

Pacific Earthquake Engineering Research (PEER) Center
Annual Meeting
Berkeley, CA
August 25, 2023

Hypergravity Experiments & Model Tests at the Center for Geotechnical Modeling

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Associate Professor

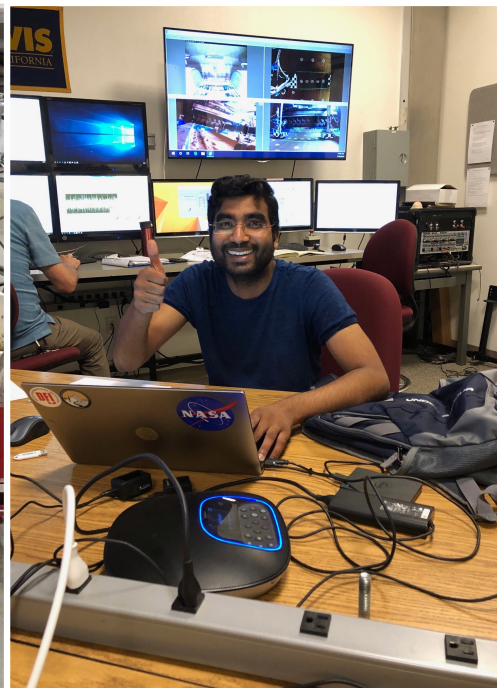
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Goals

- Discuss value of hypergravity experimentation
- Share capabilities and some modes of operation
- Some examples and options



Motivation

- Engineering advances fundamentally rely on data from field observations **and** physical experiments, especially when the former are inadequate to validate theoretical models & simulation methods
- However:
 - costs of field instrumentation
 - increasingly diverse & complex infrastructure systems, novel construction methods, & emerging ground improvement technologies
 - unpredictable and rare design-level events
 - ever-increasing service, construction, & multi-hazard loadings



New York Times



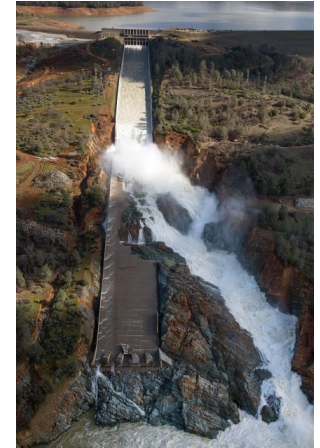
Getty Images



Hydromill

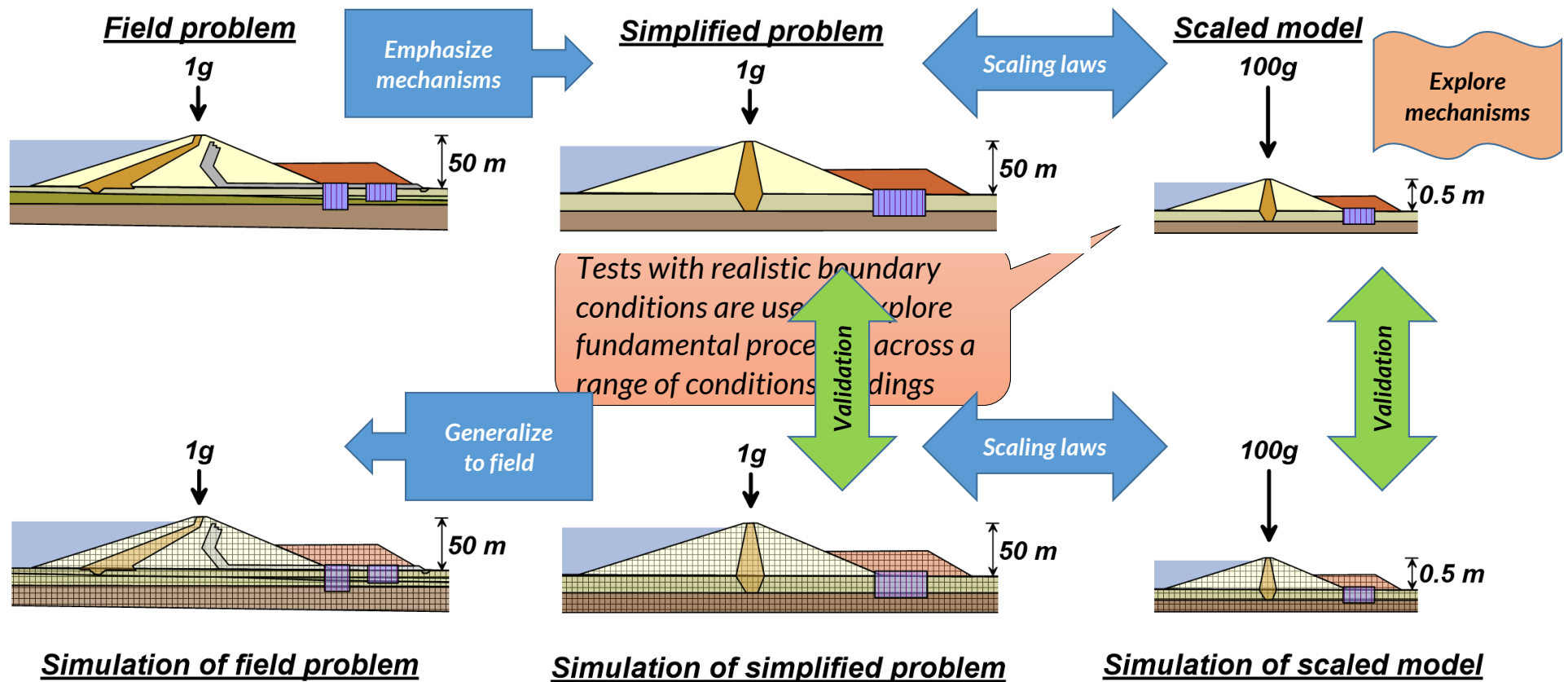


Wikimedia



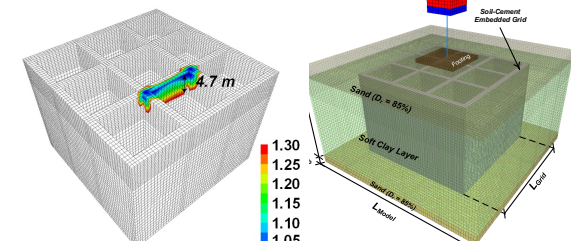
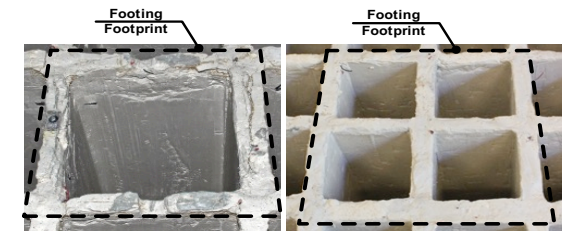
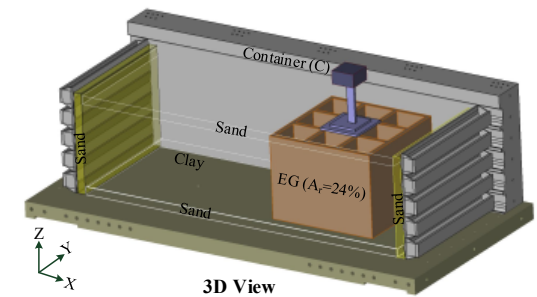
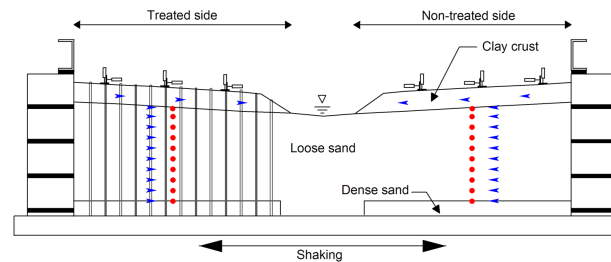
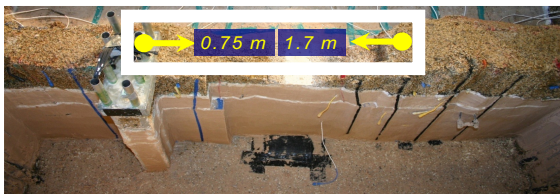
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Role of scaling

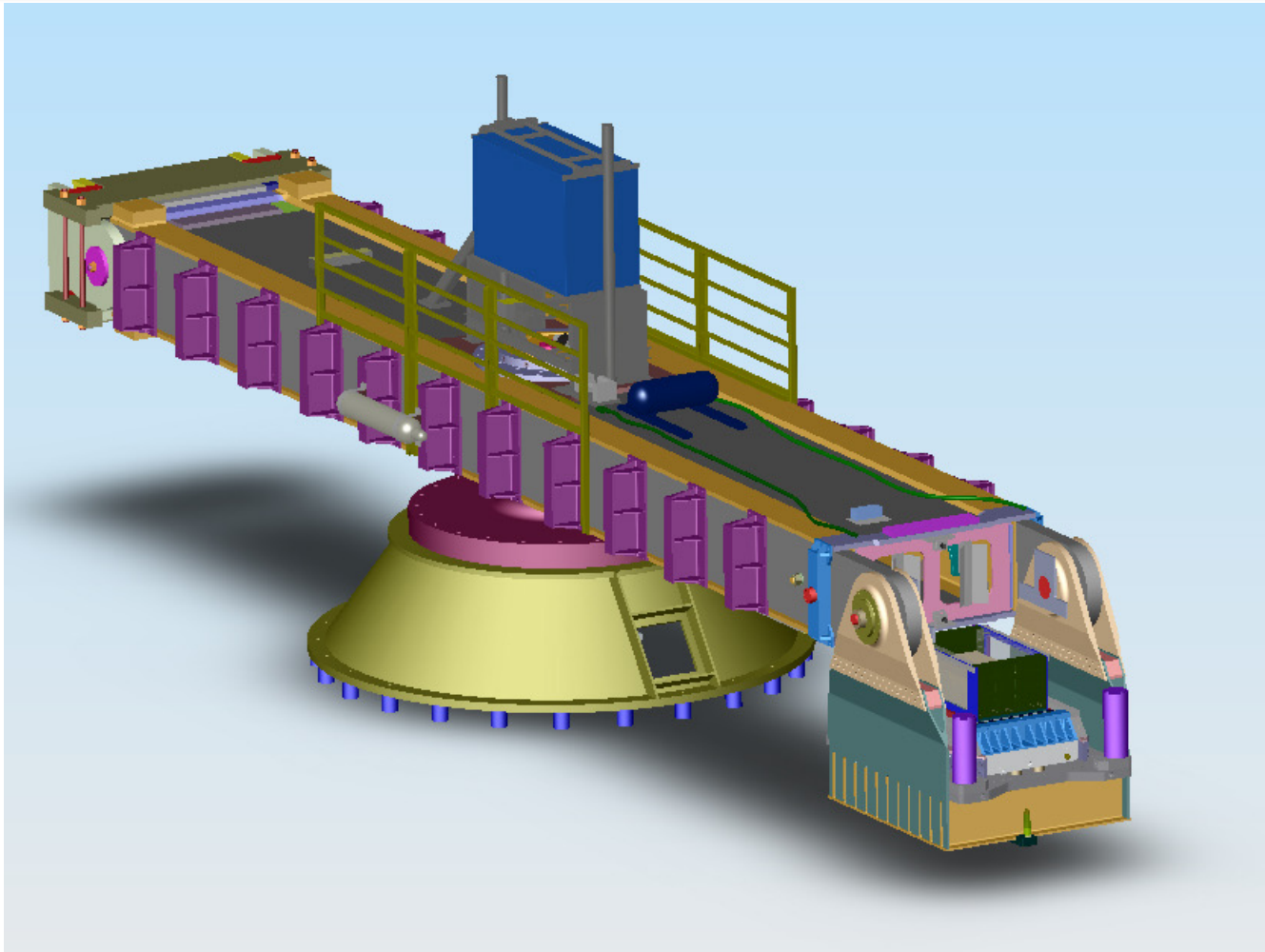


Scaled modeling provides unique data on fundamental processes

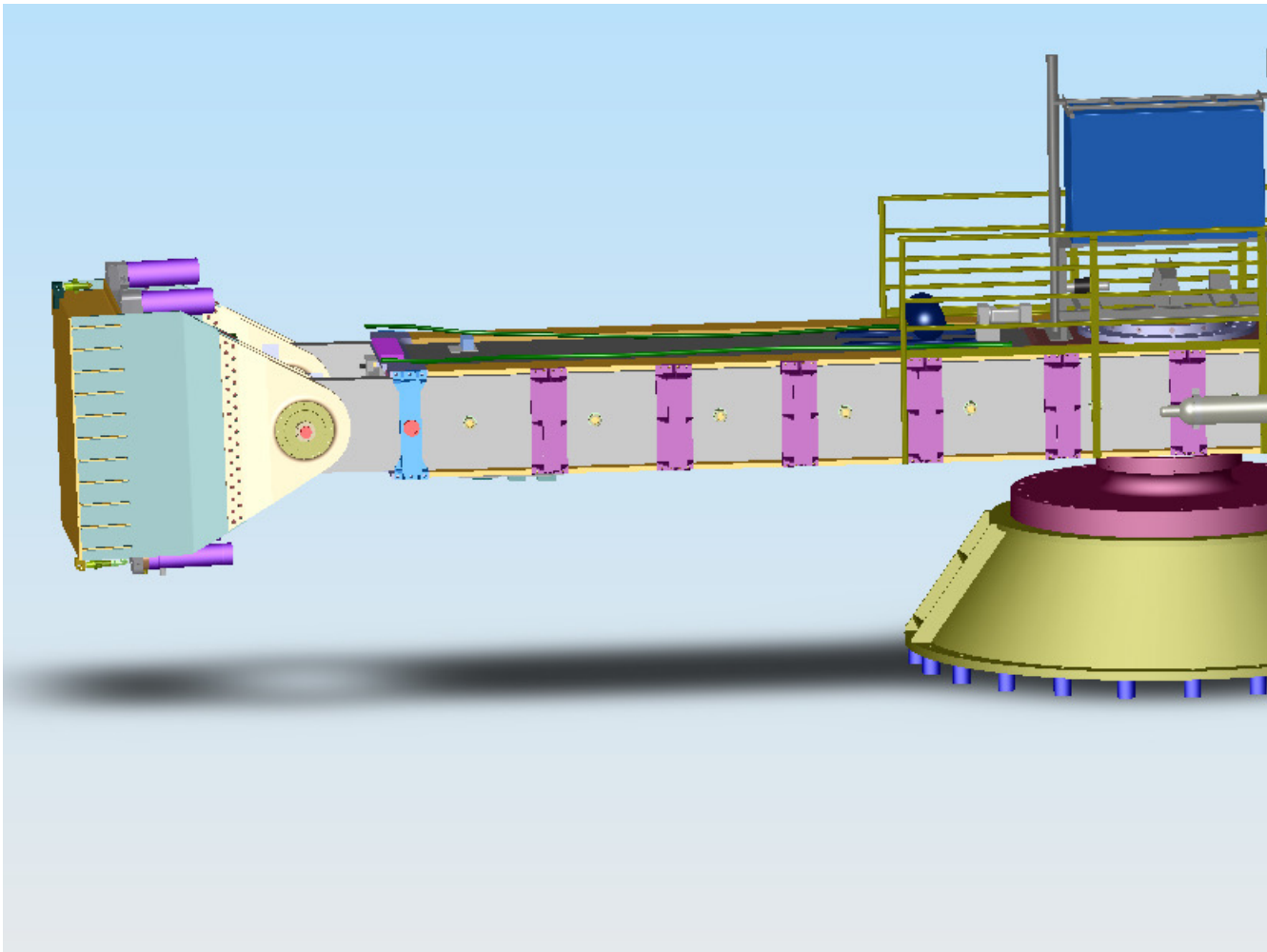
- It provides data on fundamental processes across a range of conditions/loadings that cannot be feasibly understood or quantified from field data
- Provides a basis for validating theoretical & computational models across a range of systems, loadings, and details



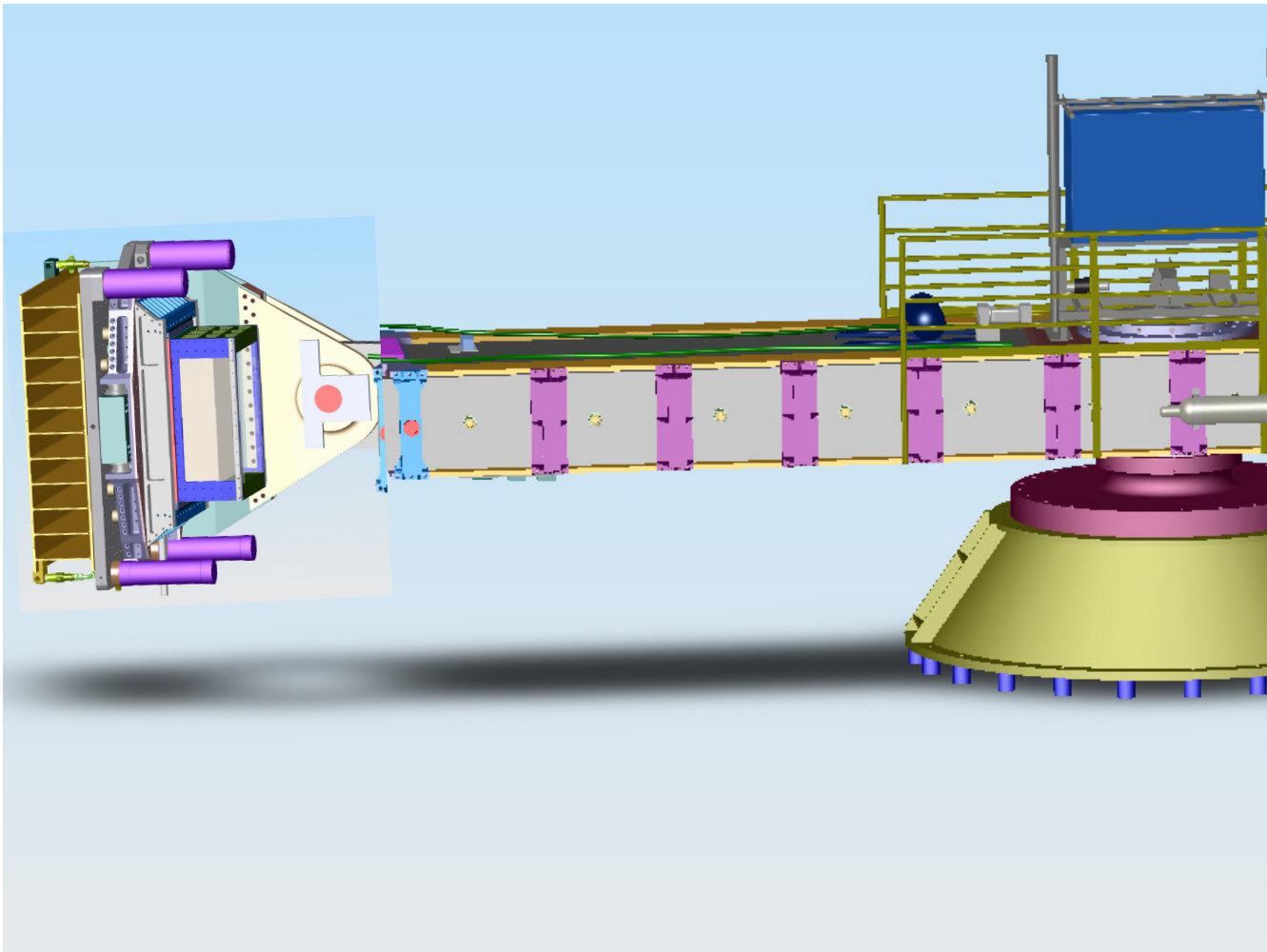
Enter... Center for Geotechnical Modeling (CGM)



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**9m model prep room &
1m centrifuge and prep room**

**Control Room,
Electronics &
Calibration**

9m centrifuge

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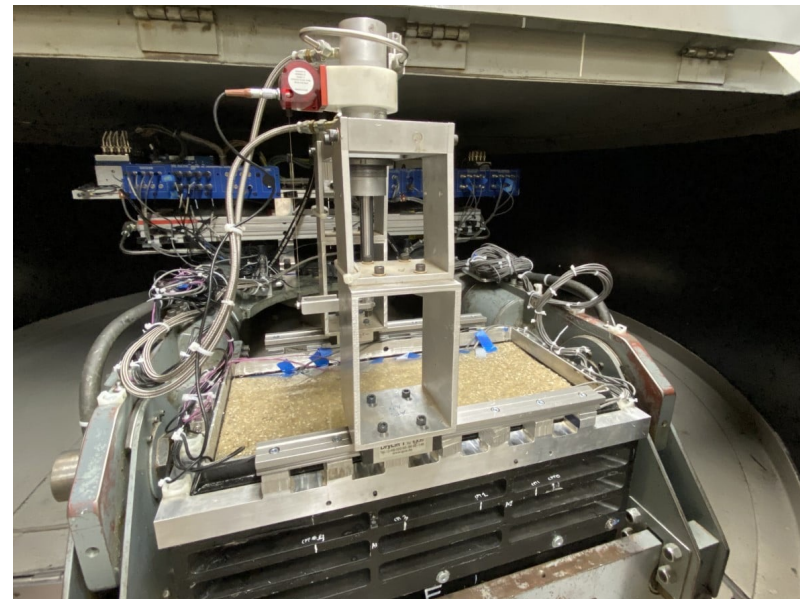


Center for Geotechnical Modeling (CGM)

- *Hypergravity can be used to study many earthquake problems affected by gravity*
- *Operational vision is to provide open & equal shared-use access*
- *Enable major advances in ability to predict & improve the performance of soil & soil-structure systems*
- *Constantly onboarding infrastructure & methods for new science*



9m centrifuge



1m centrifuge

Leadership & staff



Jason T. DeJong
CGM Director



Daniel W. Wilson
CGM Assoc. Director



K. Ziotopoulou
Faculty Advisor



Alejandro Martinez
Faculty Advisor



Ross W. Boulanger
CGM Past-Director



Bruce L. Kutter
CGM Past-Director



Tom Kohnke
R&D Engineer



Chad Justice
Development Technician



Anatoliy Ganchenko
Electronics Technician



Karissa Alarcon
Admin Assistant

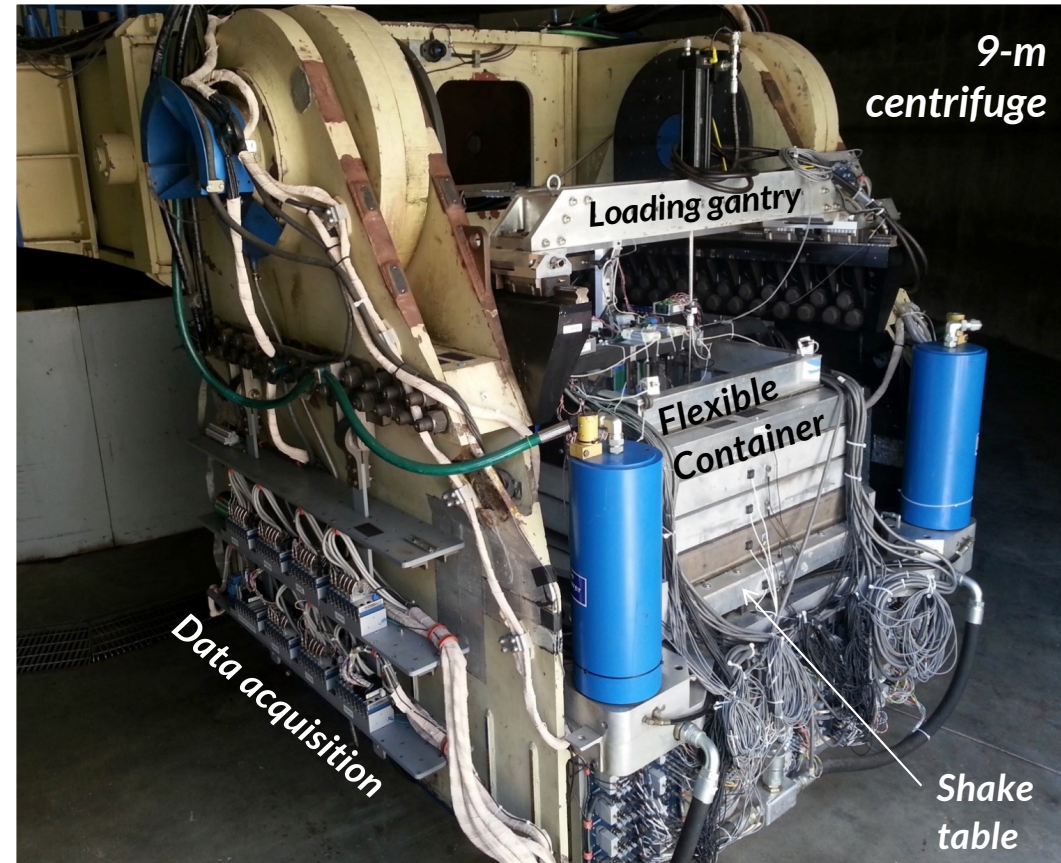
Goals & objectives

- *Help users improve their science through personalized support*
- *Promote an organizational culture of safety & risk awareness*
- *Develop members of the next-generation workforce*
- *Broaden the breadth and diversity of our user base*
- *Be effective and efficient stewards of our resources in service to society*



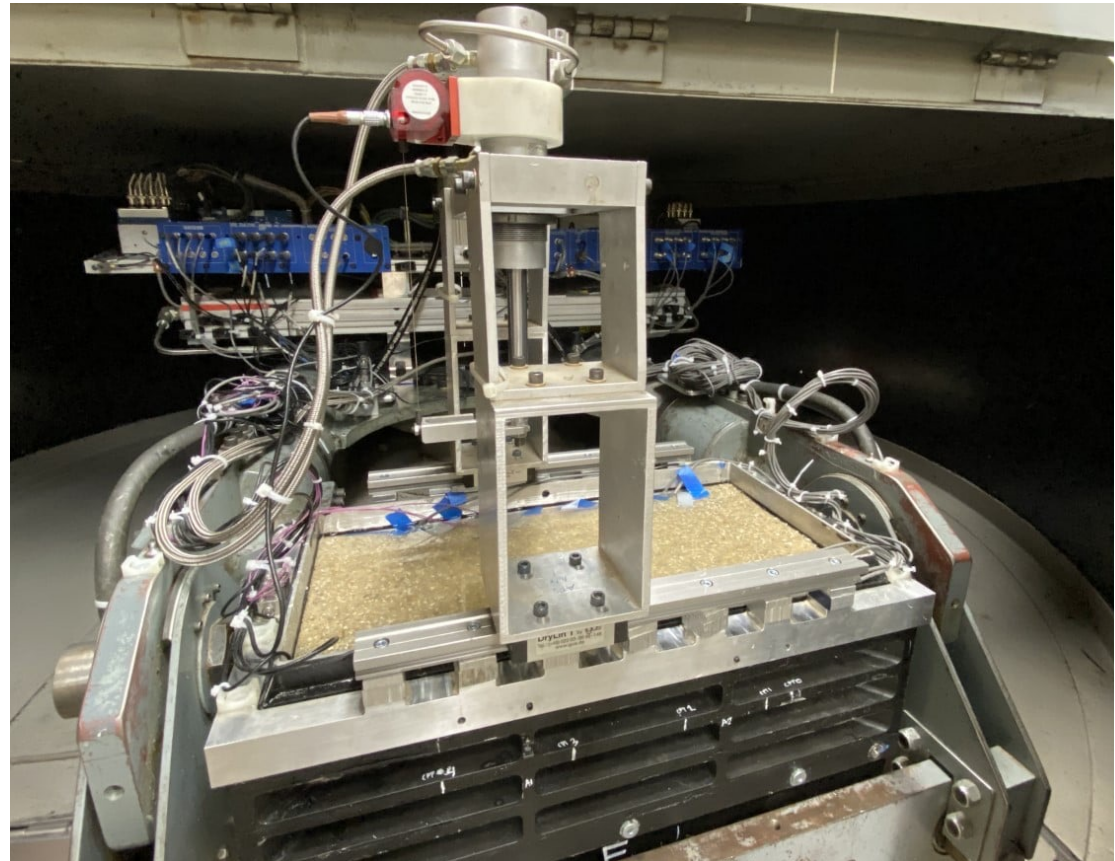
The 9m centrifuge is unique in the world

- Largest radius equipped with a **shaking table** worldwide – can test physical models with at least 1500 kg of soil
- Construct models with holistic system levels of complexity, including variations in **soil stratigraphy & structural configurations** that are not possible in smaller models
- Use **dense instrumentation arrays & inverse analysis techniques** to measure complex local mechanisms that cannot be measured by other means
- Perform **in-flight soil characterization tests** at a higher degree of resolution & across a broader range of soil types where scale effects are important

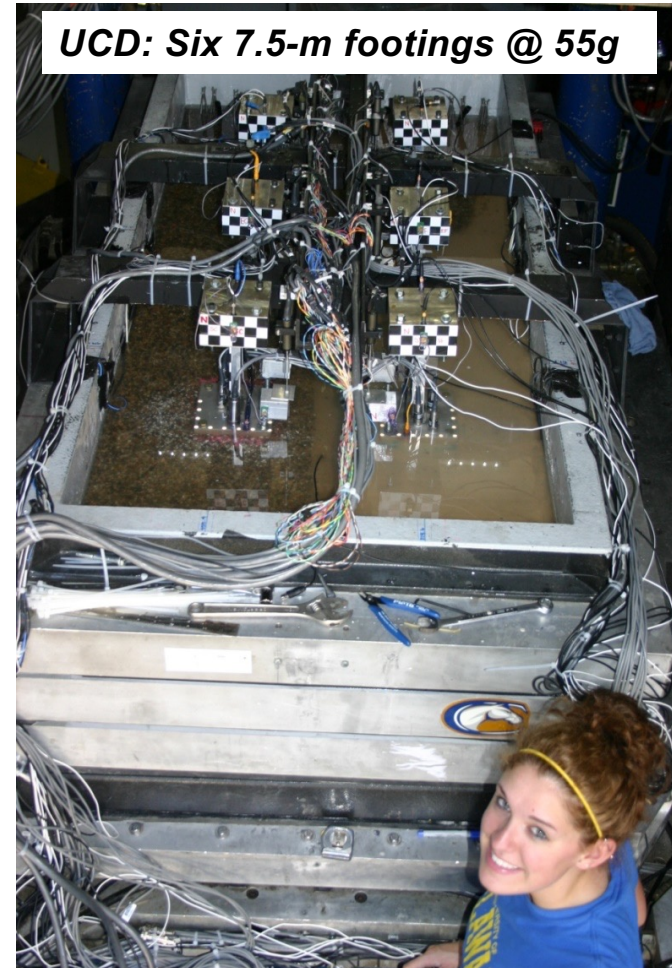


1m centrifuge

- Same data acquisition system as the large centrifuge
- Provides for a high throughput of **relatively simple (component) tests**
- Enables **efficient exploration of new ideas & rapid parametric studies**, collectively building knowledge
- Increases the **quality and complexity** of subsequent 9-m centrifuge tests

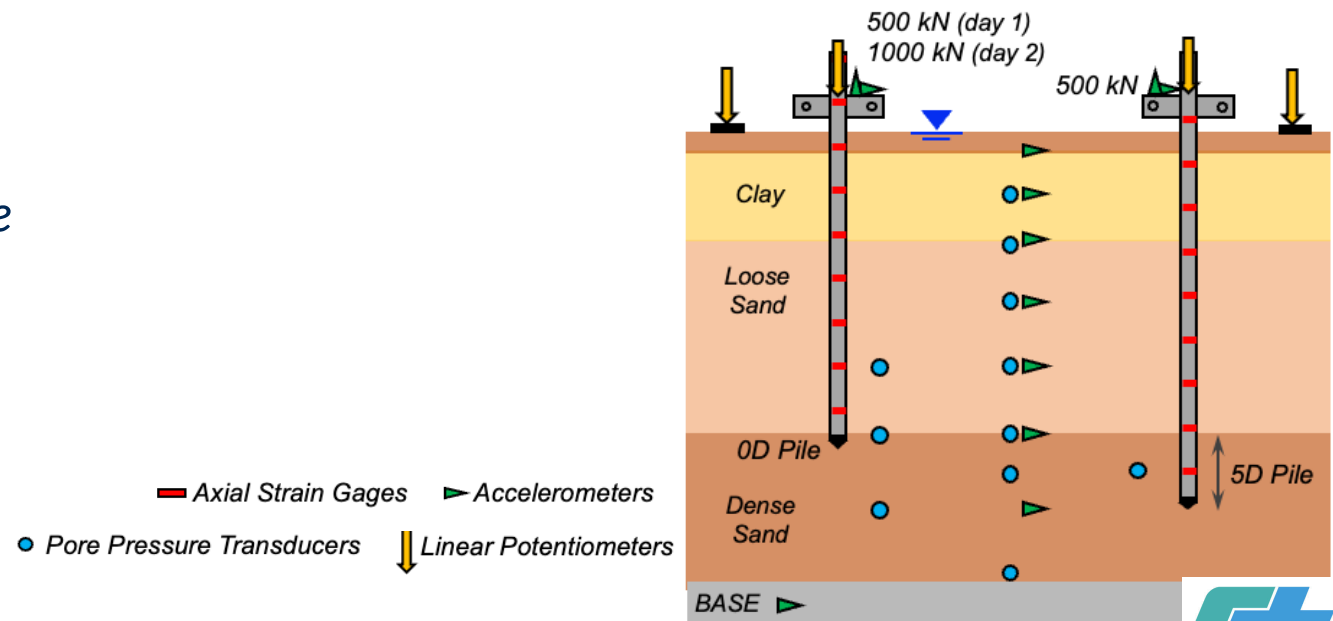


9m centrifuge: Unmatched scaled modeling



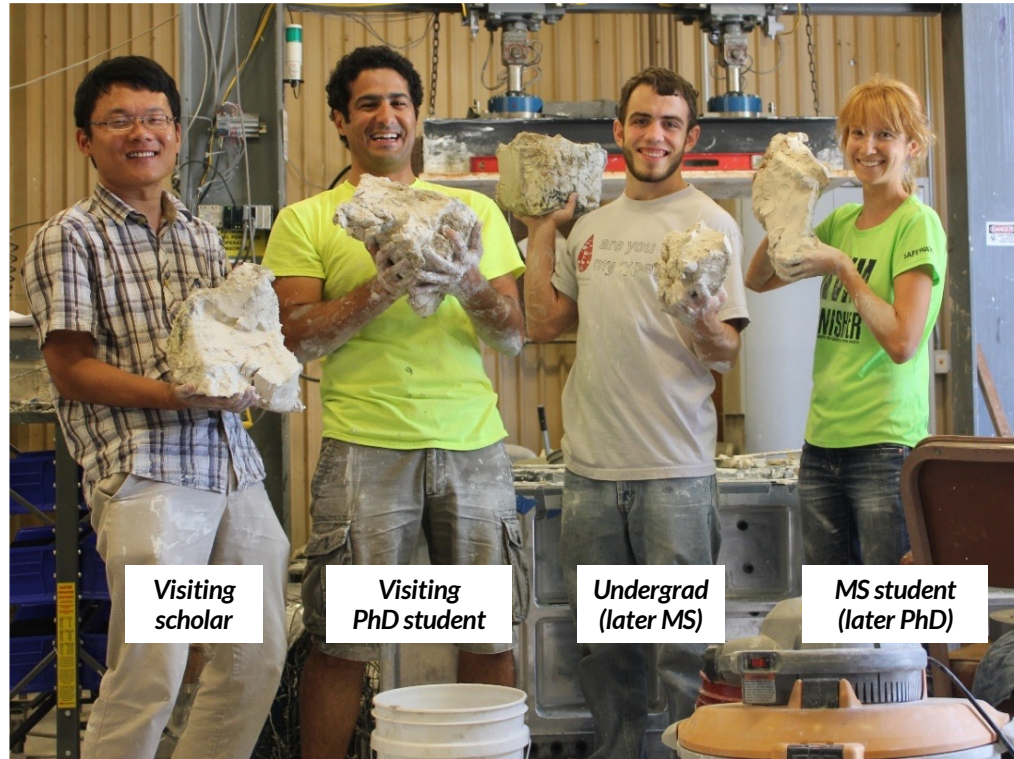
Common traits for successful projects

- Articulate the fundamental mechanism(s) that you are studying or most concerned about
- Articulate how you will be using the experimental data:
 - Validation of numerical simulations?
 - Validation of design methodologies?
 - Identification of mechanisms and behaviors using inverse-analyses or system identification methodologies?
- Design your model configuration so that it has the desired sensitivity to the fundamental mechanism of interest or will provide an appropriate test of your analysis method



Accessibility

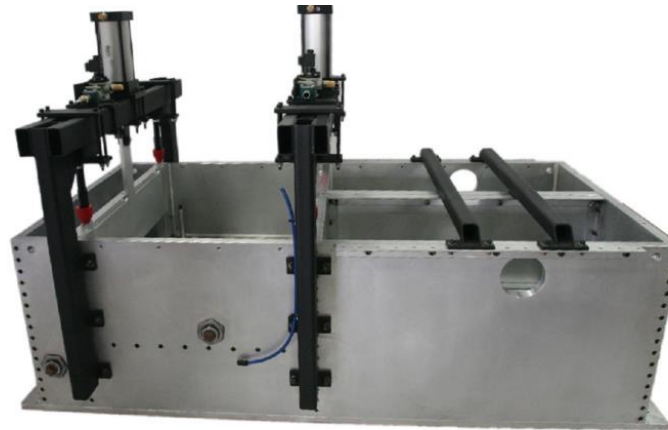
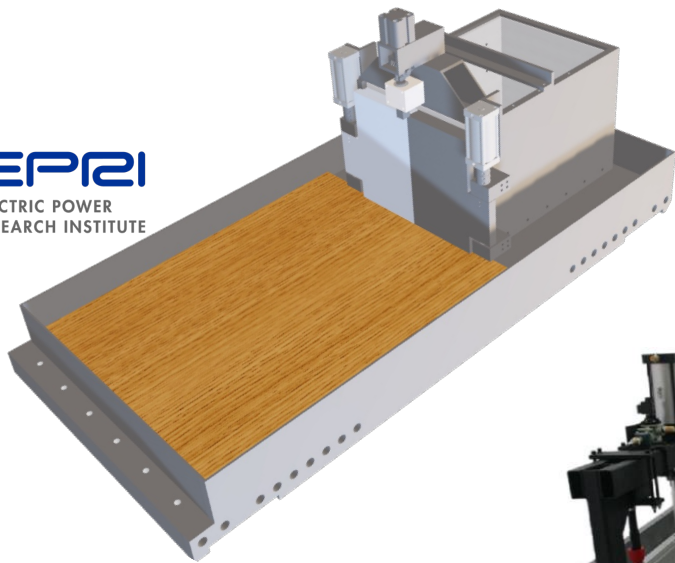
- All of us available to chat
- Mentors program: cgm.engr.ucdavis.edu/mentors-for-new-users
- Reports and data available on CGM website and/or NHERI DesignSafe
 - Documentation
 - Sample codes and data
- Parallel workflow allows scheduling flexibility
- Ladder mentoring practices for training students
- Advancing onboarding procedures
- And most importantly...



Customization

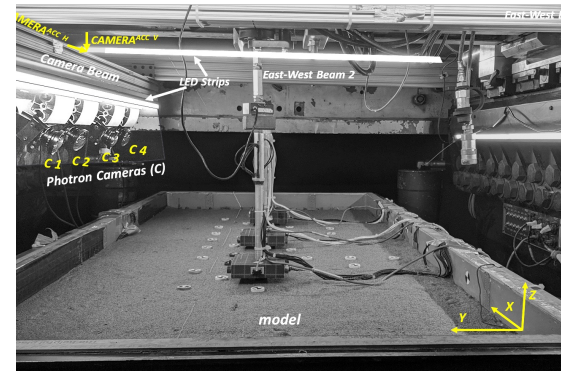
- No experiment similar to previous ones
- Different needs on specimen preparation, box, instrumentation, monitoring etc.

EPRI
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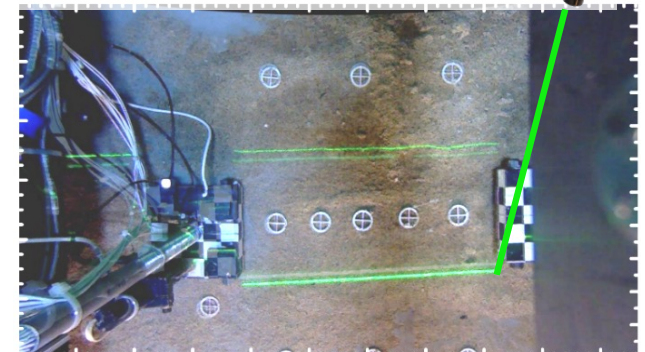


Development and Implementation of Contactless Displacement Sensing Methods

A) 3D Stereophotogrammetry



B) Line Laser and one Camera



Technology transfer

- *Research users generally have a geotechnical engineering focus*
- *Research topics generally pertain to aspects **not covered by codes or standards***
- *Research focus can be on specific **infrastructure** problems or on **general soil properties/behaviors** that are broadly applicable to a range of infrastructure*

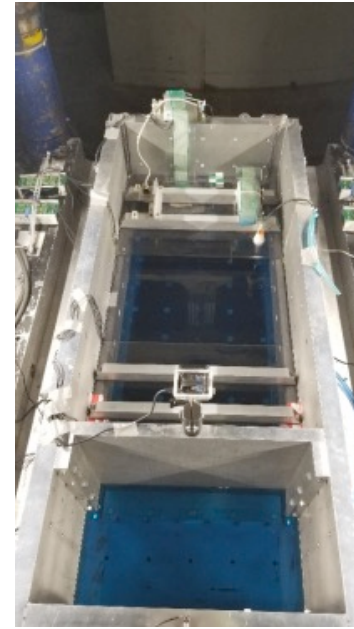
- *Technology transfer of findings has been effective when the research:*
 - *Addresses topics of current concern in practice*
 - *Engages industry partners or early adopters on research teams*
 - *Engages with developers of guidance/practice documents (e.g., FHWA, Caltrans, professional society committees)*

Recent examples of interest to the earthquake engineering community

Soil-Structure-Water Interaction in Buried Reservoirs



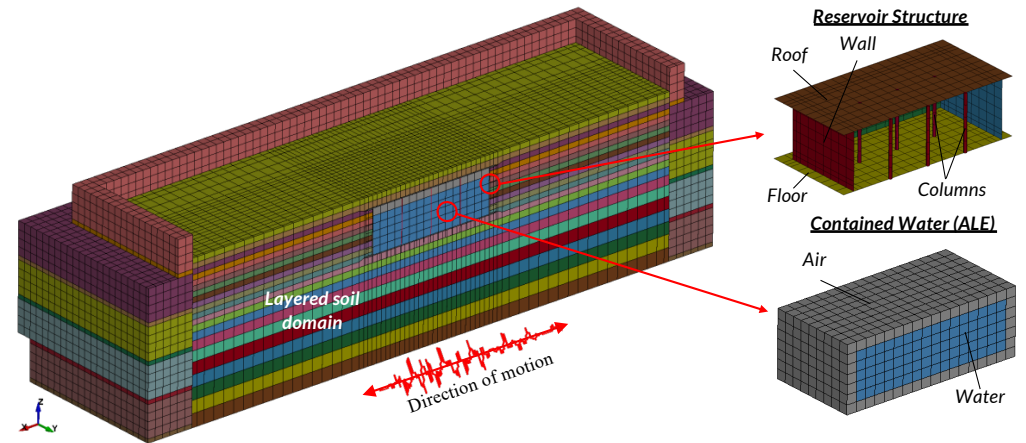
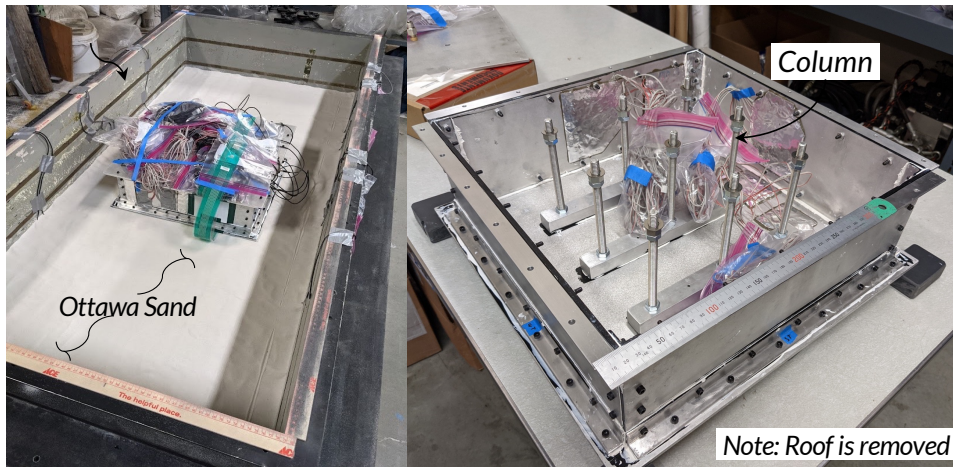
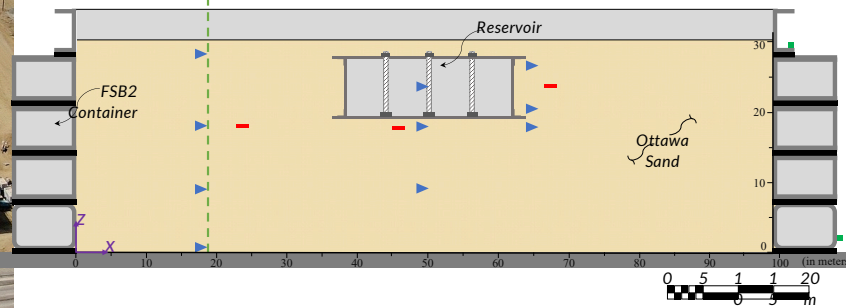
New rigid box



New strong floor, capable of accommodating various smaller boxes

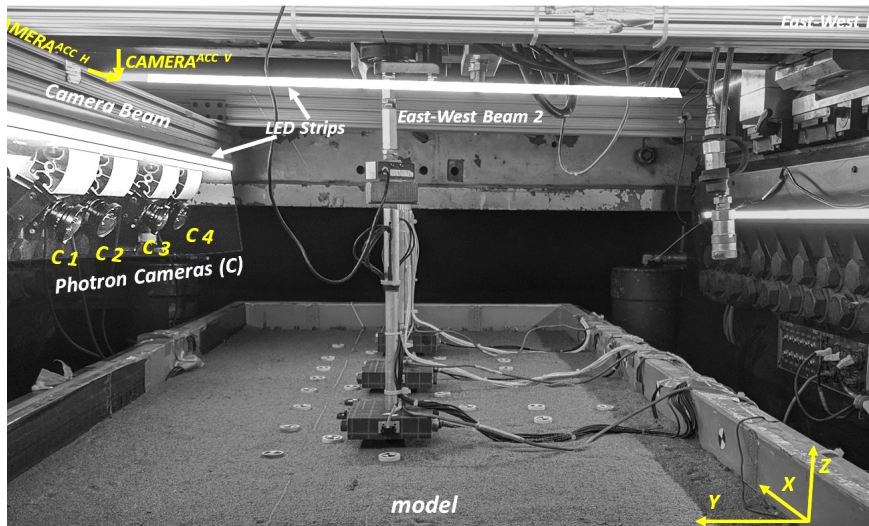
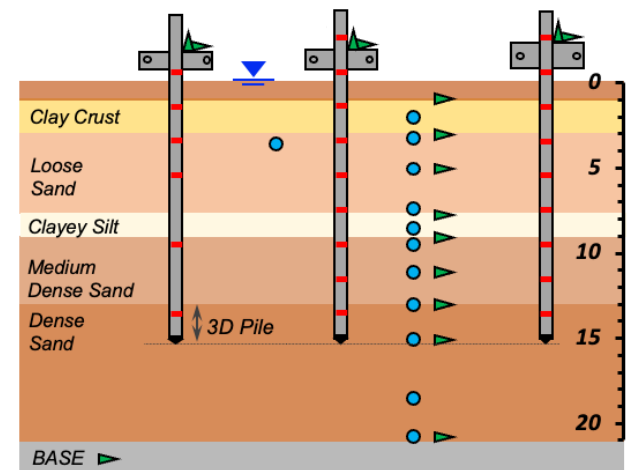
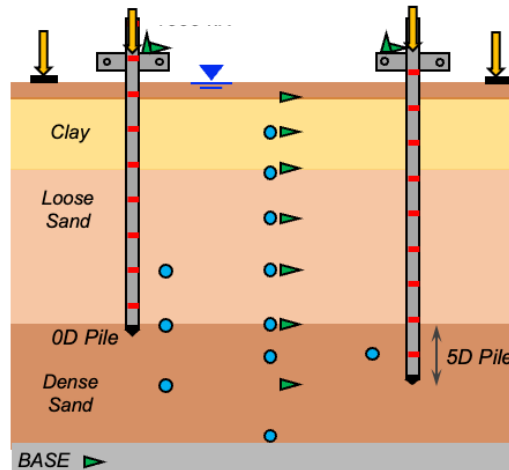
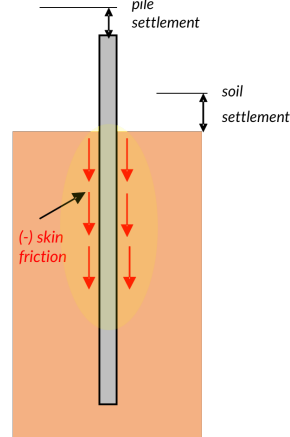
Recent examples of interest to the earthquake engineering community

Soil-Structure-Water Interaction in Buried Reservoirs



Recent examples of interest to the earthquake engineering community

Liquefaction-induced downdrag on piles



Everything has its price

- *The centrifuge facilities at UC Davis are available for use by all*
- *Recharge rates: cgm.engr.ucdavis.edu/information-for-users/*
- *NSF operations support allows NSF-funded users to access the facilities at minimal cost*
- *The CGM provides guidance, training, & support for a diverse user base.*
- *Feel free to chat with us and explore possibilities*

Questions are welcome.

Thank you for your interest.



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