The Future of the Discrete Element Method in Infrastructure Analysis

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Finite Elements Imply Continuity
Challenges in Failure Mechanics

Large deformations with discontinuities are difficult to model by conventional finite elements.

Simply having a factor of safety not enough.
Particle Methods for Large Deformation Problems

- The trap door experiment is a classical geotechnical problem from earth pressure theory.
- Soil behavior ranges from solid to flowing fluid.
- Particle methods are a natural way to address such problems.
Discontinuous Shear

• The passive resistance to motion a rigid wall into sand is an example of very large deformation.
• The discontinuous nature of the motion at the base of the wall is especially challenging for traditional numerical methods.
Vehicle mobility mechanics has much in common with failure mechanics in geotechnical engineering.

Recent advances in particle methods for mobility modeling hold promise for failure mechanics in geotechnical applications.
Particle Modeling with the Discrete Element Method

- DEM depicts the soil as individual particles rather than connected elements.
- The particles move in accordance to simple interaction laws rather than complicated constitutive models.
**DEM Mechanics**

- Physics based
- Replicates particulate nature of soil
- Slip planes and separations form between groups of particles thus capturing evolving failure mechanisms more realistically

Forces Acting on Particle k

Discrete Particle System

force → acceleration → velocity → displacement
Interaction with Finite Element Structures

\[ N_1 + N_2 + N_3 = 1 \]
Simulation of Wall Experiment

General character of deformation was reproduced well.

Quantitative agreement was achieved for displacement and force.
Simulated Laboratory Experiment

Simulated stress-strain and volume change curves

Simulate specimen after formation
Modeling Large Discontinuous Deformation with Particles

- Bearing Capacity Problems
- Penetrometers
- Slope Stability
Where is DEM Research Going

- Cohesive particles for slope stability problems
- Asphalt property test simulation
- Vehicle-soil interaction
- Water-soil interaction
- Non-spherical particles
Future of DEM

- Earth pressure and slope stability problems with soil-structure interaction
- Consequences of failure
- Piping and fines migration
- Spillway erosion
Thank You