CE394M Advanced Analysis in Geotechnical Engineering: Introduction

Krishna Kumar

University of Texas at Austin

krishnak@utexas.edu

January 12, 2019

Overview

1. Geotechnical modeling
   - Complexity in Geotechnical modeling
   - Classical vs advanced analysis
2. Numerical methods for differential equations
   - Direct method: Matrix analysis of structures
   - Numerical analysis of engineering problems
3. Governing equations in stress-deformation analysis

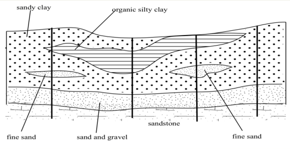
Geotechnical modeling of the complex world

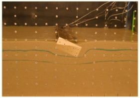
Fig. London Bridge Station, London, UK

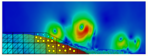
Geotechnical modeling of the complex world

Fig. London Victoria station upgrade, London, UK

Geotechnical modeling





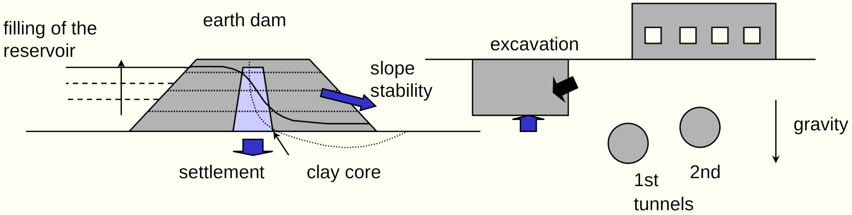


Soil behavior

- nonhomogeneous,
- anisotropic,
- non-linear,
- initial stress conditions,
- stress history
- Geometry - very complex

Soil Mechanics in practice - largely empirical

Geotechnical modeling: What should be modeled?



Advanced analysis in geotechnical engineering

Geotechnical design:

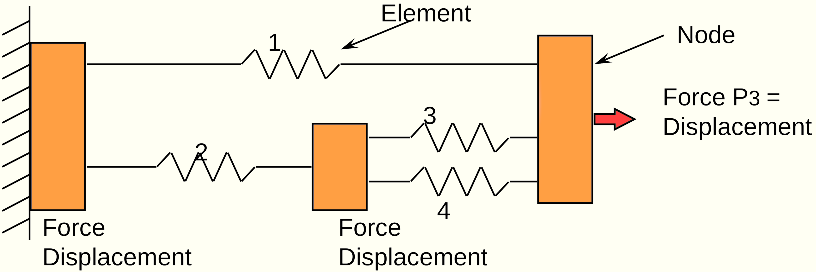
Analysis:

Classical vs advanced analysis

Classical approach:

Advanced analysis:

Matrix analysis of structures



- What are the known variables?
- What are the unknowns?
- What do we know?

Matrix analysis of structures: Equilibrium

- $P_1 =$
- What are the unknowns?
- What do we know?

Matrix analysis of structures: Compatibility

Matrix analysis of structures: Compatibility

v = internal spring distortion δ = nodal displacement

- $v_1 =$
- $v_2 =$
- $v_3 =$
- $v_4 =$

Force-distance relationship: spring constant

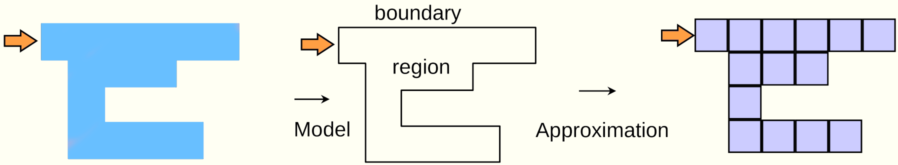
spring #	1	2	3	4
stiffness ($F.L^{-1}$)	3	2	1	2

Matrix analysis of structures: Direct Method

Combine all the equations: $\mathbf{P} =$
where $\mathbf{K} =$

Matrix analysis of structures

Physical phenomenon $\xrightarrow{\text{Model}}$ Differential equation $\xrightarrow{\text{Approximation}}$ Equations of the numerical technique



Boundary value problems

Differential equations coupled with boundary conditions

- Steady state (time-independent)
- Transient (time-dependent)

Numerical solutions to differential equations

Governing equations in stress-deformation analysis

In stress-deformation analysis, we need to consider: