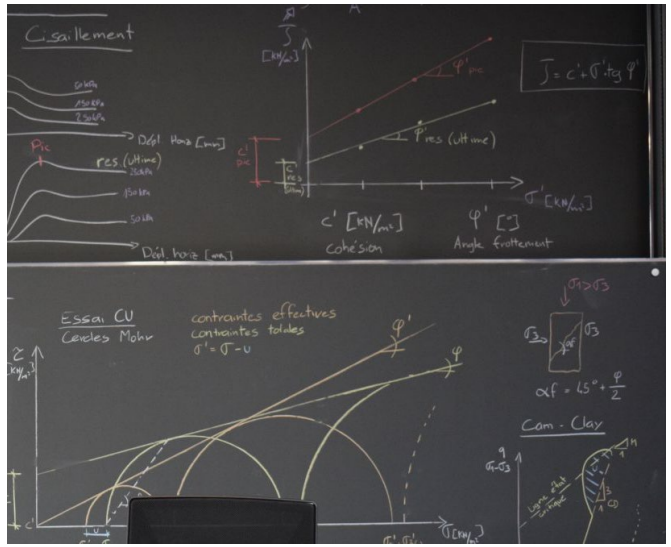


Geomechanics

LECTURE 1

COURSE INTRODUCTION

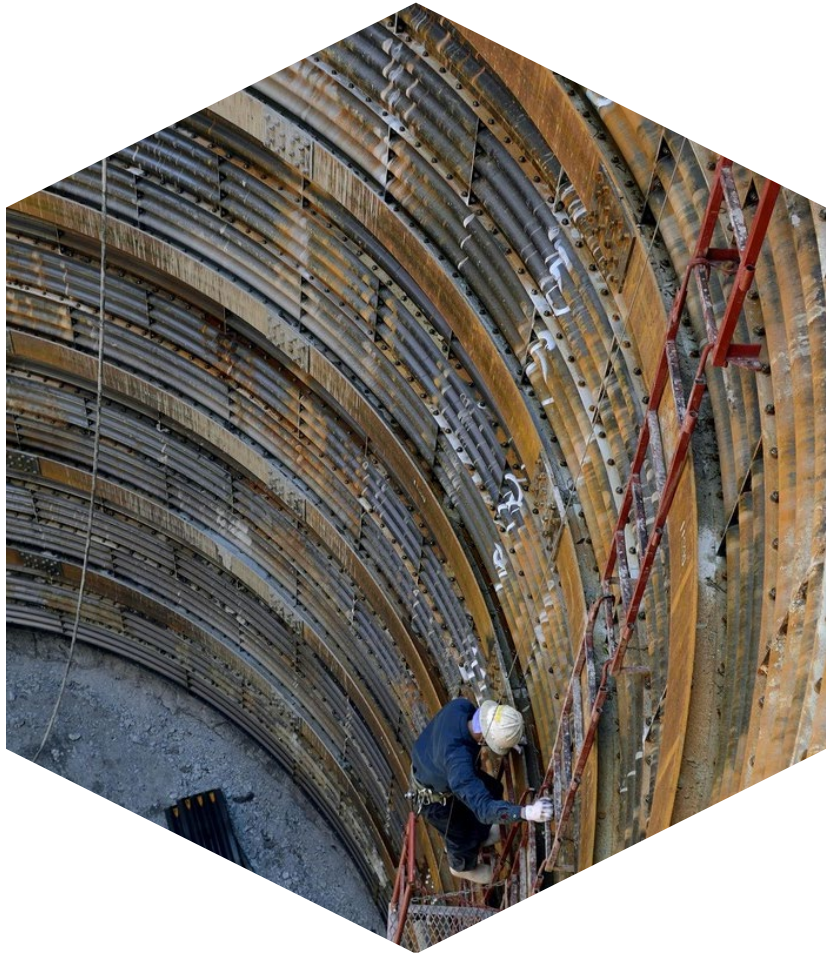
DR. ALESSIO FERRARI

Laboratory of soil mechanics – Fall 2025

Content

- Laboratory of Soil Mechanics
- Goal of the course
- Introduction to geomechanics
- General overview of the program

Laboratory of Soil Mechanics



The Laboratory of Soil Mechanics (LMS) is a world-leading geotechnical research and innovation lab. We specialize in energy geostructures, bio-improved soils, unsaturated geomechanics, and nuclear waste and CO2 storage.

Laboratory of Soil Mechanics

Research and Development

Innovation and Tech Transfer

Education

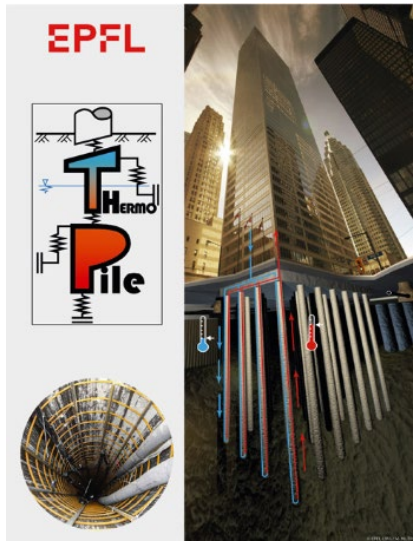
Laboratory of Soil Mechanics

Research and Development

Innovation and Tech Transfer

Education

enerdrape



medusoil

Laboratory of Soil Mechanics

Research and Development

Innovation and Tech Transfer

Education

LMS Courses

https://www.epfl.ch/labs/lms/educational-programs/

Laboratory of Soil Mechanics

LMS Projects

https://www.epfl.ch/labs/lms/master-thesis-at-lms/

Energy Geostructures

CO2 Storage

Nuclear Waste Storage

Climate change impact

Bio-Improved soils

Project in industry

Propose your own project!

Goal of the course

Goal of the course

- The course aims at providing future civil engineers with the needed knowledge on **geomechanics for professional practice**
- Be able to answer the following questions:
  - **What** are geomaterials?
  - **Why** do we study geomaterials?
  - **How complex** is the behaviour of geomaterials?

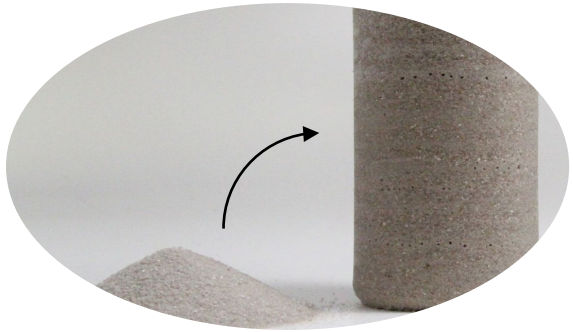
What are geomaterials ?

➢ Any material with a **geological origin**

Multiphasic
Non-homogeneous
Anisotropic

In their **natural state**

- Foundations on soils
- Tunnel excavation in rocks
- Radioactive waste disposal in shales



Engineered **materials**

- Concrete foundations
- Jet grouted columns
- Bio-cemented soil

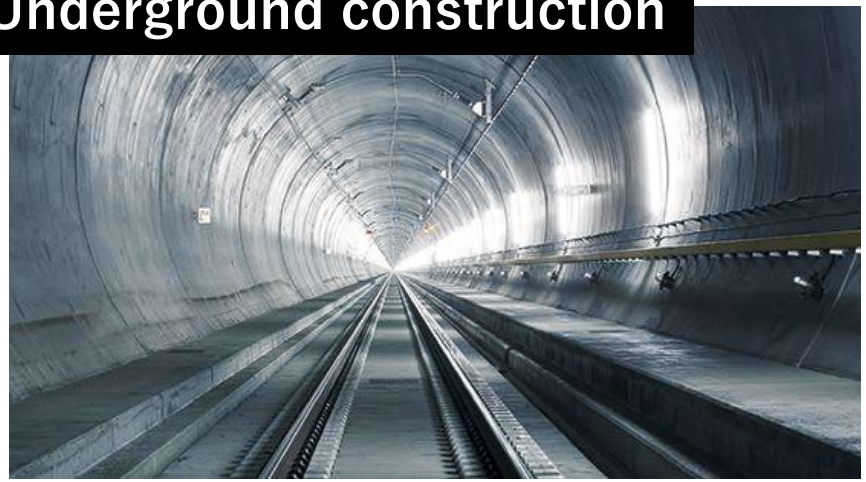
Why do we study geomaterials?

Natural hazards

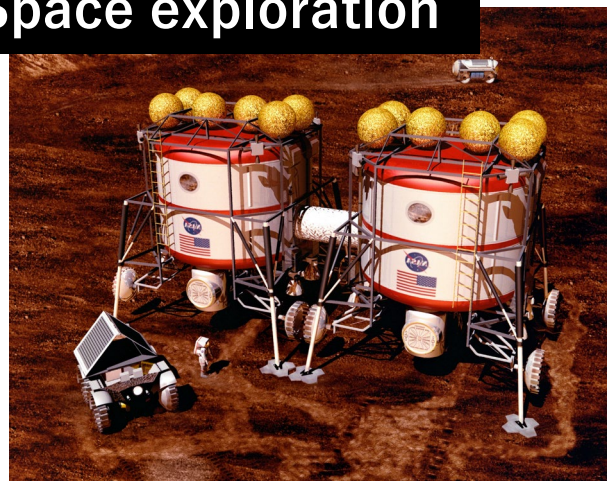
Civil infrastructure

Energy & hydraulics

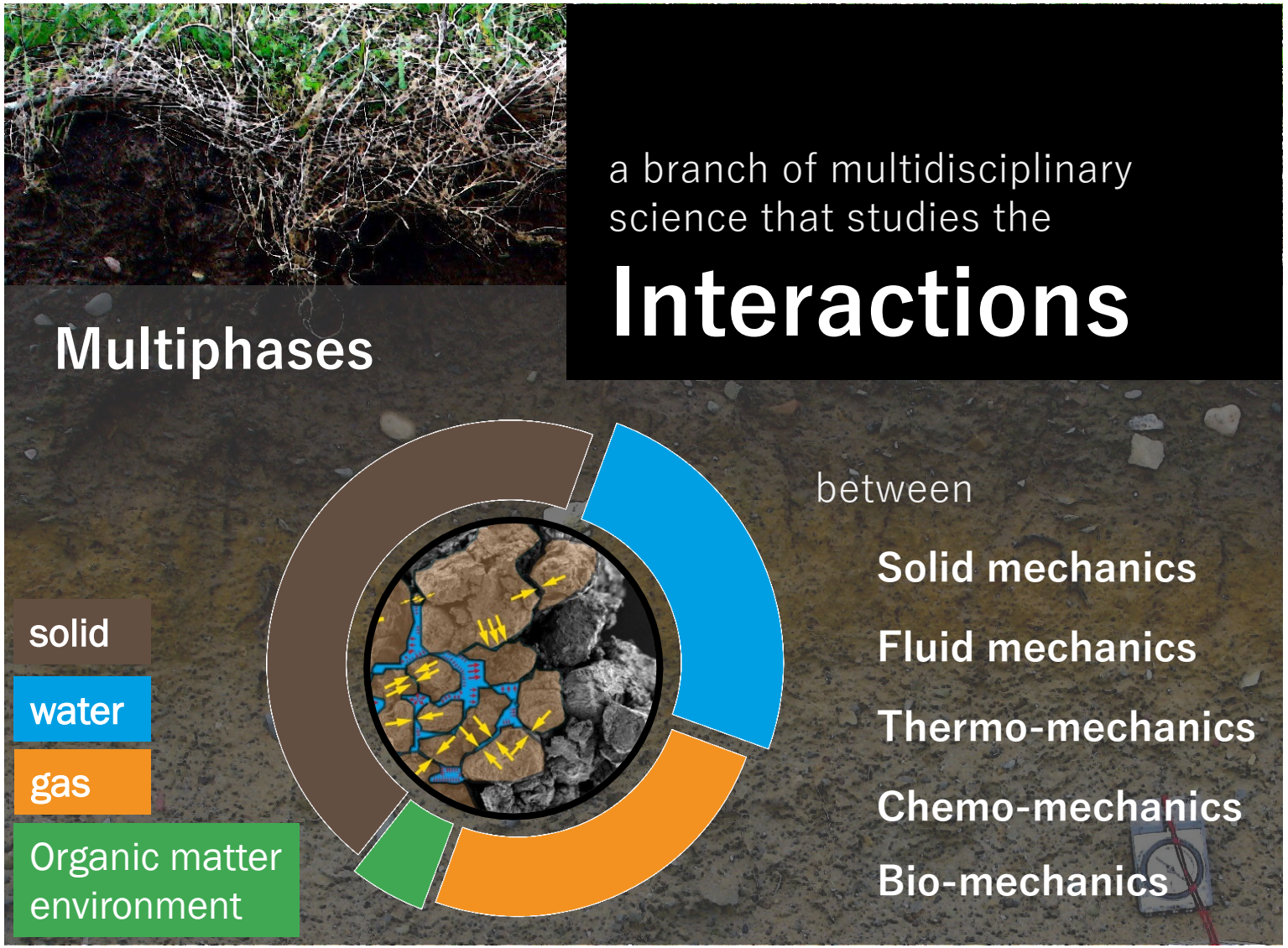
Underground construction



Space exploration



How complex is the behaviour of geomaterials?



Multiphasic porous media

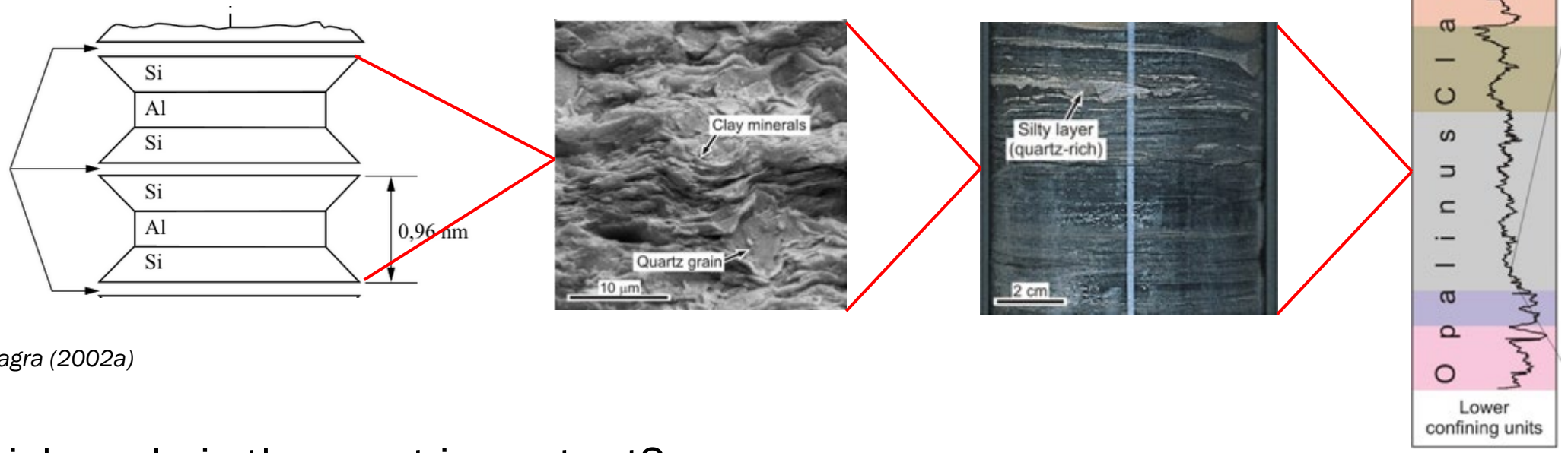
↕

Multi-physical processes

How complex is the behaviour of geomaterials?

Multiscale in porous media

- Each scale has its own **characteristics, heterogeneity, physics and uncertainty**



Nagra (2002a)

Which scale is the most important?

→ It depends on the problem !

What are you looking for?
What are your ressources (data, computational)?
Do we know the physics?

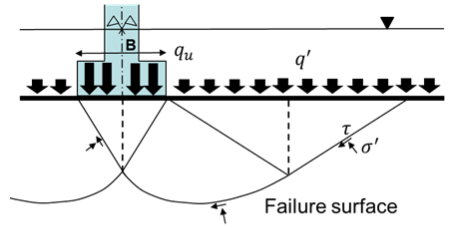
Introduction to Geomechanics

Introduction

Constitutive modelling in geomechanics

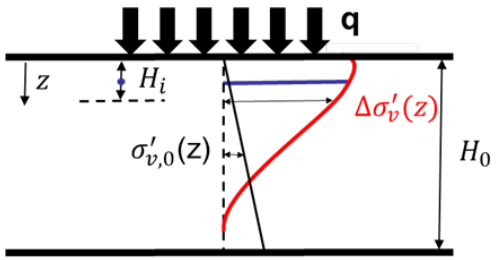
- In geotechnics, soil is more often treated as an element beside the structural elements and (usually) analytical methods are proposed to solve geotechnical problems
- In Geomechanics, geomaterials, particularly soils, are viewed as engineering materials
- Stress-strain behaviour of these materials should be modelled in the analysis.

Bearing capacity



$$q_u = \frac{1}{2}\gamma' B N_\gamma + c' N_c + q' N_q$$

Settlement

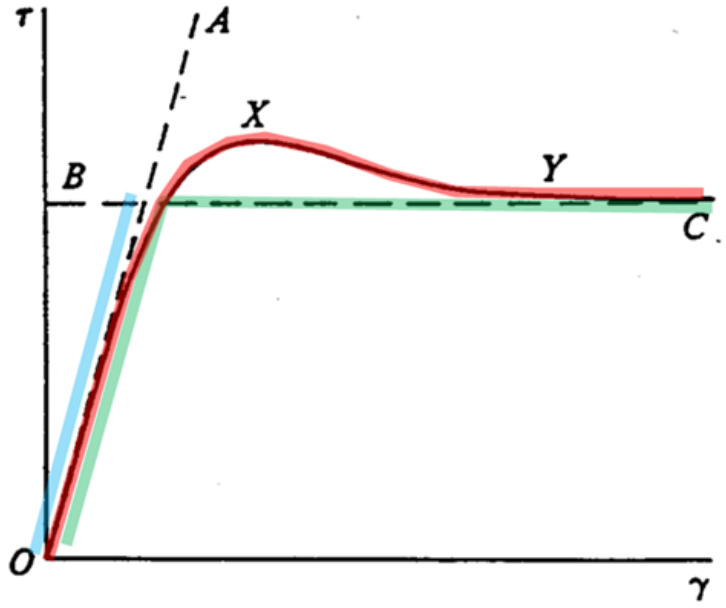


$$s_i = \frac{\Delta\sigma'_v(z_i)}{E_{oed}(z_i)} H_i$$

Introduction

Theory of constitutive equations

- A constitutive law or model represents a mathematical model that describes our idea of the behaviour of a material.
- A constitutive equation is a mathematical model that can permit reproduction of the observed response of a continuous medium.
- Common constitutive laws used in study of soil as a multiphase mixture:
  - State of fluid
  - Flow (Darcy)
  - Mechanical constitutive law: Stress-strain relation for solid

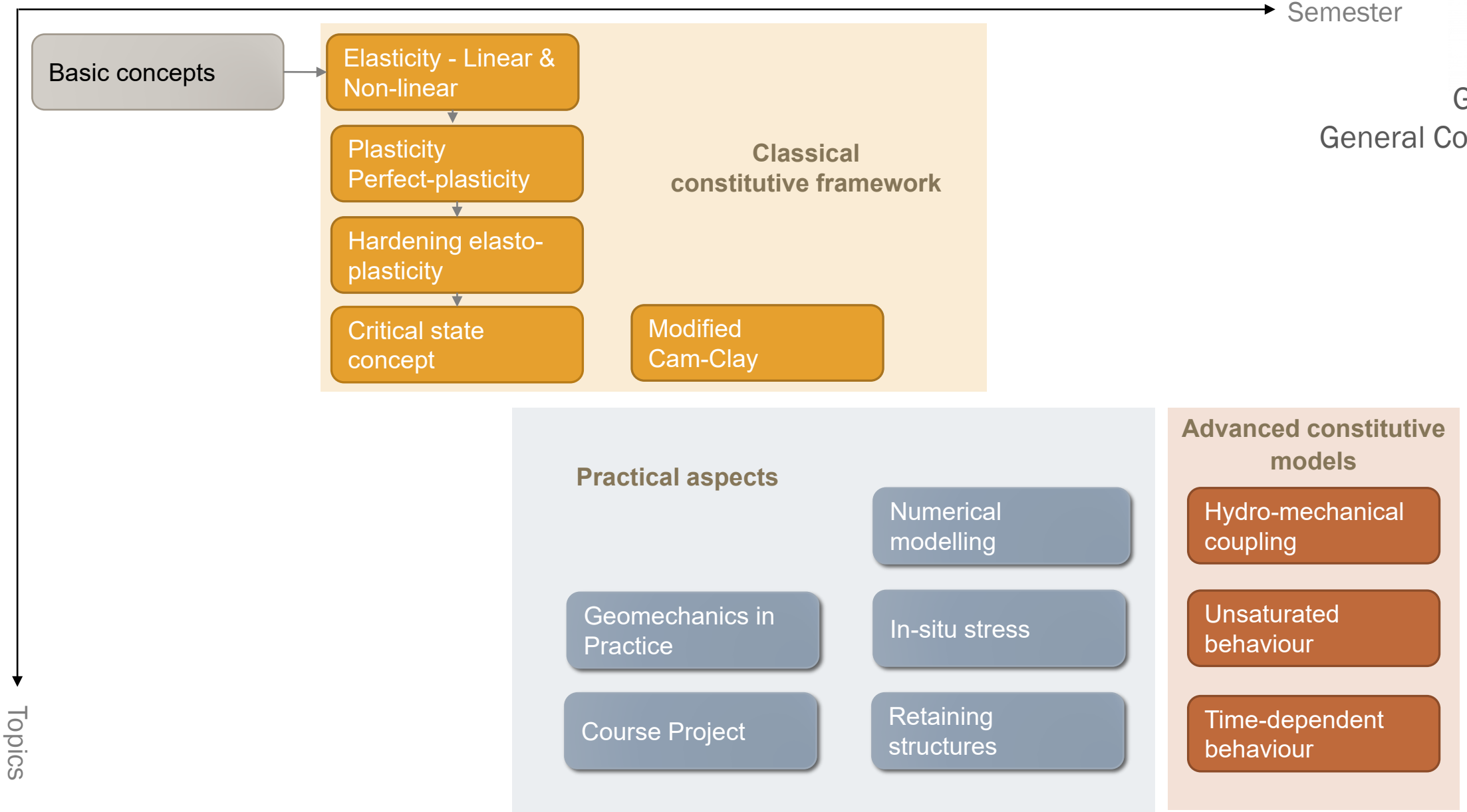


Introduction

Steps in development of constitutive law

- Mathematical formulation
- Identification of significant parameters
- Determination of parameters from laboratory, and verification that can involve the following two additional steps:
  - Prediction of observed data from which the parameters were determined and of other tests at different conditions
  - Comparison between predictions after implementation of constitutive law and observations or solutions for boundary values problems

General overview of the program


Semester
Topics
Basic concepts
Elasticity - Linear & Non-linear
Plasticity Perfect-plasticity
Hardening elasto-plasticity
Critical state concept
Classical constitutive framework
Modified Cam-Clay
Practical aspects
Numerical modelling
Geomechanics in Practice
In-situ stress
Course Project
Retaining structures
Advanced constitutive models
Hydro-mechanical coupling
Unsaturated behaviour
Time-dependent behaviour

Course details

Course sessions

- **Theory sessions – Monday, 11:15 – 14:00**

  Lecturers: Alessio Ferrari (AF), Lyesse Laloui (LL)

  Class room: GR A3 30

- **Exercise sessions – Thursday, 17:15 – 19:00** (see program for more details)

  Assistants: Ziad Sahlab (ZS), Mathilde Métral (MM), Alessandro Parziale (AP)

  Class rooms: AAC 0 06

- **Workshops – Thursday, 17:15 – 19:00** (see program for more details)

  Class rooms: see program for more details

Course details

Evaluation

- Final exam (written): 60% of the final mark
- Mid-term exam (written): 20% of the final mark
- Project report: 20% of the final mark

Mid-term and Final exam

- A formulary associated with each lecture will be created; a collection of formularies will be provided during the written exams

Project report

- The project (groups of 3/4 students), has to be submitted by Friday 19th December 2025 on a specific Moodle section
    - Within the first 2 weeks, write an email to the teaching assistants with your group of 3, or if you are looking for a group

Course details

Communication:

- This class is on Moodle forum

Exercise sessions:

- Students should bring their laptops during the exercise sessions
- Exercise session will be interactive between the TAs and the students

Have an excellent semester!