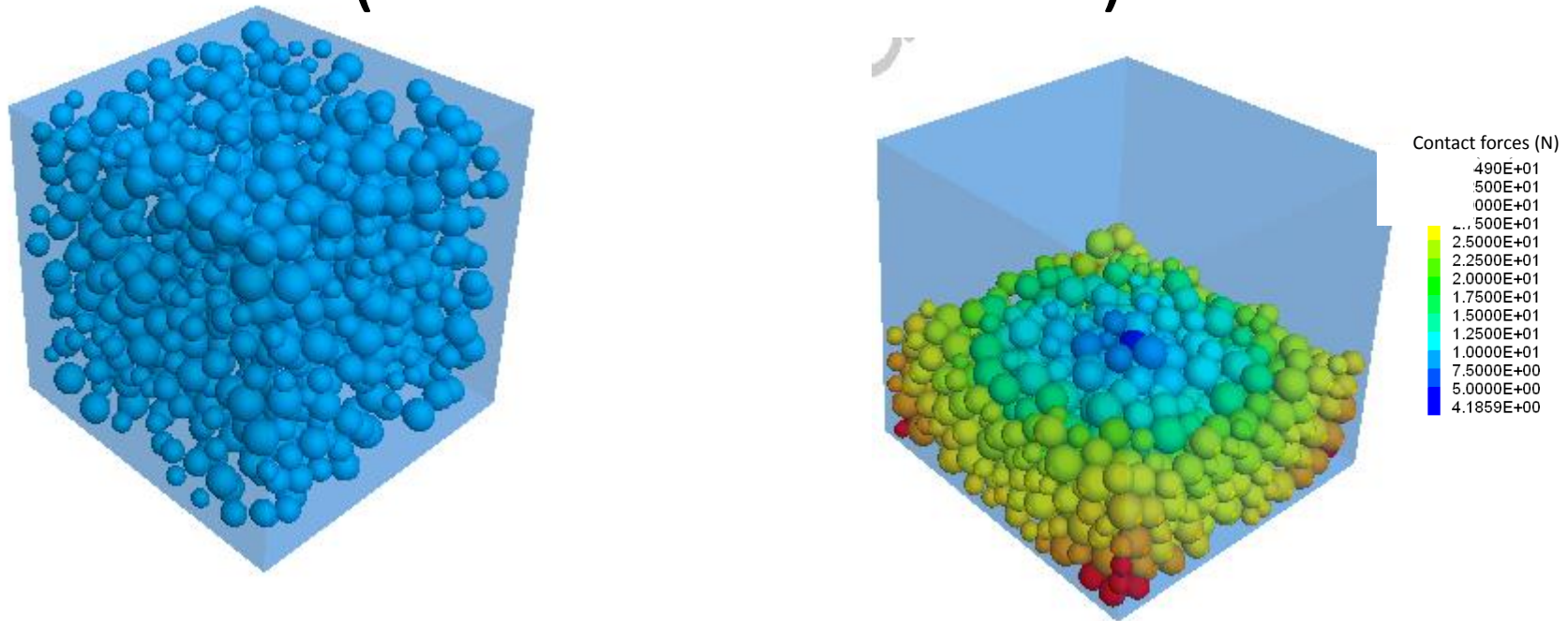


Effect of Proximity of Sheet Pile Walls on the Apparent Capacity of Driven Displacement Piles (BDV31 TWO 977-26)



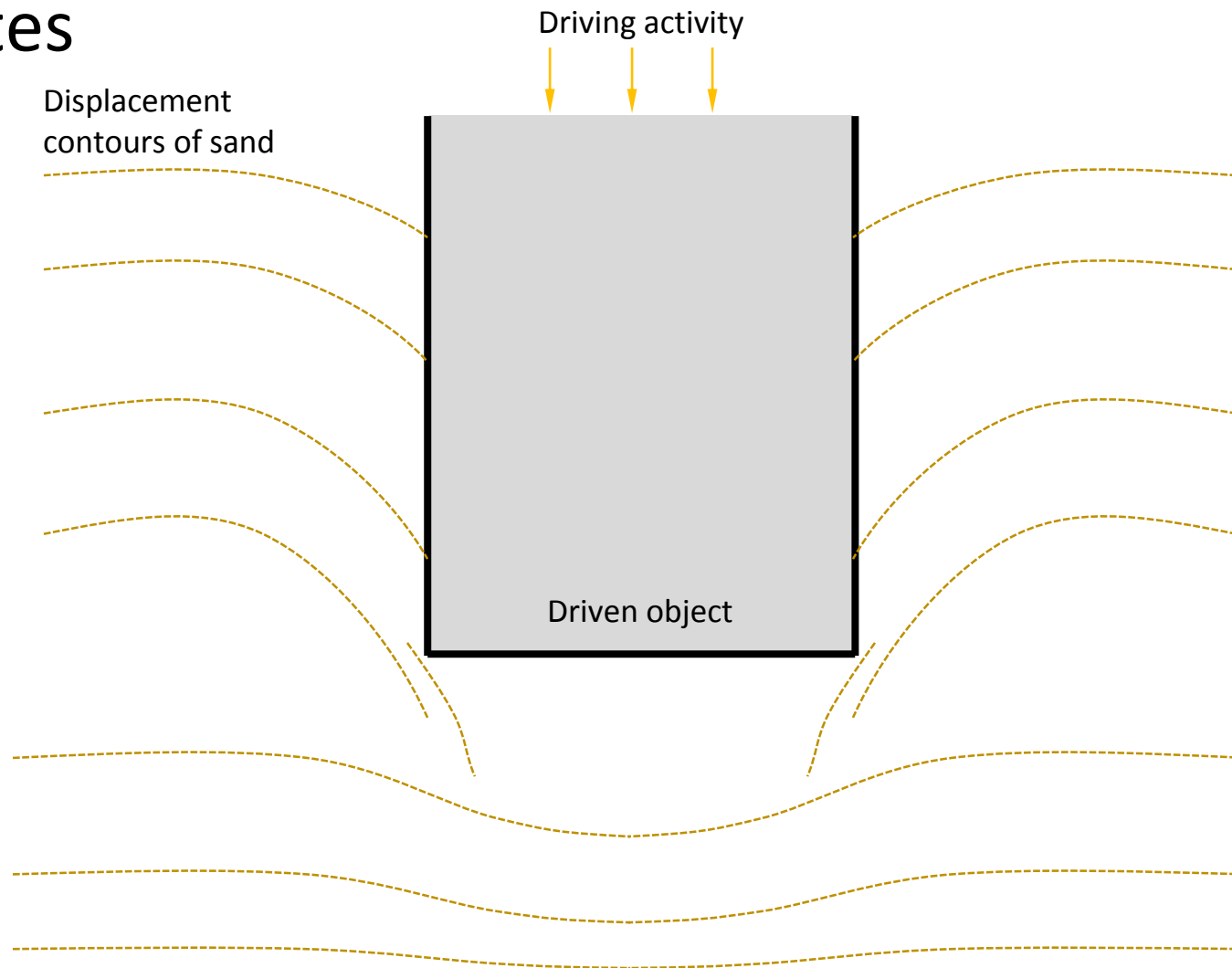
Jae H. Chung and Michael T. Davidson (Bridge Software Institute)
Michael C. McVay (Geosystems Engineering)
Engineering School of Sustainable Infrastructure & Environment
University of Florida
Gainesville, Florida
August 1, 2014

Agenda

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

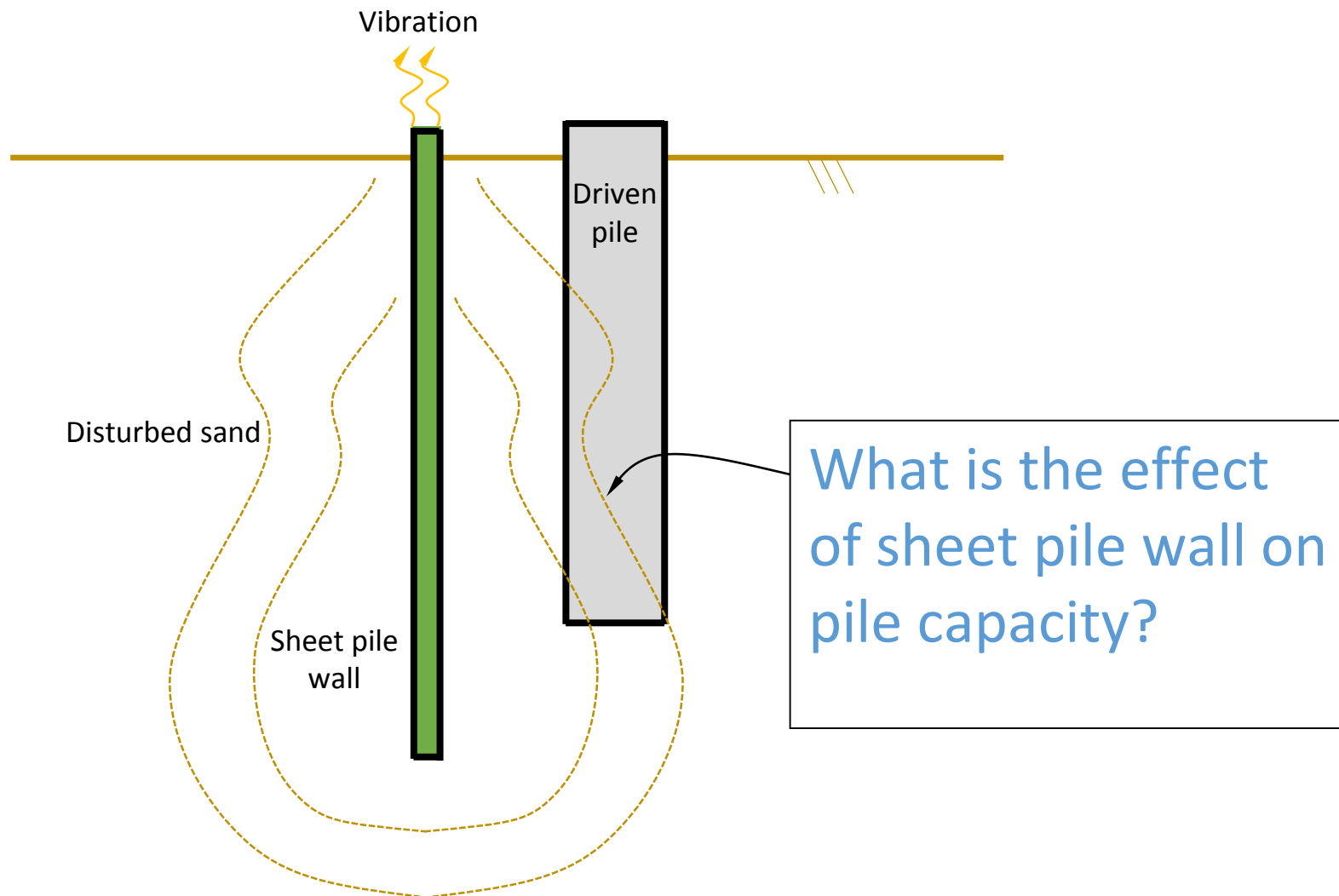
Introduction

- Effects of Driving Objects in Development of Stress States



Introduction

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



Project Goals

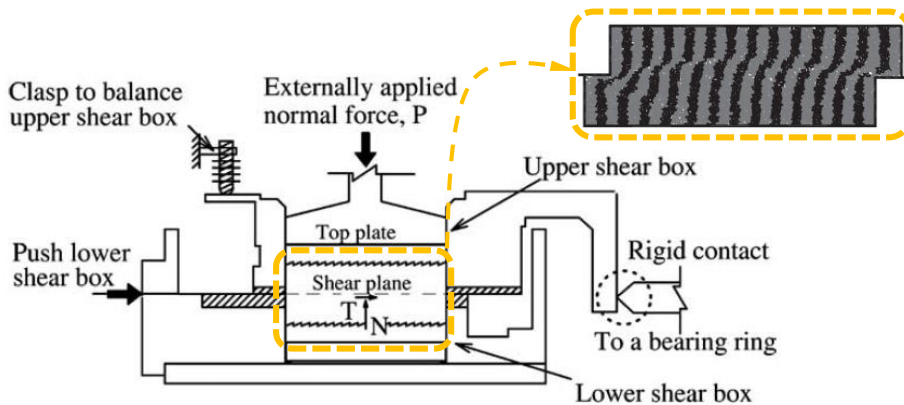
- Identify design-relevant parameters for calculating pile capacities in the vicinity of SPWs
- Develop a design chart or/and tabularized matrices for use in calculation of pile-capacity changes
- Methodology:
 - Combined Discrete and Finite Elements Analysis approach
 - Spectrum of verification (laboratory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

Project Tasks: Phase 1 Research Tasks

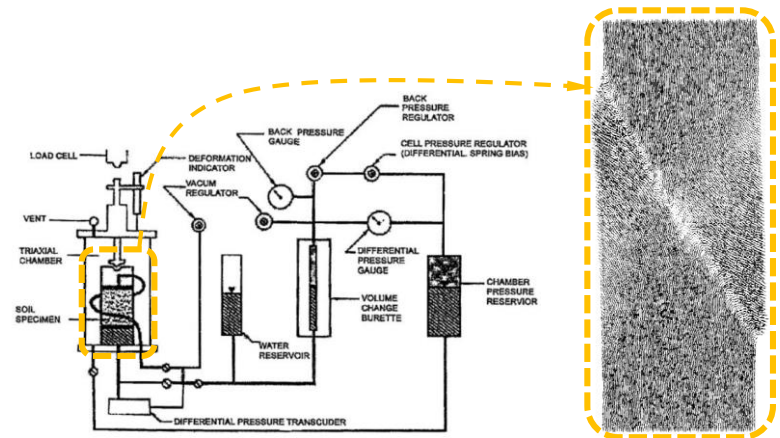
- **Task 1. Literature Review, Scenario Identification, and Field-Data Acquisition**
 - Collect data from the literature
 - Identify key modeling parameters at macroscopic scale (Continuum Mechanics)
 - Characterize micromechanical soil particles interactions using microstructural modeling tools at mesoscopic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

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

Progress: Task 1. Literature Review

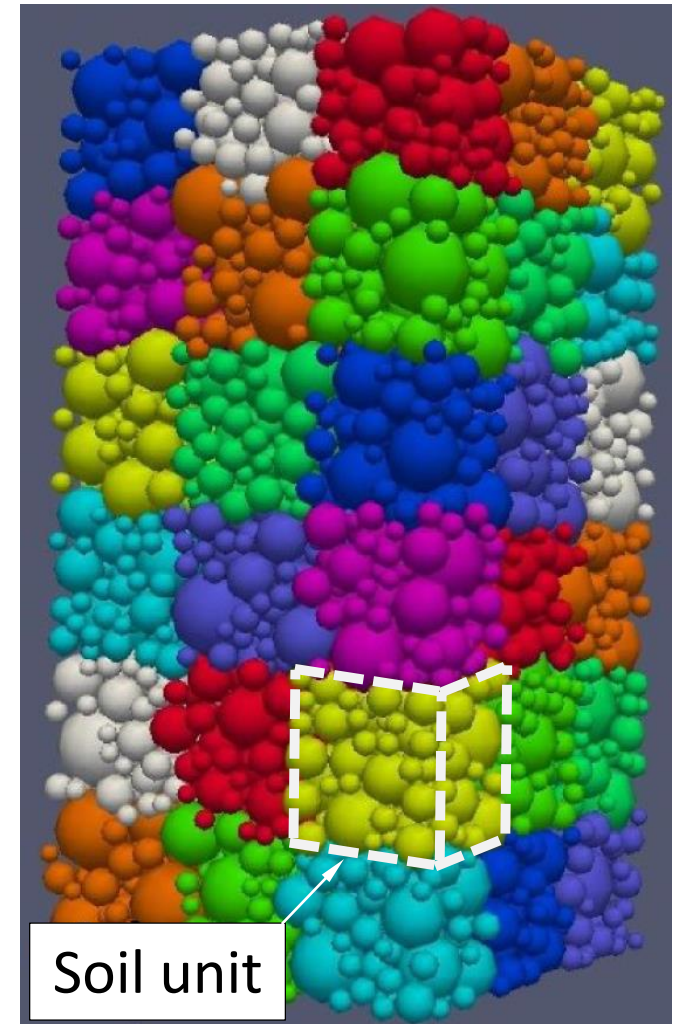
- **Focus 2: Identification and Characterization of Candidate Parameters**
 - Geotechnical Parameters
 - Relative density and void ratio; particles packing density
 - Lateral confinement, e.g., change in geostatic stress states
 - Grain size distribution; upscaling particle size to meso-scopic scale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

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  IDAMP  Fric  FricR  NormK  ShearK  CAP  MXNSC
    
```

LS-DYNA Particle to particle interaction parameters

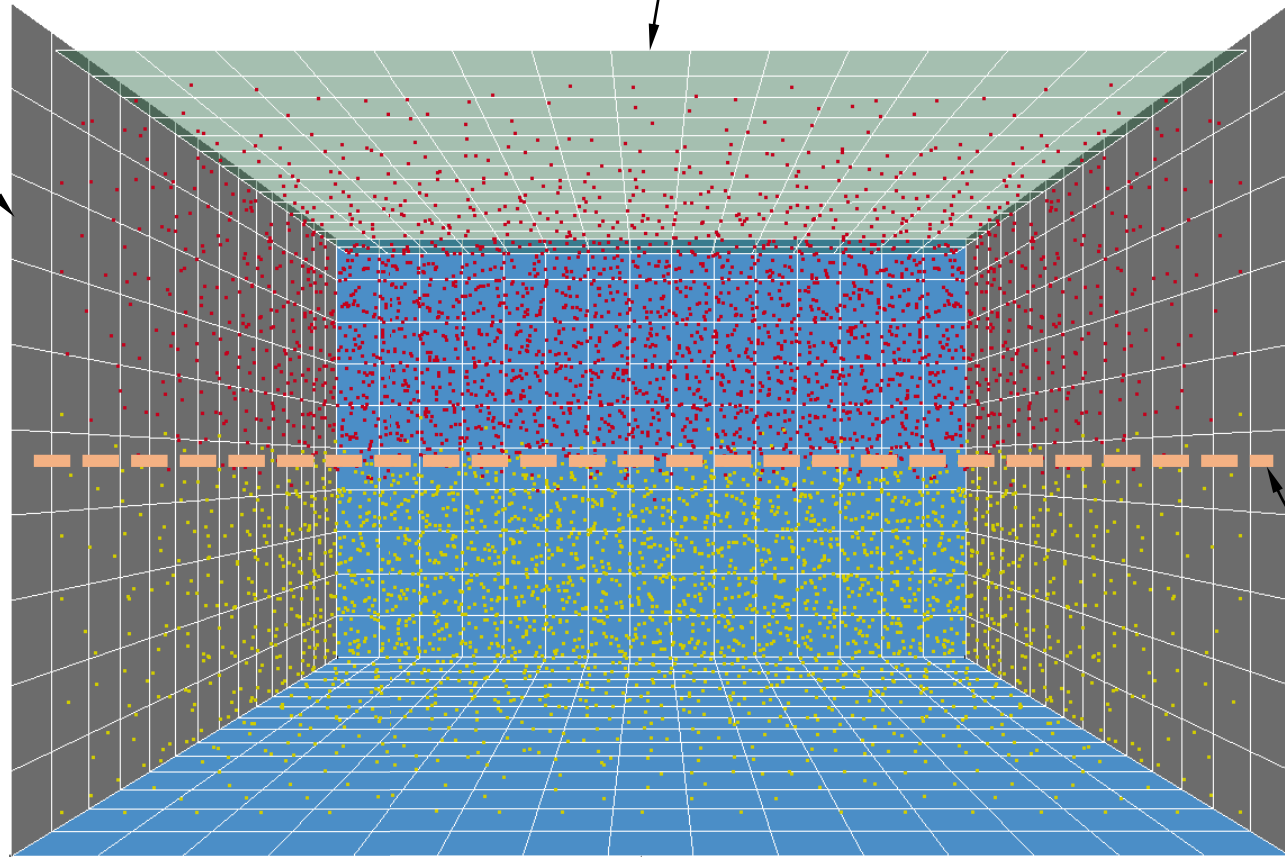
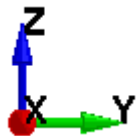


Progress: Task 2. Numerical Modeling of Granular Soils

- **Direct Shear Test Simulation**

Uniform vertical force applied to **Top Plate**

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

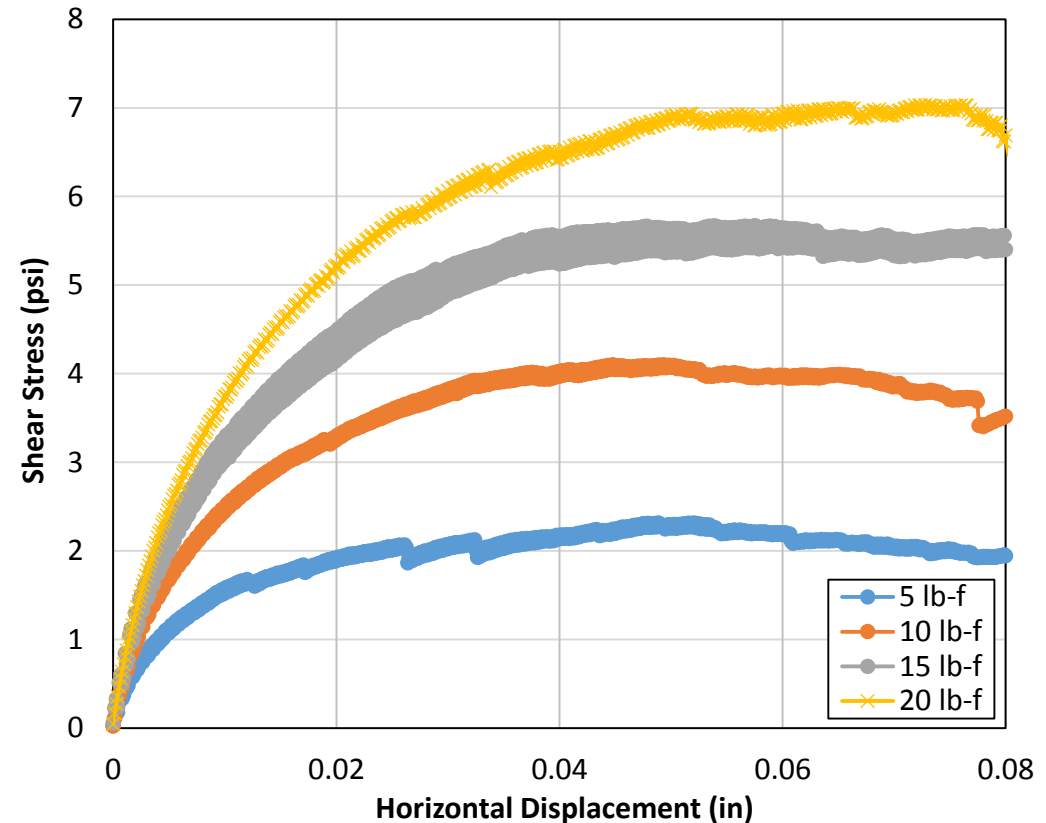
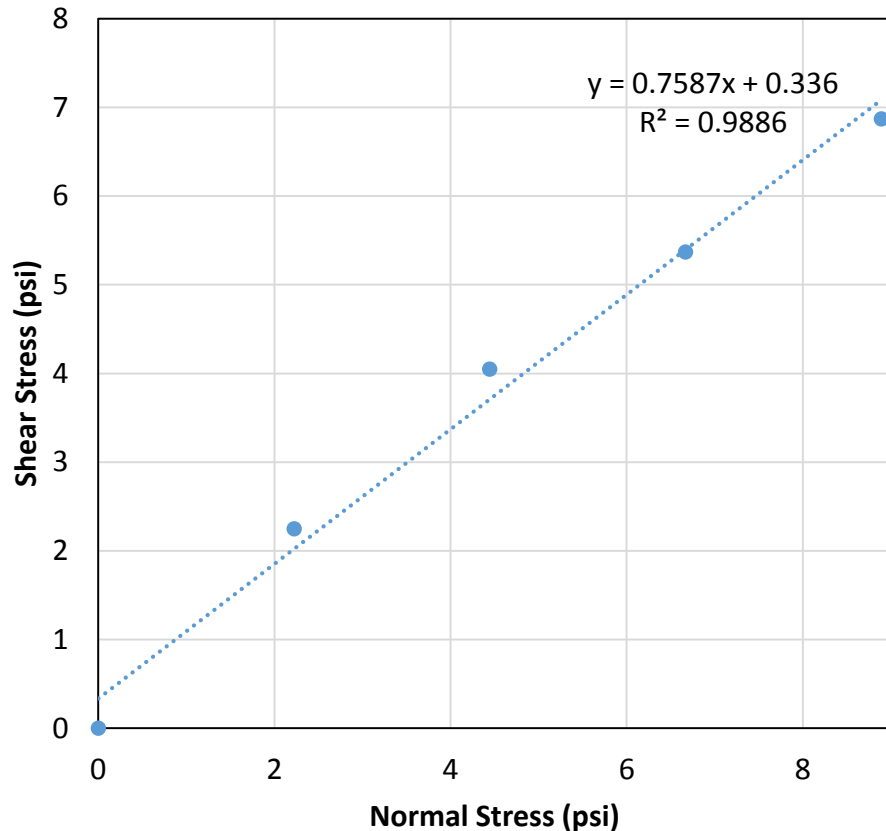


Shear plane

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

Progress: Task 2. Numerical Modeling of Granular Soils

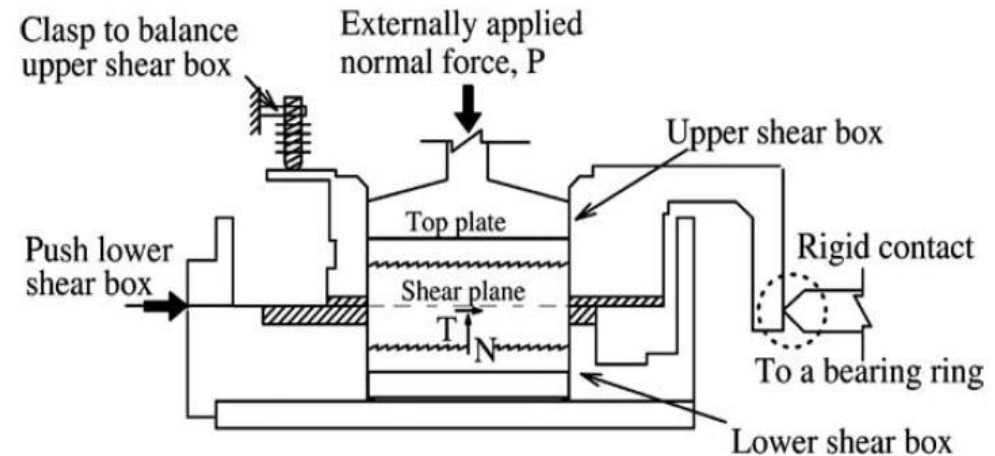
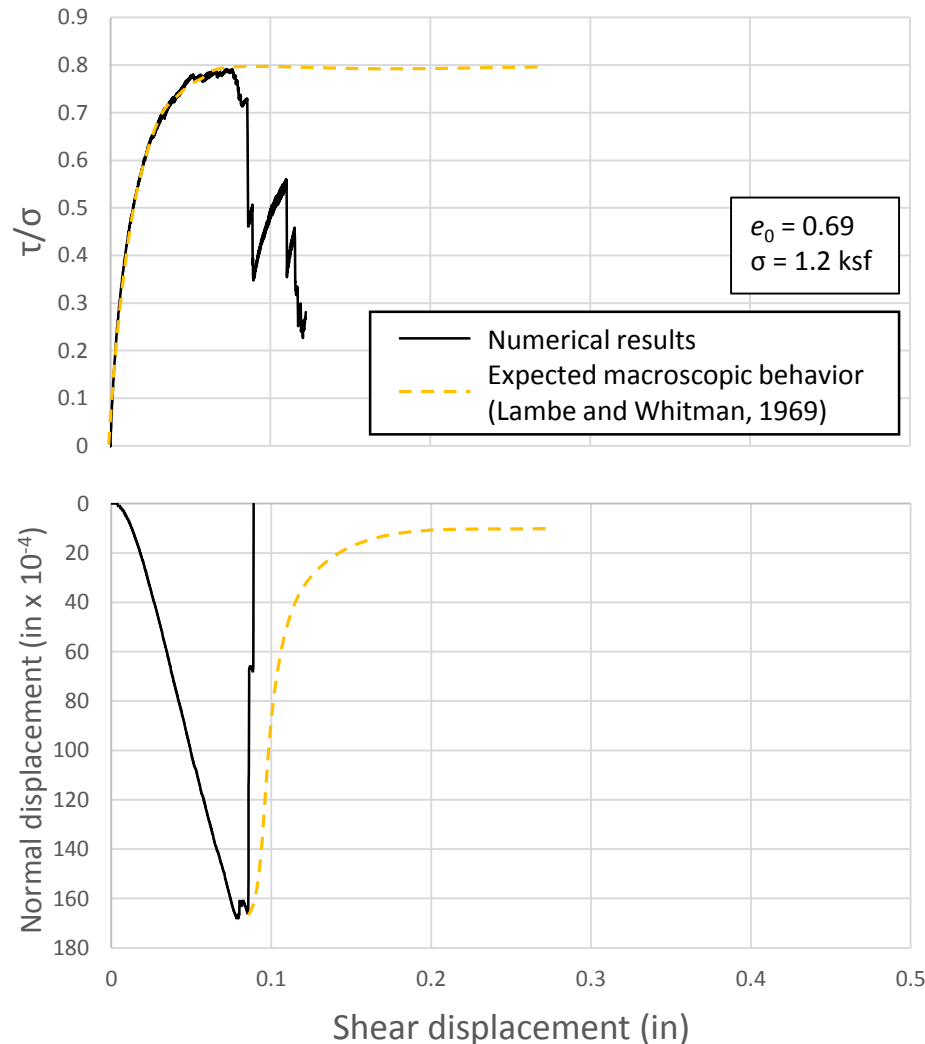
● Direct Shear Test Simulation Results



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

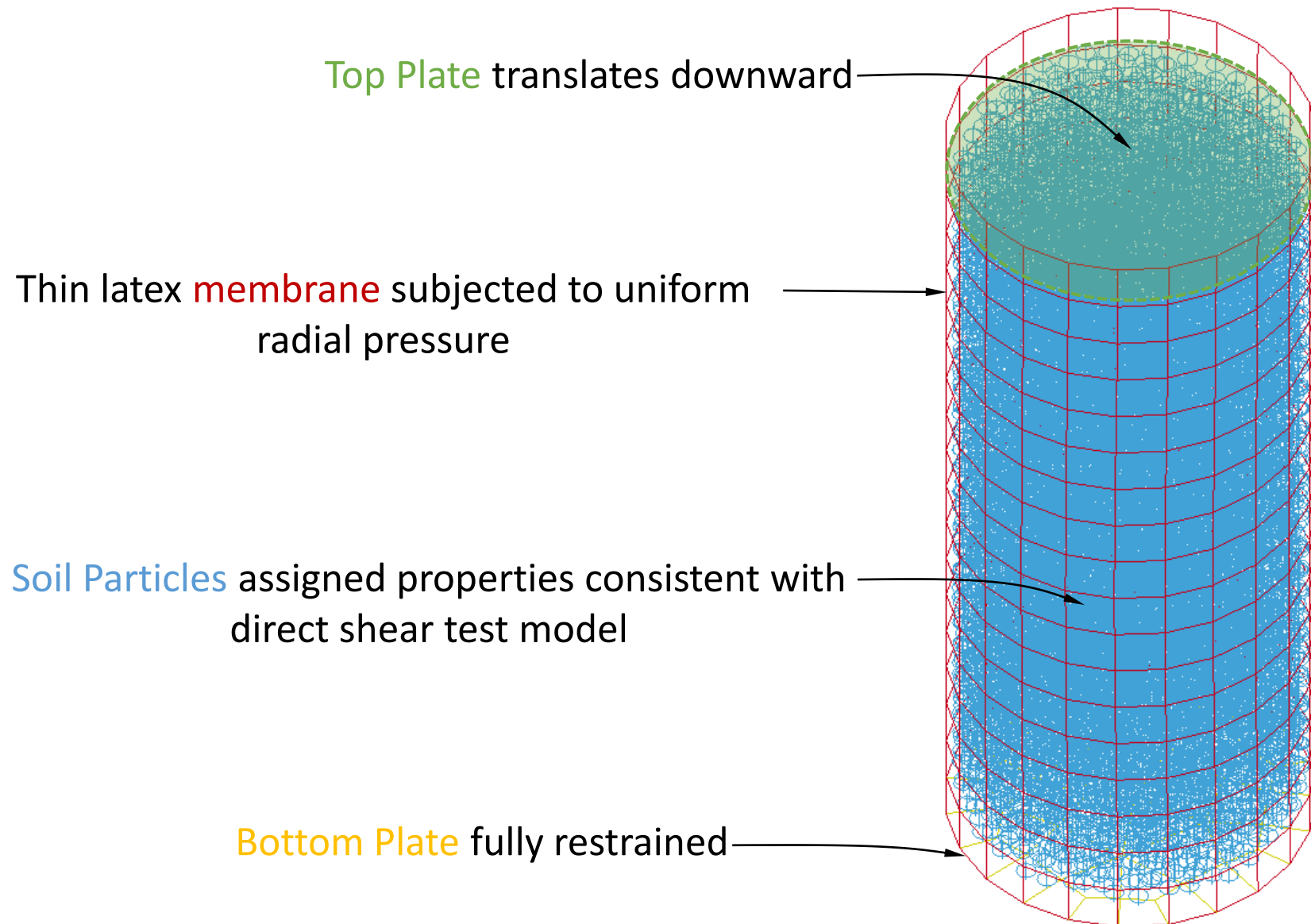
Progress: Task 2. Numerical Modeling of Granular Soils

• Direct Shear Test Simulation Results



Progress: Task 2. Numerical Modeling of Granular Soils

- **Triaxial Compression Test Simulation**



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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