Ph.D. programme in Civil Systems Engineering

Plasticity for Geotechnics: constitutive and numerical insights

prof. eng. Ferdinando Marinelli

Credits: 3 CFU
Number of hours: 24 frontal hours
Data: 3, 6, 10, 13, 17, 20, 24, 27 February 2026, 3, 6, 10, 13 March 2026

Objectives: This course is aimed to present the main hypotheses of the elastoplastic theory with focus to some constitutive approaches used to describe the behaviour of soils and rocks. Once the fundamentals equations of plasticity will be described, a set of constitutive models will be discussed starting from the most common frictional models used in engineering applications to more complex approaches characterized by more elaborated strength criteria and hardening rules. The course will continue by detailing the numerical methods used to integrate the constitutive equations. Integration techniques based on explicit and implicit algorithms will be presented. The goal of this part of the course is to provide to the students the main computational tools to integrate an elasto-plastic models. For this purpose, some lectures will be dedicated to show possible implementations within Matlab/Octave which will be used as platform for the constitutive integration of some models under different stress paths.

Course programme: The course will present the elasto-plastic theory, and some constitutive models used to simulate soil behaviour. The numerical methods implemented to integrate this set of equations is also detailed in this course. The course is organized according to the following outline:

- Introduction to modelling and the elasto-plastic theory
- Elasto-plastic approaches for geomaterials: from perfect plasticity to strain hardening
- Numerical methods used to integrate constitutive models
- Implementation of constitutive models
- Finite Element Method (FEM)

Assessment methods: Final interview

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Lectures Program

N	Date	Schedule	Duration	Teacher	Topic
1	03/02/26	14:00 - 16:00	2 hours	F. Marinelli	Introduction to constitutive modelling: fundamental hypothesis and preliminary concepts
2	06/02/26	14:00 - 16:00	2 hours	F. Marinelli	Elasto-plastic theory: one-dimensional examples
3	13/02/26	14:00 - 16:00	2 hours	F. Marinelli	Elasto-plastic theory: two-dimensional examples
4	17/02/26	14:00 - 16:00	2 hours	F. Marinelli	Constitutive model based on frictional plasticity: from perfect plasticity to strain hardening approach
5	20/02/26	14:00 - 16:00	2 hours	F. Marinelli	Constitutive models based on critical state theory
6	24/02/26	14:00 - 16:00	2 hours	F. Marinelli	Three dimensional generalisation of the elasto-plastic theory. General concepts.
7	24/02/26	14:00 - 16:00	2 hours	F. Marinelli	Explicit integration algorithms for stress integration: general procedure applied to constitutive equations
8	27/02/26	14:00 - 16:00	2 hours	F. Marinelli	Explicit integration algorithms for stress integration: general procedure applied to constitutive equations
9	03/03/26	14:00 - 16:00	2 hours	F. Marinelli	Matlab implementation of an explicit integration algorithm
10	06/03/26	14:00 - 16:00	2 hours	F. Marinelli	Implicit integration algorithms for stress integrations: general procedure applied to constitutive equations
11	10/03/26	14:00 - 16:00	2 hours	F. Marinelli	Matlab implementation of an explicit integration algorithm
12	13/03/26	14:00 - 16:00	2 hours	F. Marinelli	Finite element theory for non-linear mechanical problems

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