Inelastic Finite Element Methods for Structures

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Module number	Credits	Workload	Semester[s]	Duration	Group size
BI-WP59/CE-WP06/SE-CO-20	6 CP	180 h	3. Sem.	1 Semester[s]	no limitation

Courses	Contact hours	Self-study	Frequency
a) Inelastic Finite Element Methods for Structures	a) 4 WLH (60 h)	a) 120 h	a) each winter

Module coordinator and lecturer(s)

Prof. Dr. Roger A. Sauer

a) Dr.-Ing. Vladislav Gudzulic, Prof. Dr. Roger A. Sauer

Admission requirements

Recommended previous knowledge:

Basic knowledge of tensor analysis, continuum mechanics and linear Finite Element Methods.

Previous participation in the course Nonlinear Finite Element Method for Structures is recommended and participation Object-Oriented Modeling and Implementation of Structural Analysis Software is advantageous.

Learning outcome, core skills

After successfully completing the module the students will

- understand the fundamentals of dissipative processes in the context of modeling inelasticity in quasi-brittle materials, using concrete as the main example.
- learn the computational approaches for modeling elastoplastic, damage and friction behavior.
- be familiar with the concept of strain localization and localized failure, including their mathematical and numerical implications, as well as strategies to address them.
- gain practical experience with implementation and algorithmic treatment of inelasticity in the context of incremental-iterative nonlinear structural analysis.
- develop skills to select appropriate numerical methods and material models, including multi-scale approaches, for practical problems and critically assess their limitations.
- be able to perform incremental analyses of progressive structural failure, critically evaluate the results, and assess the key design parameters such as load and deformation at the onset of inelasticity and structural redundancy (plastic reserve/residual strength).

Contents

a)

The course is concerned with inelastic material models including their algorithmic formulation and implementation in the framework of nonlinear finite element method. Strain localization and localized failure will be explored in detail, focusing on their mathematical and numerical implications, as well as the strategies to address them. Further, the course covers the fundamental theory and implementation aspects of frictional contact. Special attention will be given to efficient algorithms for physically nonlinear structural analyses, including elastoplastic and damage models for quasi-brittle materials, as well as friction algorithms. While concrete serves as a primary example, these modeling approaches are equally applicable to other materials such as rocks, fiber composites, sea ice, bone, stiff soils, and wood. The course includes coding exercises and a final assignment, where students implement a selected inelastic model into a finite element program and apply it to nonlinear structural analysis.

Educational form / Language

a) Lecture with tutorial / English

Examination methods

• Term paper 'Inelastic Finite Element Methods for Structures' (90 h., Part of modul grade 100 %, Project work (implementation of an inelastic model into FE code) with final student presentation / bonus points for homework assignments)

Requirements for the award of credit points

- Passed final module examination

Module applicability

- M.Sc. Civil Engineering
- M.Sc. Computational Engieering
- M.Sc. Subsurface Engineering

Weight of the mark for the final score

Percentage of total grade [%] = 6 * 100 * FAK / DIV

FAK: The weighting factors can be taken from the table of contents.

DIV: The values can be taken from the table of contents.

Further Information