CE394M Advanced Analysis in Geotechnical Engineering: Introduction

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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
   - Equilibrium

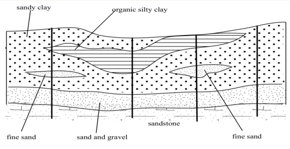
Geotechnical modeling of the complex world

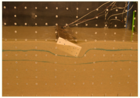
Fig. London Bridge Station, London, UK

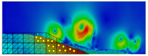
Geotechnical modeling of the complex world

Fig. London Victoria station upgrade, London, UK

Geotechnical modeling





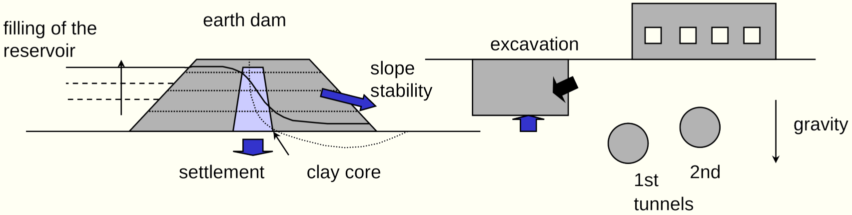


Soil behavior

- 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:

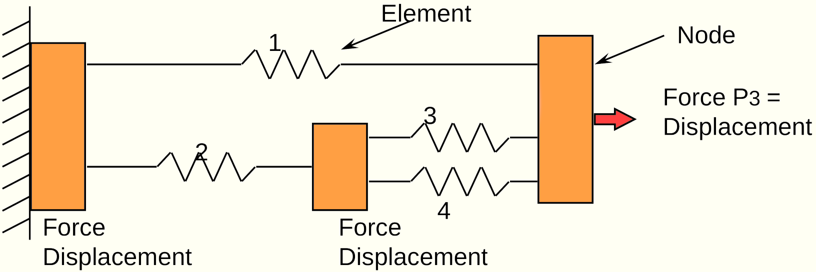
Analysis:

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

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

Matrix analysis of structures: Physical condition

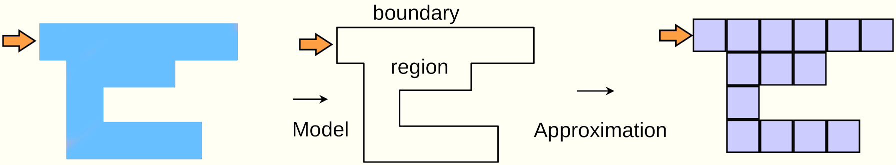
Force-distance relationship: spring constant

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

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:

Governing equations in stress-deformation analysis

The governing differential equation for equilibrium expresses: