CIVIL-449

Nonlinear analysis of structures

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Cursus	Sem.	Type
Civil Engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course deals with the nonlinear modelling and analysis of structures when subjected to monotonic, cyclic, and dynamic loadings, focusing in particular on the seismic response of structures. It introduces solution methods for nonlinear static and dynamic problems.

Content

The course is based on assignments in which students will model structures tested in the laboratory and compare numerical results to experimental results.

- Expressing the nonlinear static and dynamic problem for single-degree-of-freedom and multiple-degree-of-freedom systems.
- Solution Methods in Nonlinear Static Analysis: Newton-Raphson methods, incremental-iterative procedures with variable loading parameter.
- Modelling of different components in buildings and bridges: columns, beams, walls, foundations, slabs, and bearings.
- Uniaxial and multi-axial material models for concrete, steel and masonry for modelling plasticity and damage under cyclic loading.
- Total and incremental compatibility and equilibrium relations in beams, accounting for large displacements (corotational formulation).
- Differential equations for Euler-Bernoulli and Timoshenko beams. Sectional analysis of RC sections.
- Beam formulations with concentrated and distributed plasticity approaches (force-based and displacement-based).
- Localization issues and regularization techniques.
- Overview on other modelling approaches for structures (membranes, shell and macro-elements)
- Energy dissipation and damping models.
- Nonlinear Static Analysis (pushover curves, Capacity Spectrum Method and N2 Method).
- Nonlinear Dynamic Analysis, focusing of methods for numerical time-domain integration.
- Review of past blind prediction tests and comparison between numerical and experimental results.

The course will be taught jointly by Dr. João Almeida and Prof. Katrin Beyer.

Keywords

Finite element analysis, modelling of structures, seismic analysis

Learning Prerequisites

Required courses

- Fundamental course in linear finite element analysis (CIVIL-321 Modélisation numérique des solides et structures or equivalent)
- Structural dynamics (CIVIL-420 Dynamique des structures or equivalent)
- Reinforced concrete structures (CIVIL-234 Structures en béton or equivalent)
- Seismic engineering (e.g. CIVIL-522 Seismic engineering or equivalent)

Learning Outcomes

By the end of the course, the student must be able to:

- Hypothesize different structural members with adequate modelling approaches
- Choose appropriate constitutive laws, element formulations and solution methods for structures undergoing inelastic deformations
- Conduct nonlinear static and dynamic analyses of complete structures
- Apply a nonlinear finite element software for seismic modelling and analysis
- Interpret output and estimate achievable simulation accuracy

Transversal skills

- Make an oral presentation.

Assessment methods

The assignments (including the oral presentations) will count 50% and also the final exam will count 50%.