



Geomechanics

LECTURE 1

COURSE INTRODUCTION

PROF. LYESSE LALOU

Laboratory of soil mechanics – Fall 2024

09.09.2024

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



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.

Research and Development

Innovation and Tech Transfer

Education

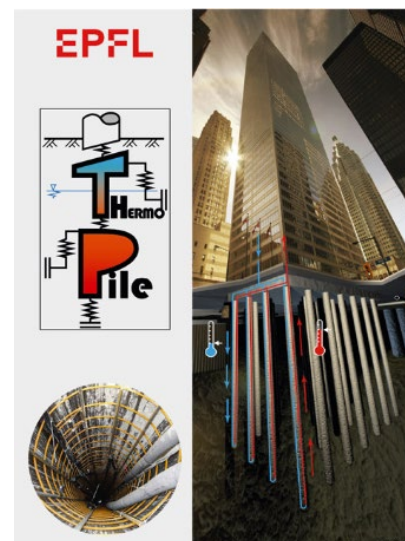


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Research and Development

Innovation and Tech Transfer

Education



Research and Development

Innovation and Tech Transfer

Education

LMS Courses

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

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**

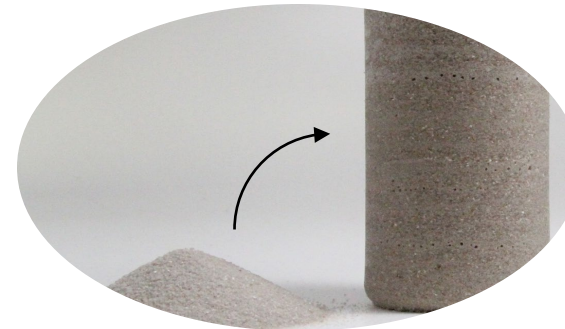


Multiphasic
Non-homogeneous
Anisotropic



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



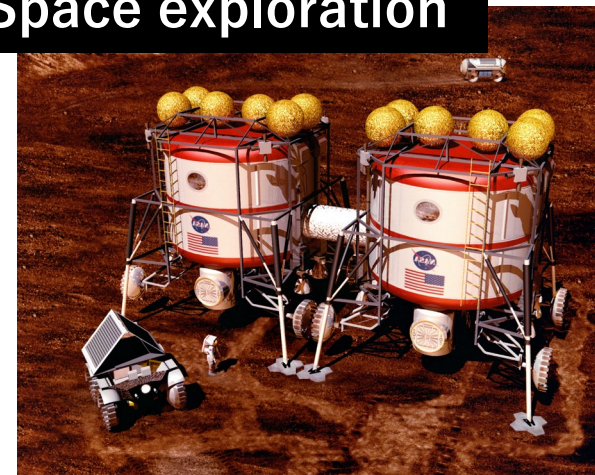
Energy & hydraulics



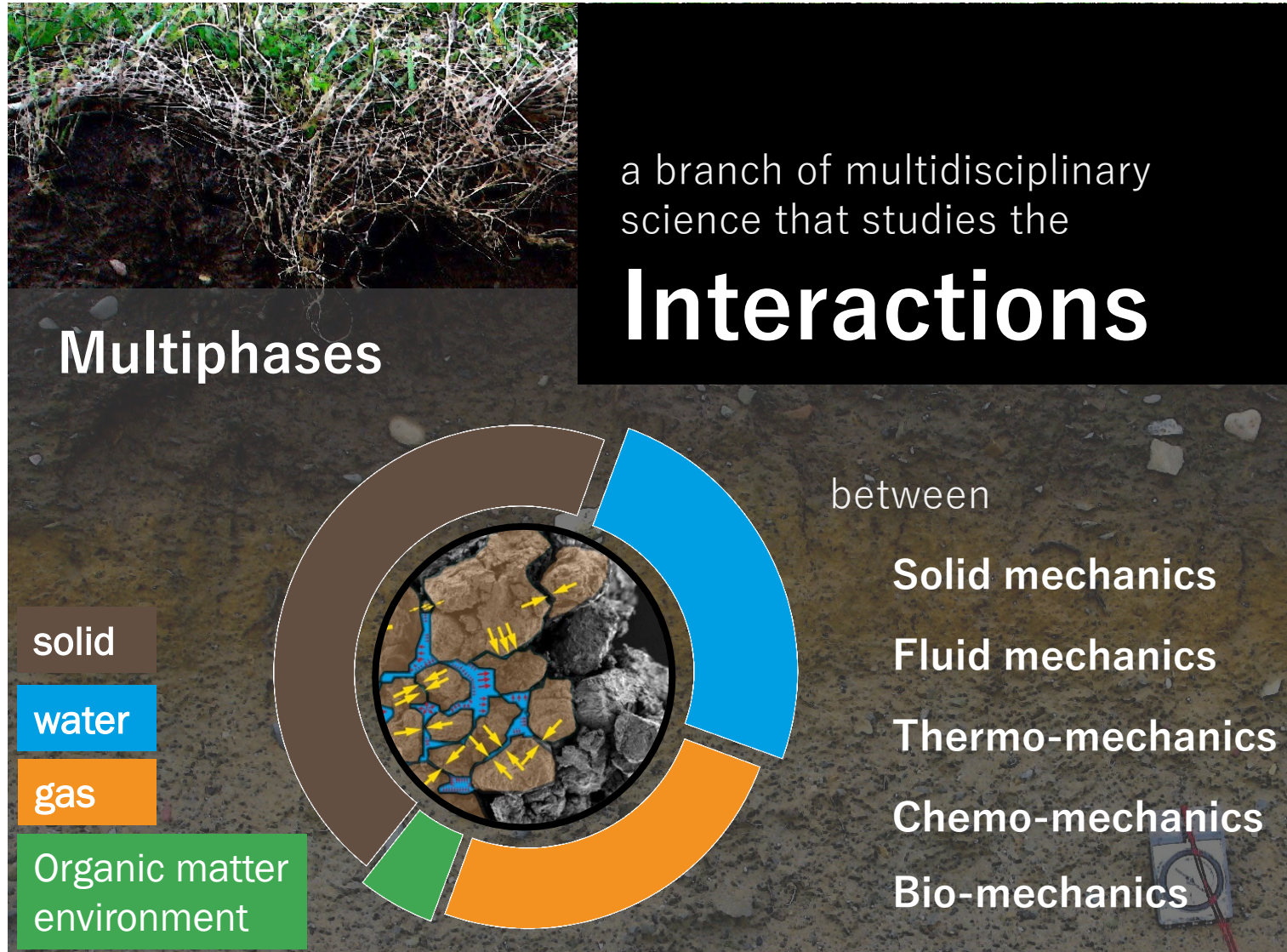
Underground construction



Space exploration



How complex is the behaviour of geomaterials?



Multiphasic porous media

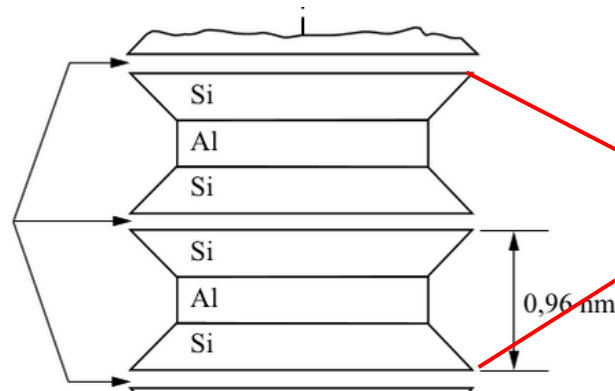


Multi-physical processes

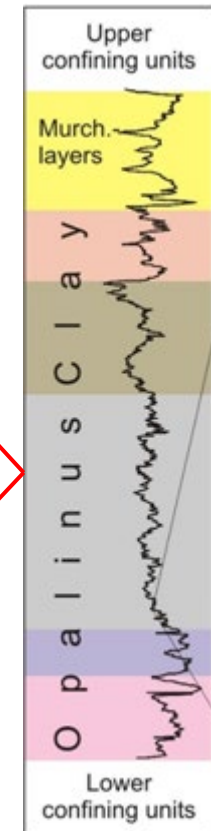
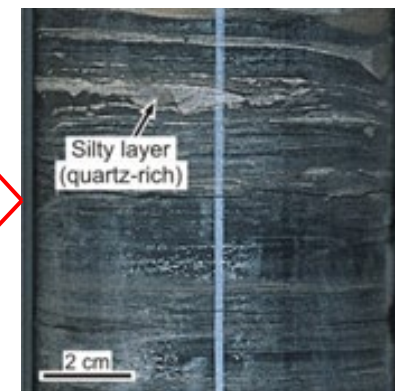
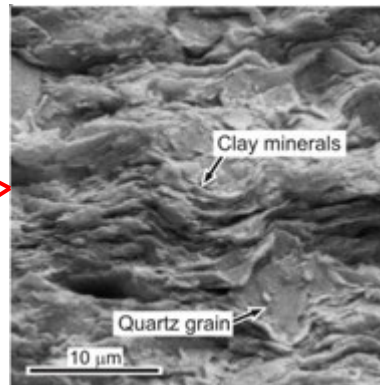
How complex is the behaviour of geomaterials?

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 resources (data, computational)?

Do we know the physics?

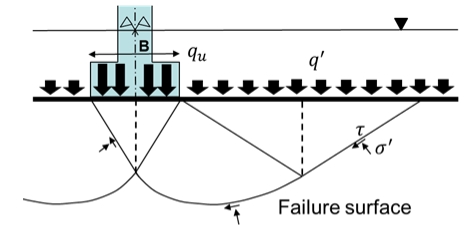
Introduction to geomechanics

Introduction

Constitutive modelling in geomechanics

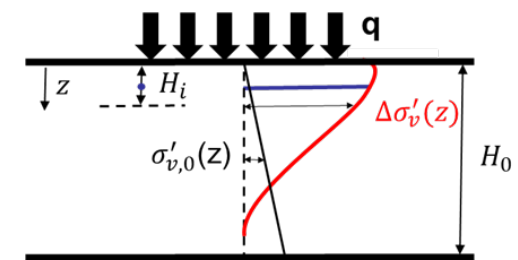
- In geotechnics, soil is more often treated as an element beside the structural elements and (usually) analytical methods are proposed to solve geotechnical problems
- In Geomechanics, geomaterials, particularly soils, are viewed as engineering materials
- **Stress-strain behaviour** of these materials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

Bearing capacity



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

Settlement

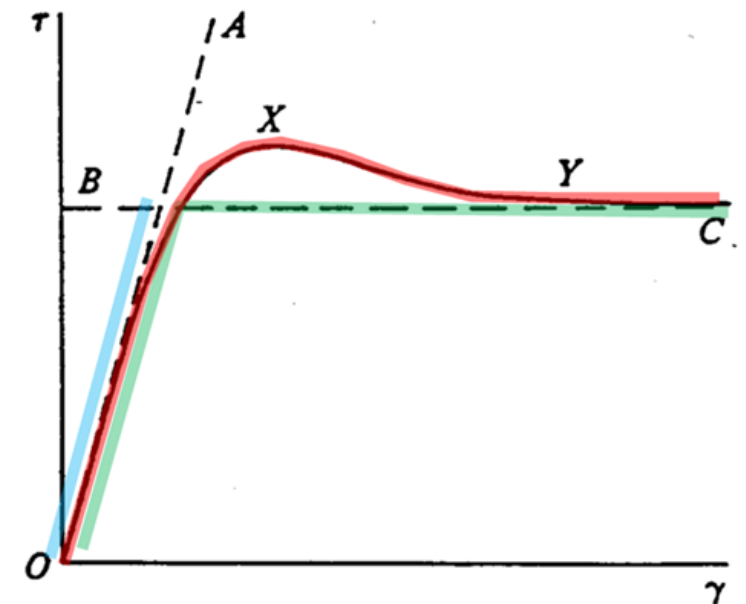


$$s_i = \frac{\Delta \sigma'_v(z_i)}{E_{oed}(z_i)} H_i$$

Introduction

Theory of constitutive equations

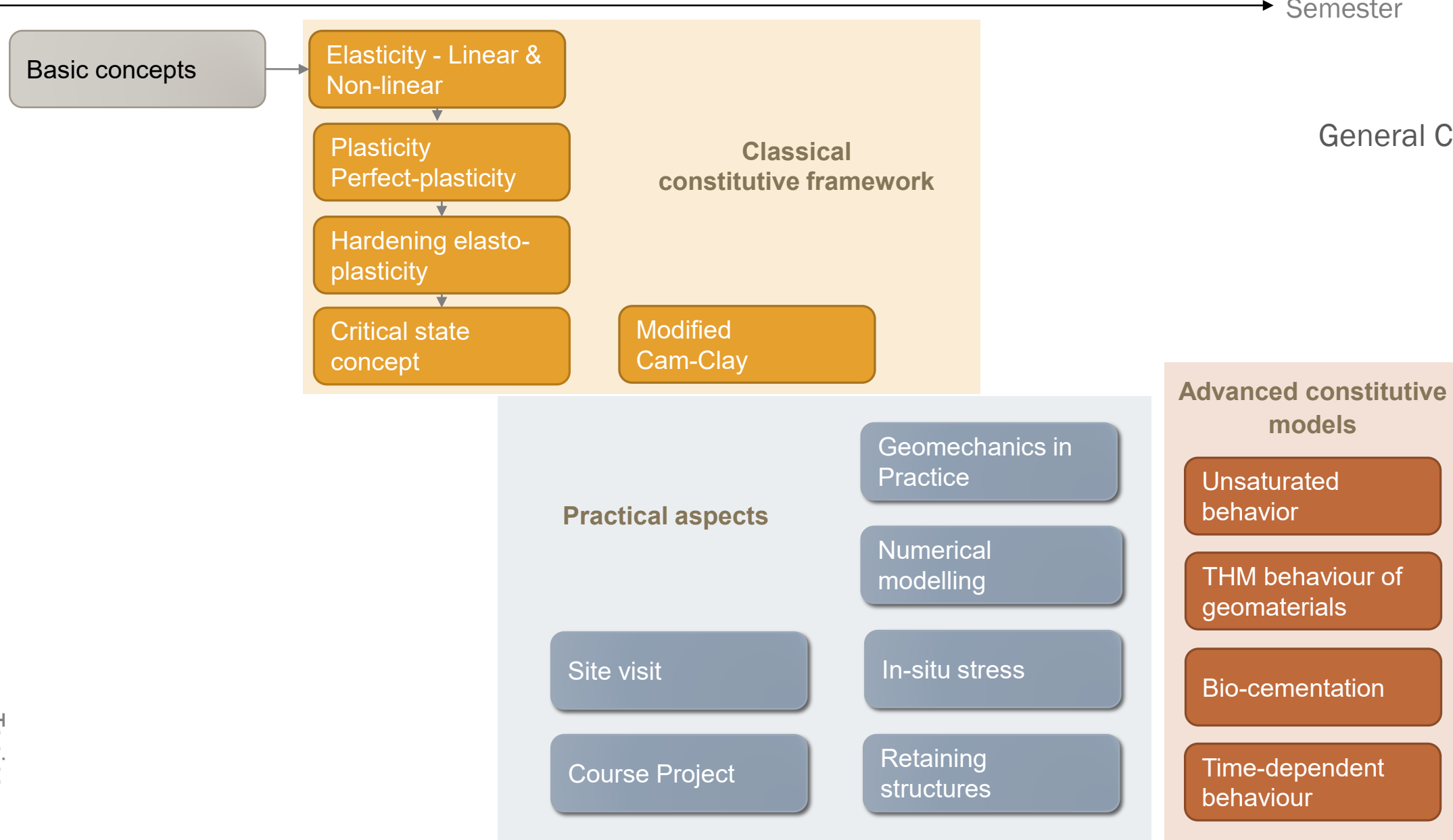
- A constitutive law or model represents a mathematical model that describes our idea of the behaviour of a material.
- A constitutive equation is a mathematical model that can permit reproduction of the observed response of a continuous medium.
- Common constitutive laws used in study of soil as a multiphase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



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



Course details

Course sessions

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

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

Class room: GR A3 30

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

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

Class rooms: GC B3 30

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 students), has to be submitted by Friday 20th December 2024 on Ed Discussion as “private” in the project category
 - Within the first 2 weeks, write an email at ziad.sahlab@epfl.ch with your group of 3, or if you are looking for a group

Course details

Communication:

- This class is on  [Ed Discussion forum – Geomechanics – CIVIL-402](#)

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!

