CENG6202: Advanced Computational Methods in Geotechnical Engineering

Instructor: Yared Worku (PhD)
Email: yaredworku@gmail.com

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Course Outline

Course Description

The course introduces advanced computational methods with a focus on practical geotechnical applications. Introductory material in geotechnical analysis and applied mathematics is first covered as a preparation for the topics that follow. A primary focus will be on the finite difference and finite element methods. Examples of mathematical descriptions for various geotechnical engineering problems is discussed. The basic principles of the finite difference method and its application to geotechnical engineering problems is presented. The fundamentals of the finite element method in the context of geomechanical simulations is dealt with in detail. Application to real world problems using finite element software and evaluation of simulation results is discussed. Other computational methods, such as the boundary element method, are introduced.

Learning Outcomes

After taking this course, the student is expected to:

- Have an overview of the various analysis methods in geotechnical engineering and their application areas.
- Understand the mathematical principles behind advanced computational methods in geomechanics.
- Identify practical geotechnical problems that can be tackled using computational methods and propose appropriate models.
- Be aware of the possibilities and limitations of various numerical tools/software, select tools and perform simulations accordingly.
- Perform geotechnical simulations using advanced numerical tools/software and report results.
- Critically evaluate the results of advanced simulations from a theoretical/practical standpoint and make engineering judgements.

Course Content

1. Geotechnical Analysis
    - Introduction
    - Analysis and Design Requirements

- Theoretical Considerations
- Idealized Computational Domains
- Analysis Methods

2. Mathematical Preliminaries
    - Vectors
    - Matrices
    - Linear System of Equations
3. The Finite Difference Method (FDM)
    - Basic Principles
        - Derivatives as Differential Equations
        - Difference Equations for Partial Derivatives
        - Solving Differential Equations
    - One-dimensional Problems
        - Steady-state Groundwater Flow
        - One-dimensional Consolidation
    - Two-dimensional Problems
        - Steady-state Groundwater Flow
4. The Finite Element Method (FEM)
    - Basic Principles
        - Geometric Discretization
        - Elements and Shape Functions
        - Interpolation of Field Variables
        - Formulation of Element Equations
        - Assembly and Solution
    - Constitutive Models
        - Linear Isotropic Elasticity
        - Mohr-Coulomb Model
        - Modified Cam-Clay Model
    - Numerical Simulations
5. Introduction to Hybrid Methods
    - Boundary Element Method (BEM)
    - Discrete Element Method (DEM)
    - Coupled Methods