de Carreteras, 1996. ISBN 8449802245.
- Mirambell Arrizabalaga, E. Apuntes de estructuras mixtas. Barcelona: ETSECCPB, 2000.
- Martinez Calzón, J.; Ortiz Herrera, J. Construcción mixta: hormigón-acero. Madrid: Rueda, 1978. ISBN 8472070107.
- Revista Hormigón y Acero. Madrid: Revista Hormigón y Acero 185, 1992.
- Rangel, J.L.; Mirambell, E. Pilares mixtos. Barcelona: ETSECCPB, 2008. ISBN 8487691250.
- Johnson, R.P. Composite structures of steel and concrete : beams, slabs, columns and frames for buildings. 4th ed. Hoboken: Wiley, 2019. ISBN 9781119401414.
- Steinle, A.; Bachmann, H.; Tillmann, M. Precast concrete structures. 2nd ed. Berlin: Wilhelm Ernst & Sohn Verlag fur Architektur und Technische, 2019. ISBN 9783433609033.
- Ghali, A.; Favre, R.; Elbadry, M. Concrete structures: stresses and deformations: analysis and design for sustainability. 4th ed. London ; New York: Spon Press, 2012. ISBN 9780415585613.
- Gilbert, R.I.; Ranzi, G. Time dependent behaviour of concrete structures. New York: Spon Press, 2011. ISBN 9780203879399.