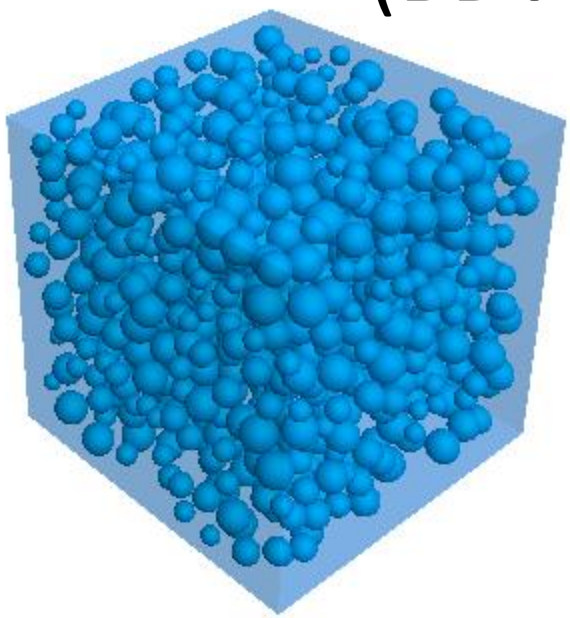
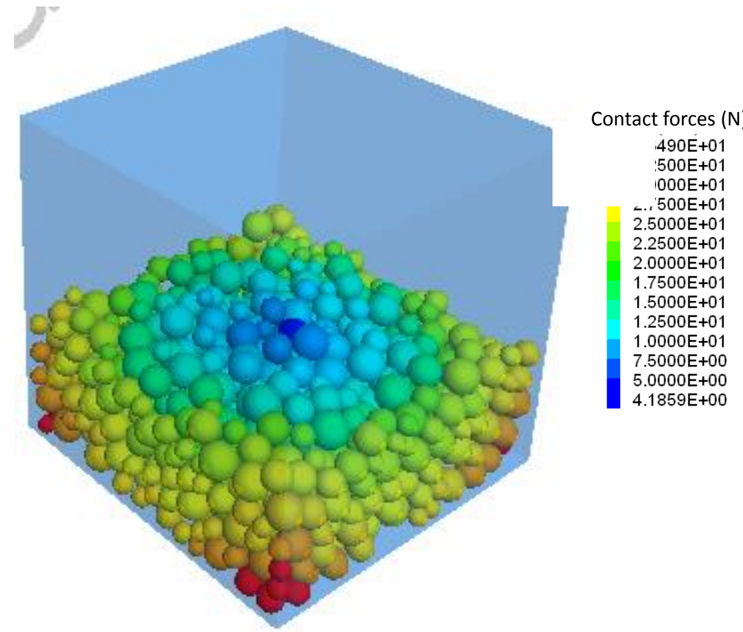
Effect of Proximity of Sheet Pile Walls on the Apparent Capacity of Driven Displacement Piles (BDV31 TWO 977-26)





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August 1, 2014

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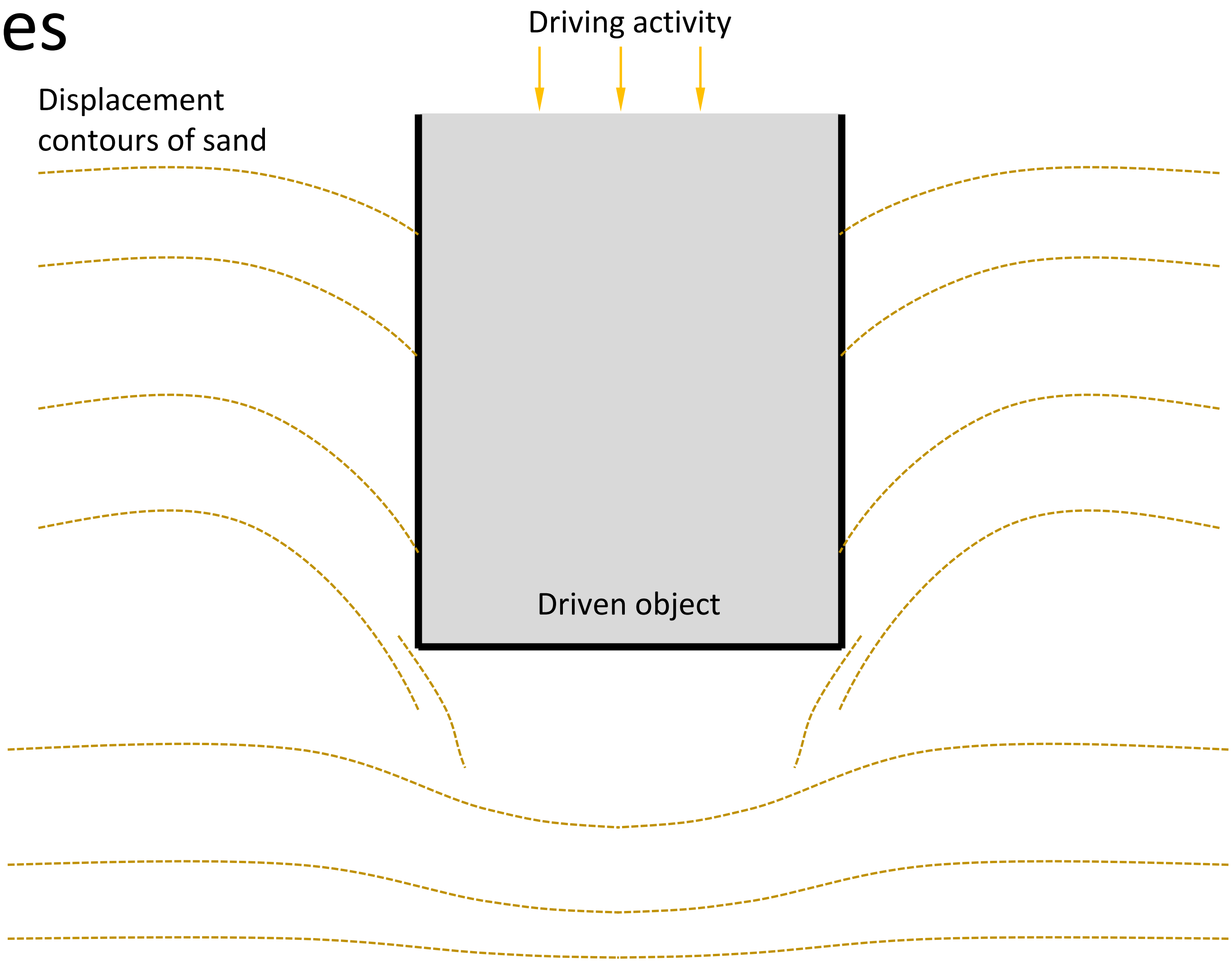
Agenda

- Introduction
- Project Goals
- Project Tasks
- Research Tasks
  - Numerical Model Development
  - Centrifuge Testing
  - Laboratory Testing
- Research-in-Progress Summary

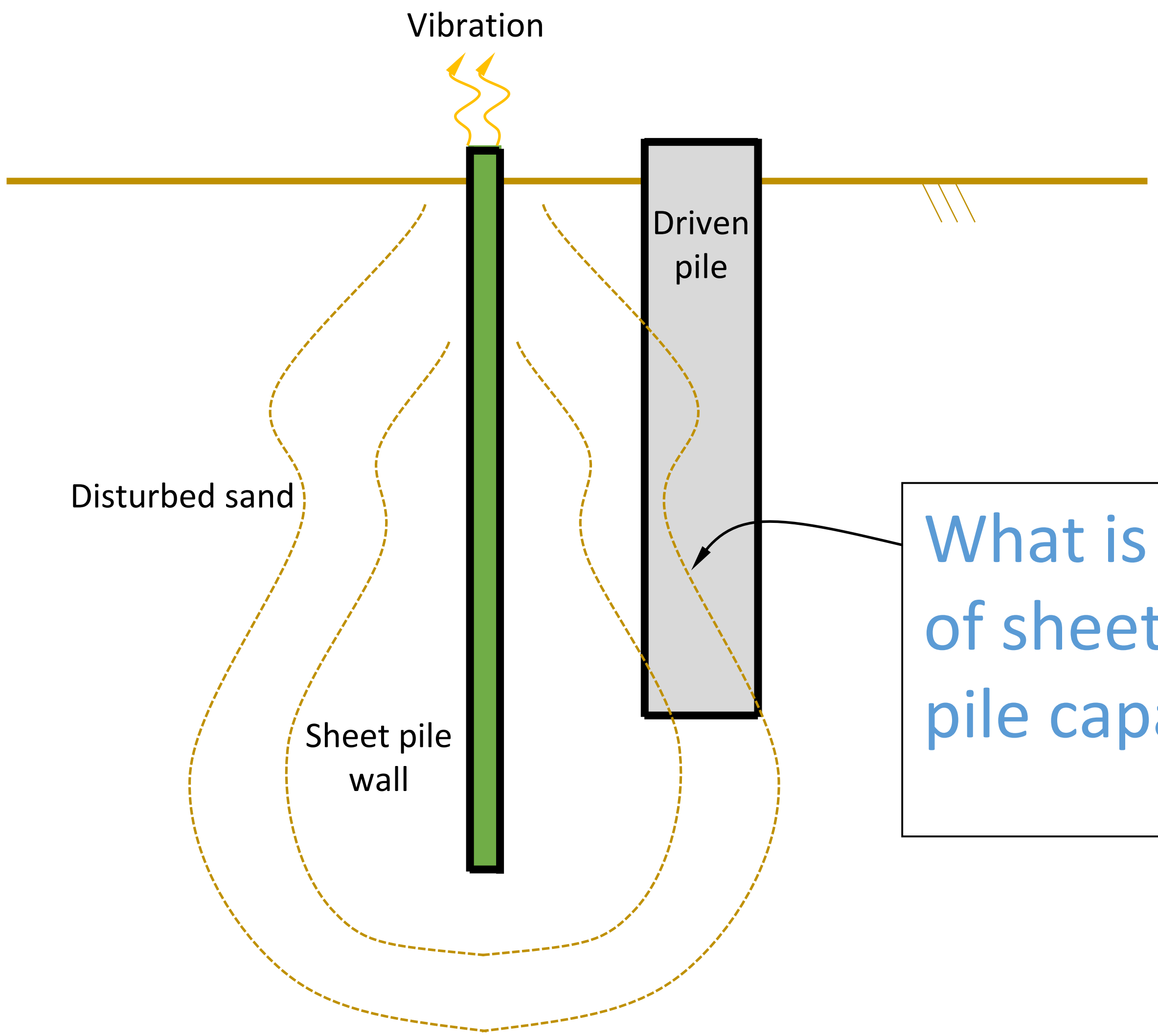
Introduction

- Effects of Driving Objects in Development of Stress States



Introduction

- Effect of Sheet Pile Walls in the Vicinity of Driven Piles



What is the effect of sheet pile wall on pile capacity?

Project Goals

- Identify design-relevant parameters for calculating pile capacities in the vicinity of SPWs
- Develop a design chart or/and tabularized matrices for use in calculation of pile-capacity changes
- Methodology:
  - Combined Discrete and Finite Elements Analysis approach
  - Spectrum of verification (laboratory and centrifuge testing)
  - Comparison to load-deformation observation in previous field tests

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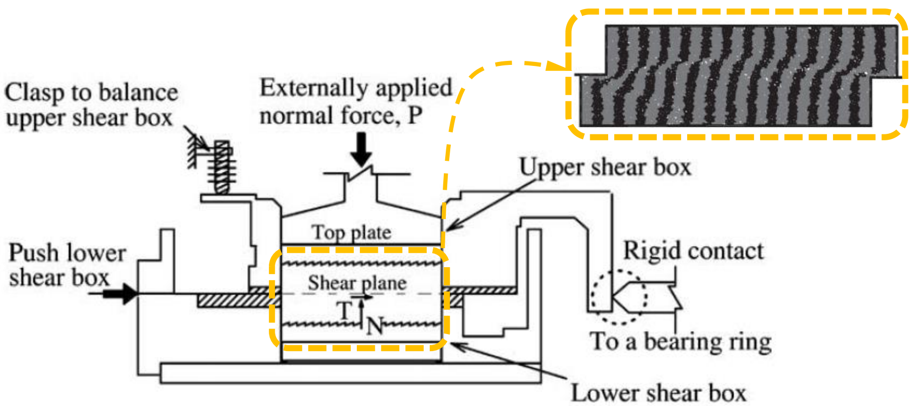
Project Tasks: Phase 1 Research Tasks

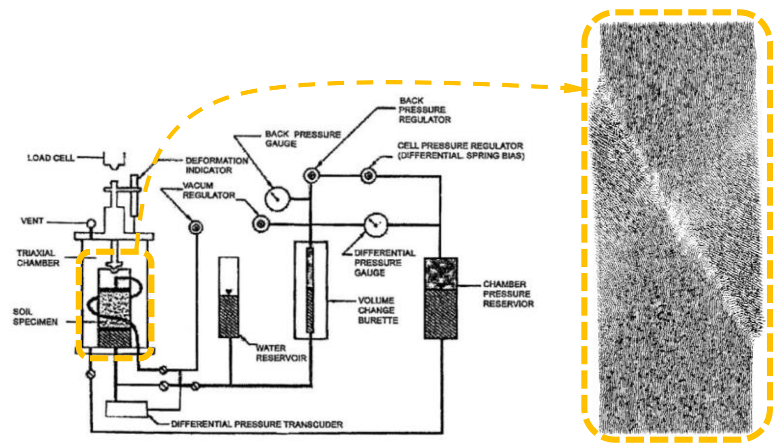
- **Task 1. Literature Review, Scenario Identification, and Field-Data Acquisition**
  - Collect data from the literature
  - Identify key modeling parameters at macroscopic scale (Continuum Mechanics)
  - Characterize micromechanical soil particles interactions using microstructural modeling tools at mesoscopic scale
- Sources
  - Technical literature
  - Design documents

Project Tasks: Phase 1 Research Tasks

- **Task 2. Numerical Modeling of Granular Soils**
  - Methodology for modeling direct shear and triaxial tests of granular soil
  - Creation of standardized DEM “soil-unit” library
  - Evaluation of Mohr-Coulomb failure envelopes



Direct shear test



Triaxial test

Project Tasks: Phase 2 Research Tasks

- **Task 3. Numerical Modeling of Driven Structural Members in Granular Soils**
  - Parametric-stochastic simulation set
- **Task 4. Physical Laboratory Experimentation**
  - Centrifuge, triaxial, and direct shear tests
- **Task 5. Synthesize Numerical Results**
  - Identify trends, and formulate design parameters
- **Task 6. Final Report**

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Progress: Task 1. Literature Review

- **Focus 1: Establishing a record of capabilities and limitations of combined DEM-FEM approach**
  - Capabilities
    - Allow for modeling of penetration into discontinua
    - Characterization of soil stress state states at meso-scopic scale
  - Challenges
    - Calibration of particle parameters (to achieve desired macro-behavior)
    - Simulation efficiency (dynamic relaxation, particle size)
    - Stress plotting

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Progress: Task 1. Literature Review

- **Focus 2: Identification and Characterization of Candidate Parameters**
  - Geotechnical Parameters
    - Relative density and void ratio; particles packing density
    - Lateral confinement, e.g., change in geostatic stress states
    - Grain size distribution; upscaling particle size to meso-scopic scale
    - Strength (friction angle) and service (shear modulus, Poisson's ratio) parameters

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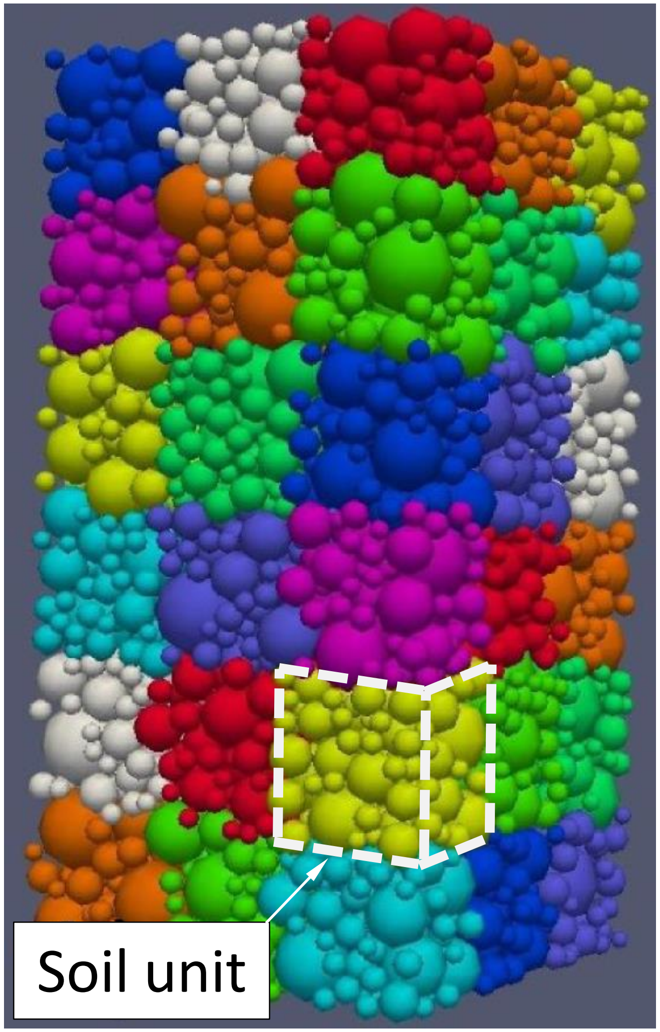
Progress: Task 1. Literature Review

- **Focus 2: Identification and Characterization of Candidate Parameters**
  - Structural Parameters
    - Installation method (driving energy)
    - Displacement pile configuration (width)
    - Horizontal offset (pile to sheet pile wall)
    - Relative depth (pile tip to embedment depth of sheet pile wall)

Progress: Task 2. Numerical Modeling of Granular Soils

- **Creation of LS-DYNA Soil Unit Library**

- Each unit simulates a macroscopic granular soil behavior
- A total of 8-10 soil 'units' covers a range of soil from loose state to very dense state.
- Pseudo-random distributions of the soil units per geostatistical characterization are simulated to describe in-situ granular soil conditions.



Source: ESyS-Particle User's Manual

Progress: Task 2. Numerical Modeling of Granular Soils

- Micro-mechanical material properties calibrated to achieve desired macro-mechanical behavior
- Numerical parameters:
  - Particule Contact friction
  - Particle Contact stiffness

LS-DYNA Parameter Summary	
Prescribed motion with constant velocity, (in/s)	0.013
Number of soil particles above shear plane	2772
Number of soil particles below shear plane	2701
Particle radius, in	0.04
Particle volume, in^3	2.68E-04
Particle inertia, in^4	1.72E-07
Particle density, lbm/in^3	2.45E-04
Particle Young modulus, psi	1.00E+07
Particle Poisson ratio	0.17
Gravity, in/s^2	384
Sleeves, top plate, and bottom plate	Rigid
Sliding p-p contact friction (Fric)	**0.64**
Rolling p-p contact friction (FricR)	**0.01**
Normal stiffness contact factor (NormK)	**0.01**
Shear stiffness contact factor (ShearK)	**0.0029**
Static p-w contact friction	0.55
Dynamic p-w contact friction	0.43
Damping p-p contact	0.05
Damping p-w contact	0.05

```
*CONTROL_DISCRETE_ELEMENT
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
$#    NDAMP     TDAMP      Fric     FricR     NormK    ShearK       CAP     MXNSC
```

LS-DYNA Particle to particle interaction parameters

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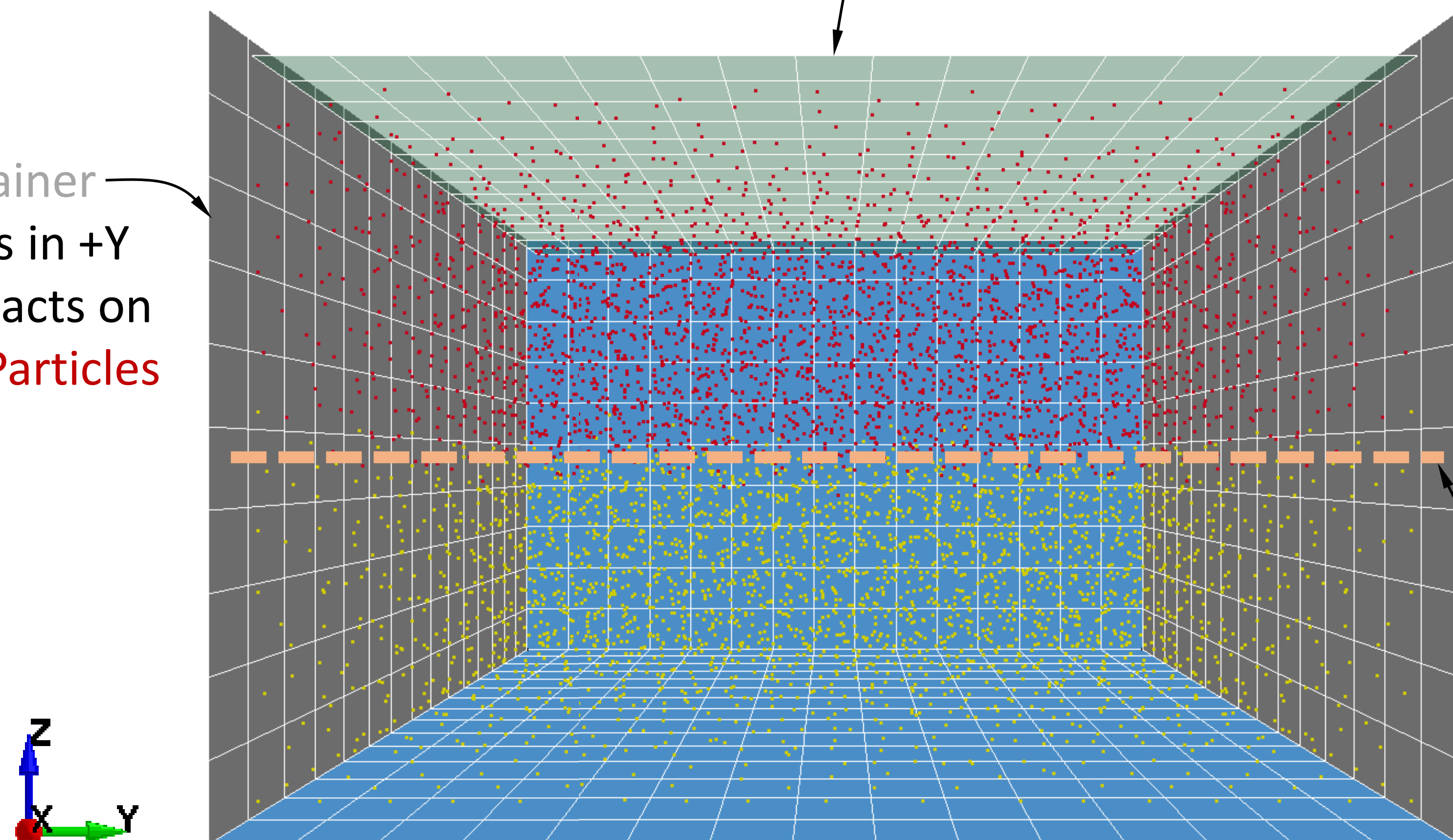
Progress: Task 2. Numerical Modeling of Granular Soils

- **Direct Shear Test Simulation**

Uniform vertical force applied to Top Plate

Top container translates in +Y and only acts on Top Soil Particles



Shear plane

Bottom container restrained from motion and only acts on Bottom Soil Particles

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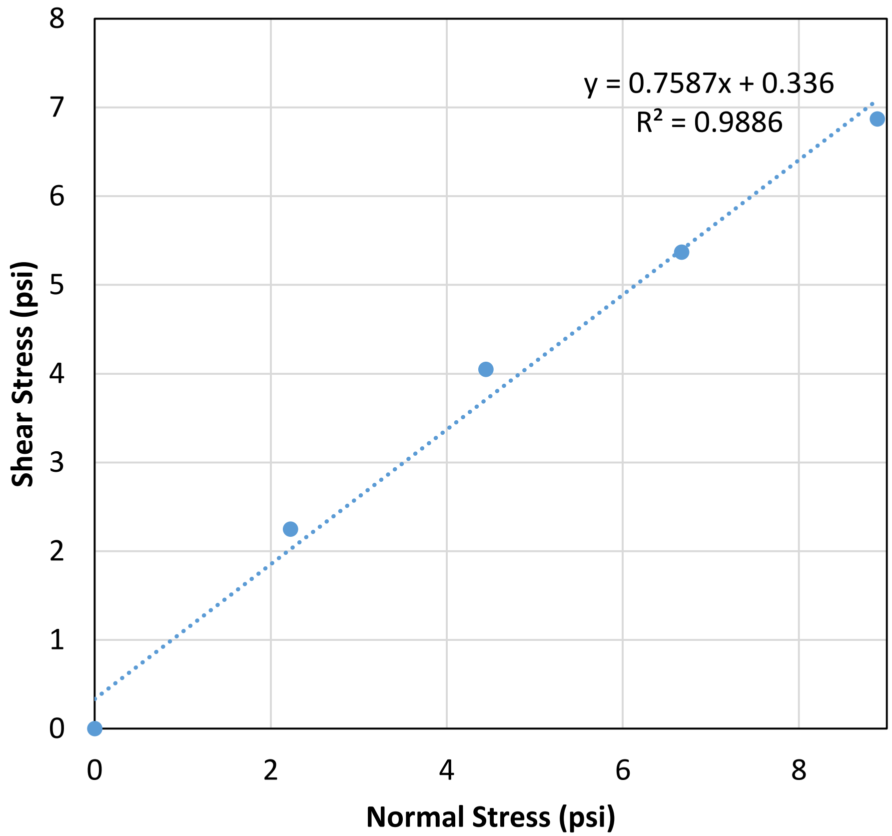
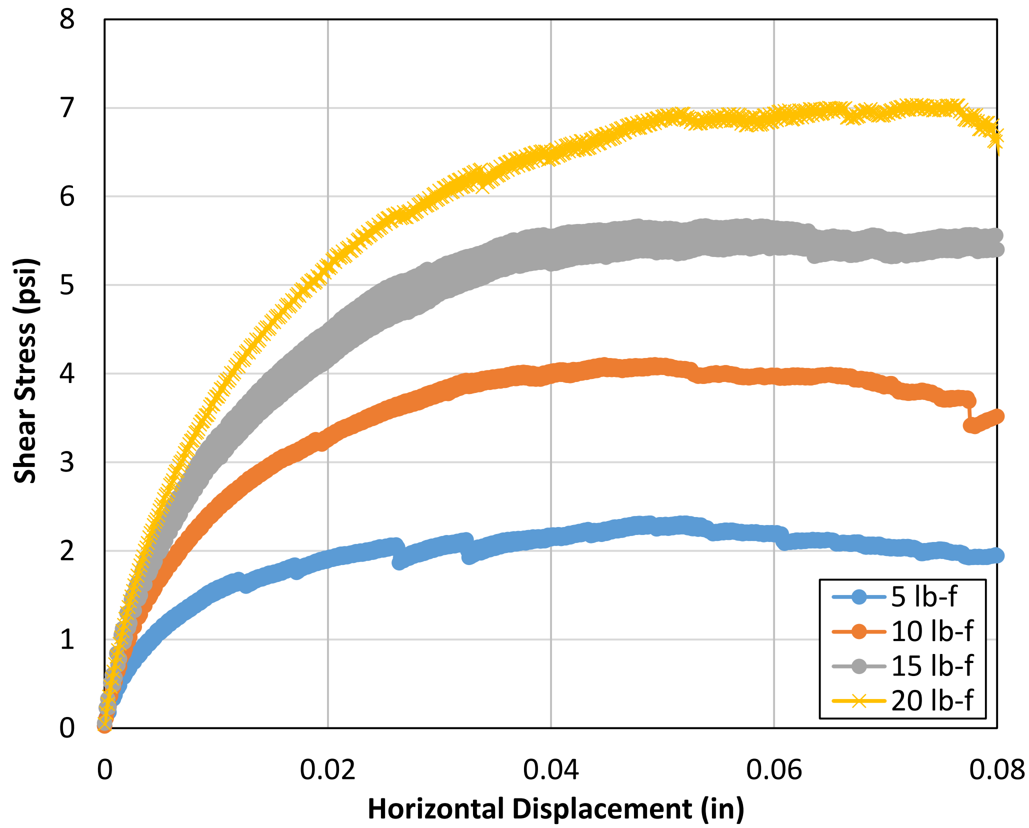
Progress: Task 2. Numerical Modeling of Granular Soils

- **Direct Shear Test Simulation Results**

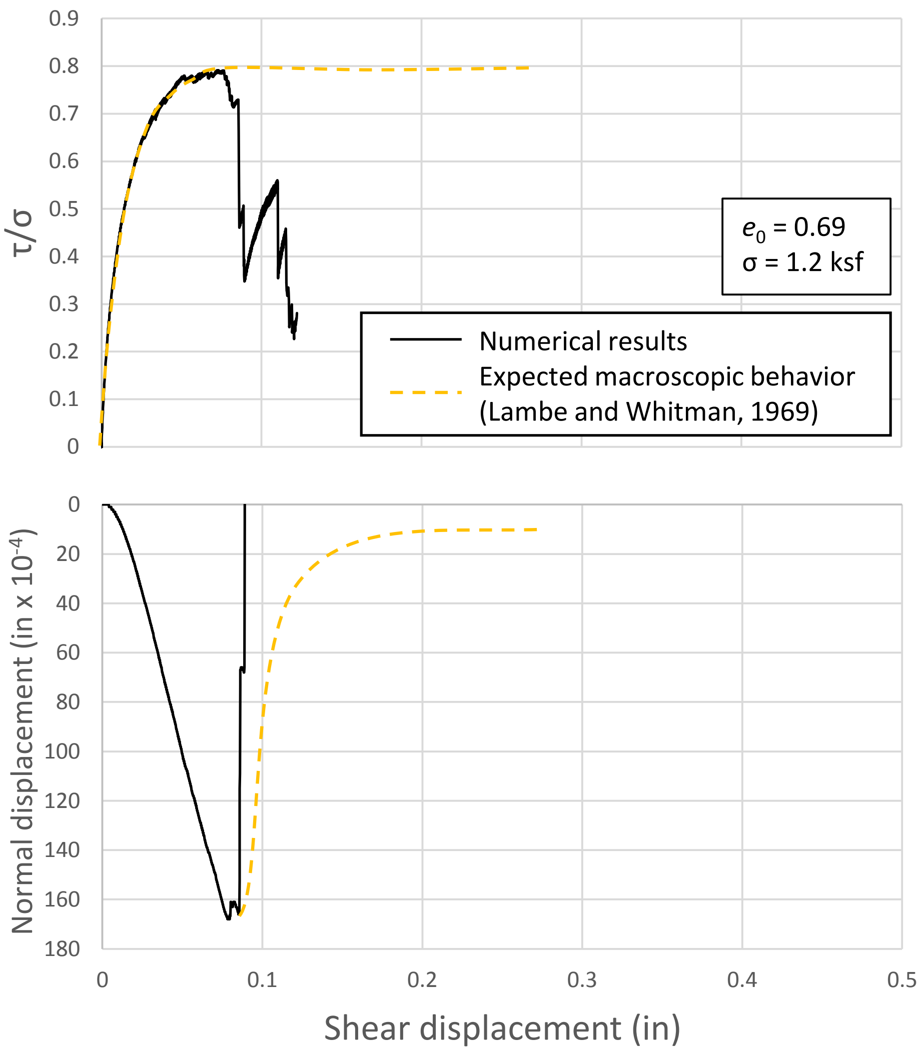


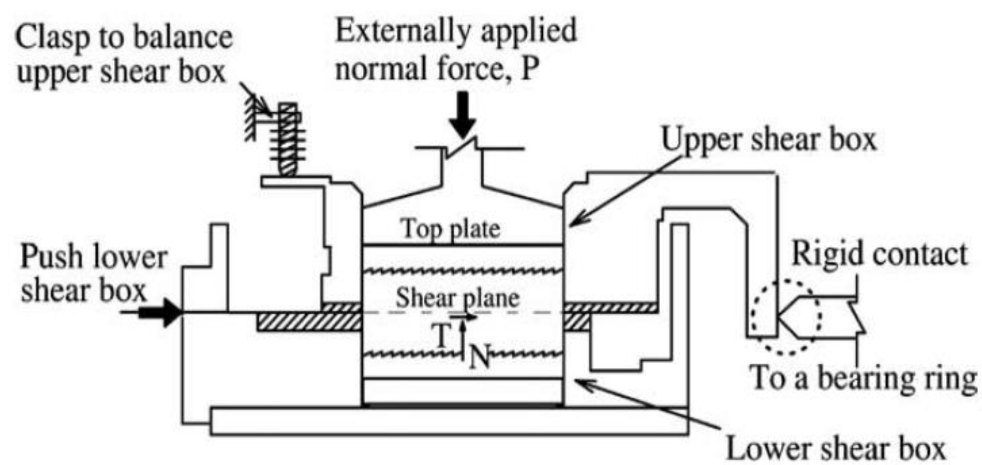


Observational macro-mechanical properties: ϕ (internal friction angles) can be simulated at a set of particle frictional parameters

Progress: Task 2. Numerical Modeling of Granular Soils

- **Direct Shear Test Simulation Results**





Progress: Task 2. Numerical Modeling of Granular Soils

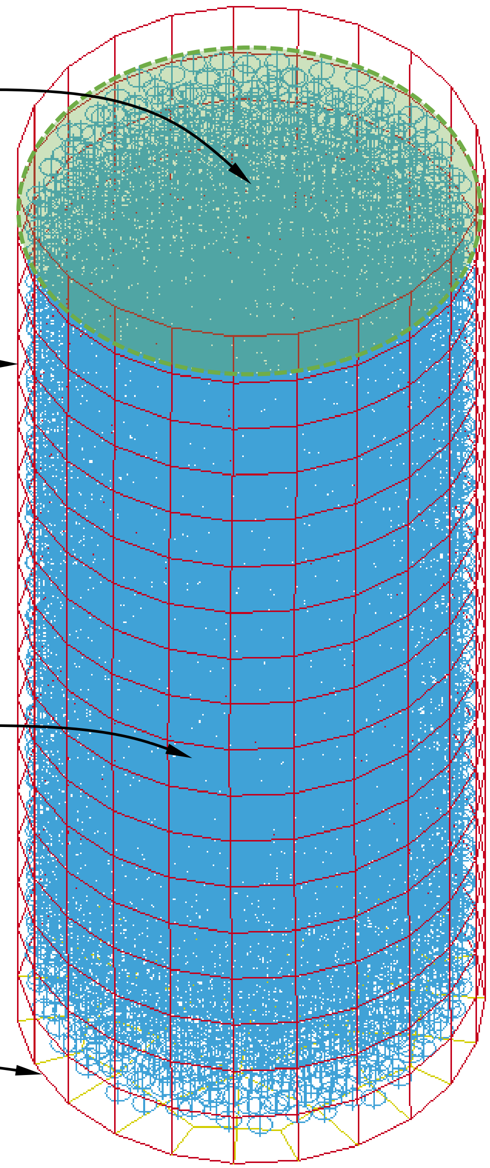
- **Triaxial Compression Test Simulation**

Top Plate translates downward

Thin latex membrane subjected to uniform radial pressure

Soil Particles assigned properties consistent with direct shear test model

Bottom Plate fully restrained



Research-in-Progress Summary

- **Phase I (12 months; July 2014 - June 2015)**
- Task 1. Literature Review, Scenario Identification, and Field-Data Acquisition
- Task 2. Numerical Modeling Schemes and Granular Soil Units (ranging from loose to very dense state)

- **Phase II (18 months; July 2015 - December 2016)**
- Task 3. Numerical Modeling of Driven foundation in Granular Soils
- Task 4. Physical Laboratory/Centrifuge Experimentation
- Task 5. Reporting of Findings and Design-Oriented Recommendations
- Task 6. Final Report

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