

CIVIL-449

Nonlinear analysis of structures

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Cursus	Sem.	Type
Civil Engineering	MA1, MA3	Opt.
Civil engineering minor	H	Opt.
Mechanical engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	5 weekly
Courses	3 weekly
Exercises	2 weekly
Number of positions	

Summary

This course provides an introduction to the nonlinear modelling of civil engineering structures.

Content

The course is based on assignments in which students either implement the nonlinear analysis from scratch (for models with truss elements) or use an open-source software (for models with beam elements). The topics that are covered are the following:

- Truss models: Hand calculations and finite element calculations of truss models with material and geometric nonlinearity;
- Nonlinear material laws: Plasticity, Continuum Damage Mechanics, Smearred Crack Models
- Beam element formulations: Total and incremental compatibility and equilibrium relations of beams, accounting for large displacements. 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).
- Nonlinear analyses: Solution methods for nonlinear static and dynamic analysis. Damping models.
- Review of past blind prediction tests and comparison between numerical and experimental results.
- Use of nonlinear simulations in civil engineering practice.

Keywords

Nonlinear analysis, beam-column elements, seismic assessment, geometric nonlinearities, material nonlinearities

Learning Prerequisites**Required courses**

CIVIL-321 Numerical modelling of solids and structures (or similar)
Courses on structural mechanics

Learning Outcomes

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

- Implement nonlinear finite element approaches for truss elements
- Assess / Evaluate the consequences of modelling hypotheses on analysis results

- Choose appropriate finite element formulations for nonlinear structural analysis problems
- Develop models that represent the essentials of the nonlinear response of structures

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Set objectives and design an action plan to reach those objectives.
- Use a work methodology appropriate to the task.
- Communicate effectively with professionals from other disciplines.
- Access and evaluate appropriate sources of information.
- Use both general and domain specific IT resources and tools
- Communicate effectively, being understood, including across different languages and cultures.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.

Teaching methods

Lectures, exercices

Expected student activities

Solution of assignments, active participation in case studies (in-class exercices)

Assessment methods

Assignments

Project during the semester

Final exam

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Ressources en bibliothèque

- [Finite element analysis for building assessment / Lourenço & Gaetani](#)

Moodle Link

- <https://go.epfl.ch/CIVIL-449>

Prerequisite for

Master projects in seismic engineering, assessment of existing structures