Course guide
250733 - 250733 - Computational Methods for Advanced Assessment of Concrete Structures

Last modified: 09/01/2026

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

Degree: MASTER'S DEGREE IN STRUCTURAL AND CONSTRUCTION ENGINEERING (Syllabus 2015). (Optional subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: JESÚS MIGUEL BAIRÁN GARCÍA

Others: Duarte Gómez, Noemí

TEACHING METHODOLOGY

The course consists of 3 hours of lectures per week over one semester, where concepts are discussed alongside problems, exercises, and other supervised activities.
Throughout the course, students will complete deliverable coursework or seminars. The students will require approximately 60 hours of personal work throughout the semester for personal study and development of deliverable work.
Classes may be complemented with laboratory practices, use of software for the non-linear simulation of concrete structures, and visits to the Structural Technology Laboratory of the UPC to assist to experimental testing, according to availability.
Support material will be available through ATENEA, as the guide of the course, the lectures programed schedule, content, evaluation, supervised activities material, bibliography and other support material.

LEARNING OBJECTIVES OF THE SUBJECT

1. Understand sources of non-linear behaviour in concrete structures and their implications in practice for safety and performance.
2. Model the realistic behaviour of concrete structures under service and ultimate conditions.
3. Understand and select adequate approaches and discretization for frame and bidimensional, and solid structures.
4. Understand and select adequate solution strategies for non-linear problems.
5. Understand and constitutive models for concrete, reinforcement, prestressing, and bond, and select suitable models for different applications.
6. Apply computational methods in special cases of design and assessment.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	64.00
Hours large group	45,0	36.00

Total learning time: 125 h

CONTENTS

Introduction

Description:
Non-linear behaviour in concrete structures.
Examples.
Notation.

Full-or-part-time: 1h 30m
Theory classes: 1h 30m

Discretization and modelling for non-linear problems

Description:
General principles: equilibrium, compatibility, energy balance, and the principle of virtual works.
Types of discretization: solid, 2D, 1D, cross-section, fibre.
Overview of the finite element method

Full-or-part-time: 1h 30m
Theory classes: 0h 45m
Practical classes: 0h 45m

Solution strategies for non-linear problems

Description:
Newton-Raphson and modified Newton-Raphson methods.
Convergence norms.
Load-step subdivision, Line-search, displacement control, arch-length.

Full-or-part-time: 3h
Theory classes: 1h 30m
Practical classes: 1h 30m

Uniaxial behaviour of concrete and reinforcement

Description:
Monotonic and cyclic behaviour of concrete and steel in tension and compression.
Bond.
Cracking, tension-stiffening.
Time-dependent response of concrete and steel.

Full-or-part-time: 6h
Theory classes: 6h

Frame models

Description:
Cross-section fibre discretization.
Displacement-based elements.
Force-based elements.
Prestressing.
Confinement.
Shear and torsion.

Full-or-part-time: 6h
Theory classes: 3h
Practical classes: 3h

Multiaxial behaviour

Description:
Phenomenological response of concrete and steel under multiaxial loads.
Plasticity models.
Damage models.
Damage-plasticity models.
Modified-compression field theory.
Shear and torsion in frames.
Solids, shells, membranes.

Specific objectives:

Full-or-part-time: 6h
Theory classes: 3h
Practical classes: 3h

Applications for design and assessment

Description:
Frame structures.
Solids, slabs, shells, membranes.
Segmental and phased construction.
Special cases and large structures.
Existing structures: deterioration, repair, and strengthening.

Full-or-part-time: 16h 30m
Theory classes: 5h 30m
Practical classes: 5h 30m
Guided activities: 5h 30m

Randomness, reliability, and safety assessment

Description:
Uncertainty and randomness.
Random fields.
Failure probability.
Safety formats for non-linear analysis.

Full-or-part-time: 3h
Theory classes: 1h
Practical classes: 2h

GRADING SYSTEM

The course will be assessed continuously by performing work deliverables and seminars (approximately 2 papers and 2 seminars will be held) and a written test at the end of the course.

The course grade will be computed as follows:
30% Short exercises and assignments
40% Coursework
30% Exam and presentations

The minimum mark to pass is 5 out of 10.

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:
- Bairan, J.M.. Class notes of Non-linear analysis and behaviour of concrete structures.
- Haussler-Combe, U.. Computational methods for reinforced concrete structures.. Ernst & Sohn, ISBN 978-3-433-03054-7.

Complementary:
- Jirásek, M.; Bazant, Z.P. Inelastic analysis of structures. Chichester: Wiley, 2002. ISBN 0471987166.
- Practitioners' guide to finite element modelling of reinforced concrete structures. Lausanne, Switzerland: International Federation for Structural Concrete (fib), 2008. ISBN 9782883940857.
- Hendrix, M.; Boer, A., Beletti, B.. Guidelines for nonlinear analysis of concrete structures. 2.0. Netherlands: Rijkswaterstaat Centre for Infrastructure, 2017.
- Maekawa, K.; Pimanmas, A.; Okamura, H.. Nonlinear mechanics of reinforced concrete structures. London: Spoon, 2003. ISBN 9780367865559.