

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

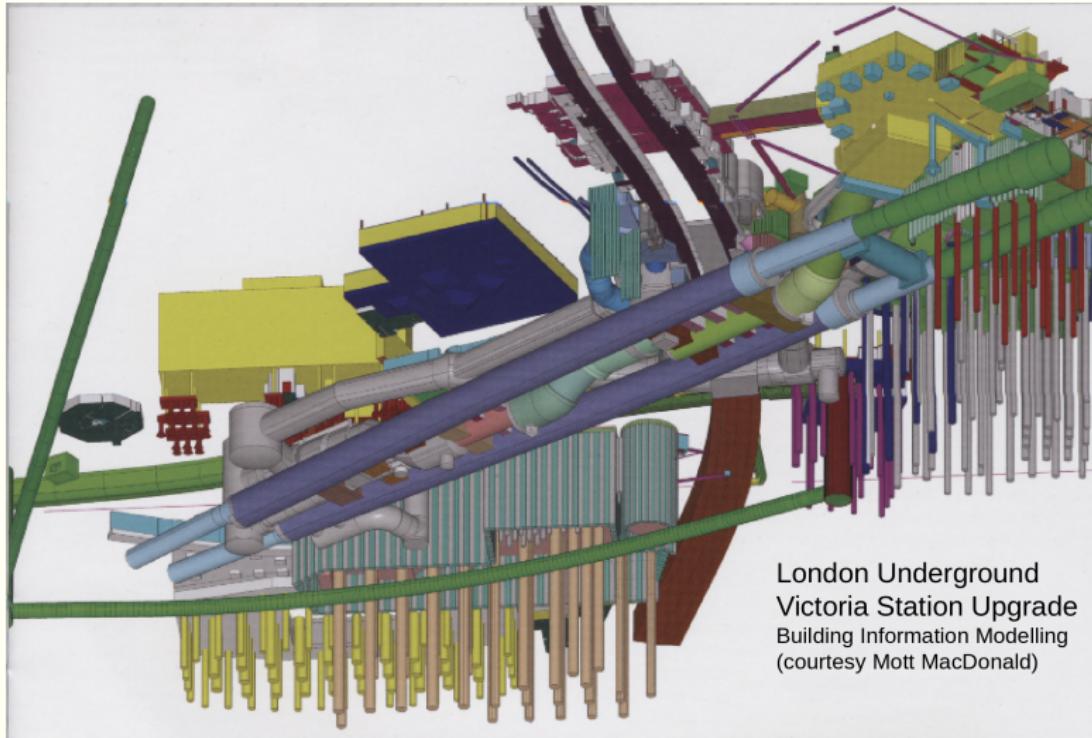
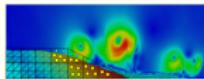
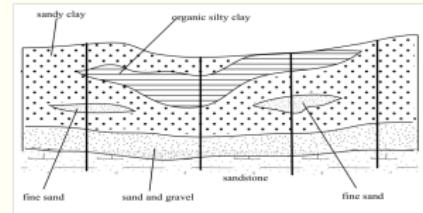


Fig. London Victoria station upgrade, London, UK

Geotechnical modeling

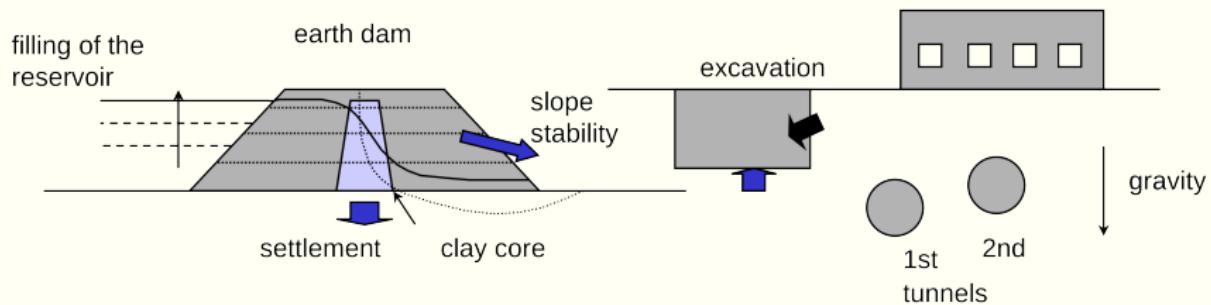


Soil behavior

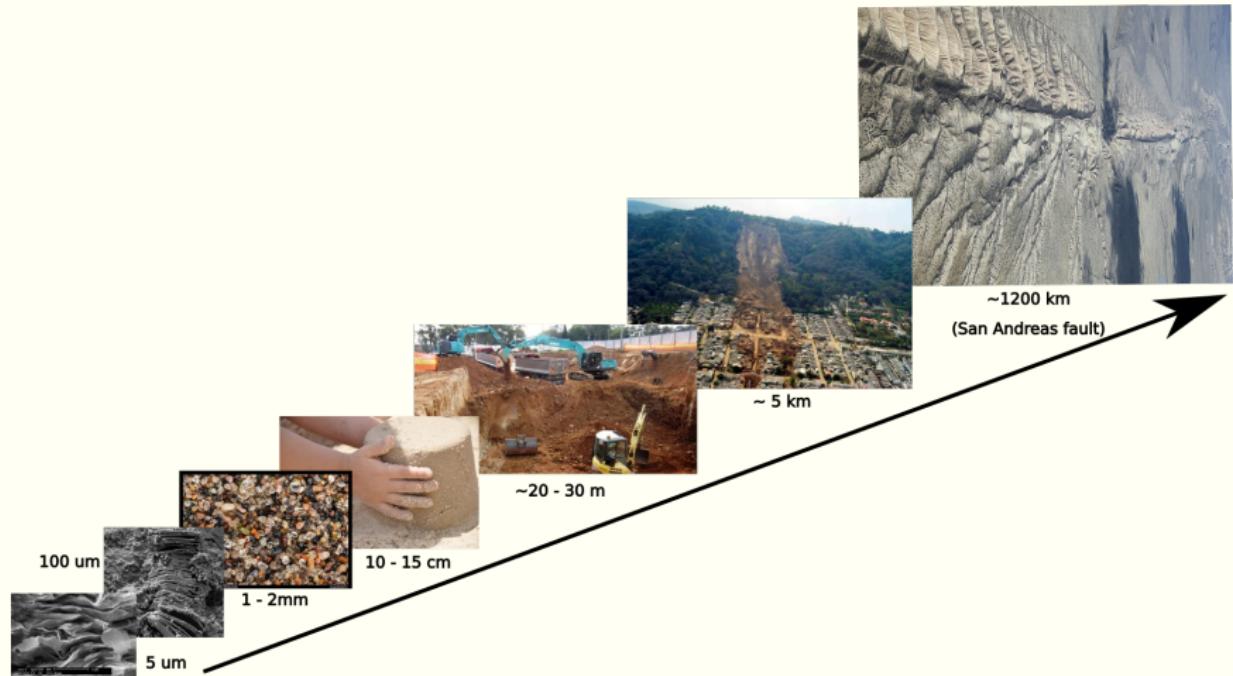
- nonhomogeneous,
- anisotropic,
- non-linear,
- initial stress conditions,
- stress history
- Geometry - very complex

Soil Mechanics in practice - largely empirical

Geotechnical modeling: What should be modeled?



Scales of modeling in geotechnical engineering



Advanced analysis in geotechnical engineering

Geotechnical design:

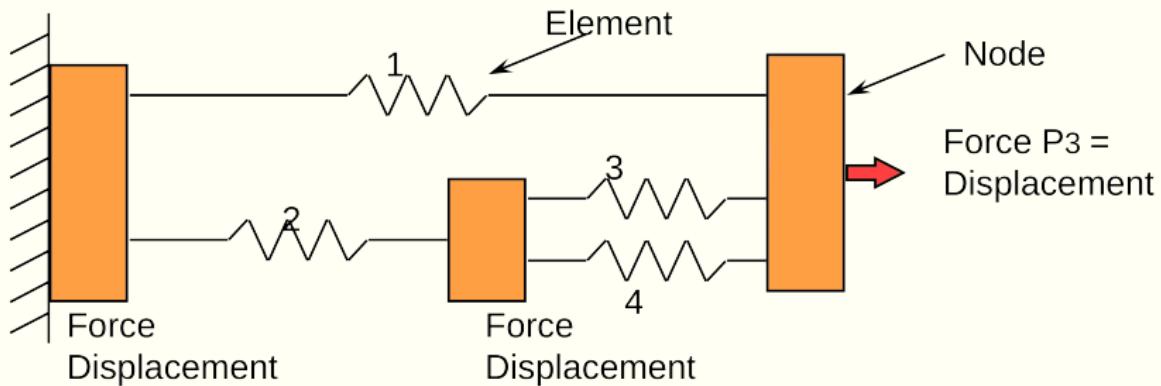
Analysis:

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

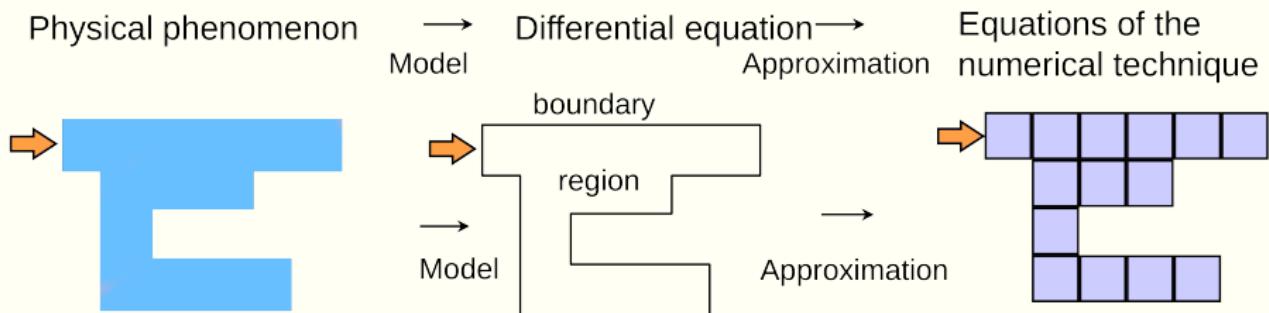
Matrix analysis of structures: Direct Method

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

where $\mathbf{K} =$

Matrix analysis of structures

Numerical analysis of engineering problems



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:

