Transportation Systems Research Program (TSRP)

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Acknowledgements:
Dr. Amarnath Kasalanati
Dr. Selim Günay

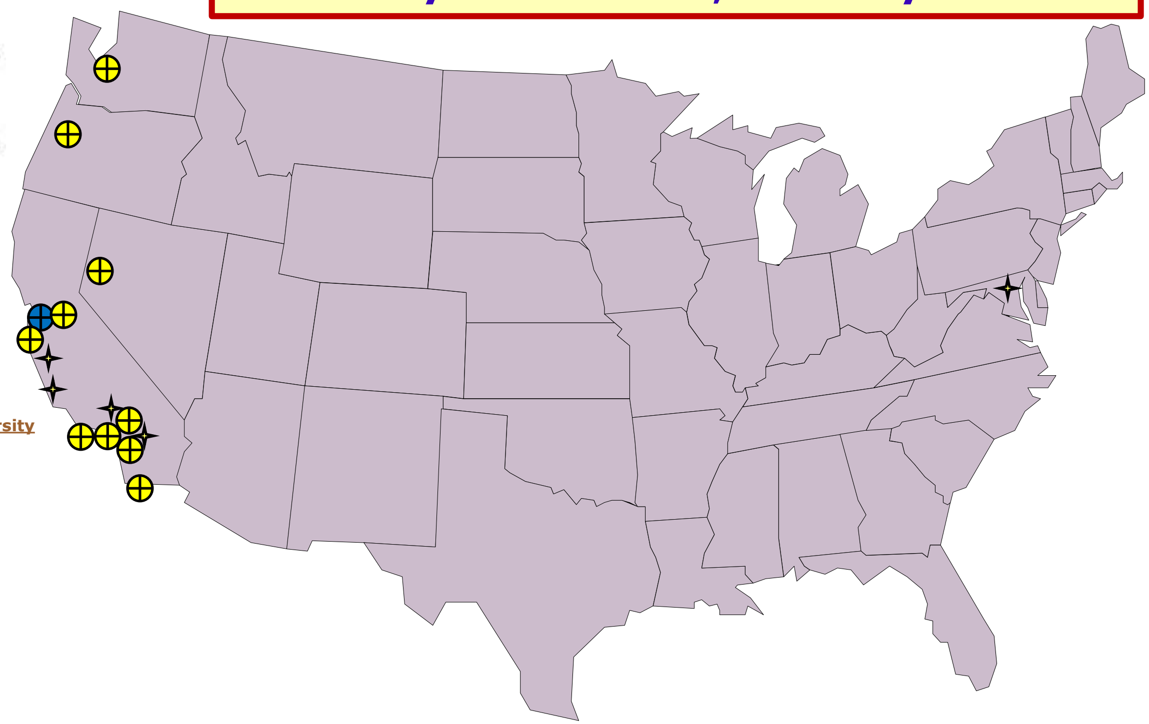
PEER

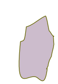
PEER: University, Government, Professional & Industry Alliance

The Pacific Earthquake Engineering Research (PEER) Center is a multi-institutional research & education center with headquarters at the **University of California, Berkeley**.

Educational Affiliates

- California Polytechnic State University, San Luis Obispo
- California State University, Los Angeles
- California State University, Northridge
- San Jose State University
- University of Hawaii
- Johns Hopkins University





Core Institutions

- University of California, Berkeley - Lead Institution
- California Institute of Technology
- Oregon State University
- Stanford University
- University of California, Davis
- University of California, Irvine
- University of California, Los Angeles
- University of California, San Diego
- University of Southern California
- University of Nevada, Reno
- University of Washington

PEER combines resources of major research universities in western US where earthquake hazards are largest. PEER is able to represent consensus of many experts.

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PEER TSRP Program

The purpose of PEER TSRP is to reduce impacts of earthquakes & Tsunamis on California's transportation systems, including highways, bridges, port facilities, high speed rail & airports.

https://peer.berkeley.edu/research/transportation-systems

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PEER TSRP Program Overview

1. TSRP emphasizes:
    1. PEER Performance Based Earthquake Engineering (PBEE) Methodologies
    2. Developing fundamental knowledge
    3. Making use of enabling technologies and systems
    4. Applications on practical problems related to the broad transportation systems
2. TSRP engages:
    1. Researchers
    2. Practitioners
    3. Government officials from DOT
3. TSRP domains are:
    1. Seismological
    2. Geotechnical
    3. Structural
    4. Hydrodynamical
    5. Socioeconomical
4. TSRP approaches include:
    1. Theoretical
    2. Computational
    3. Experimental
    4. Field studies
    5. Hybrid

Thrust Areas

- Geo-Hazards
- Computation & Modeling
- Experimental Research
- Network Performance-based Design
- Other Systems & Other Hazards

PEER's Management of TSRP Fund

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Request of Proposals to 11 Institutions, Sept. 12 of Each Year

Multiple Funded Proposals: 17 in 2018; 11 in 2019

Products: Reports; Presentations; Workshops; Data; Software

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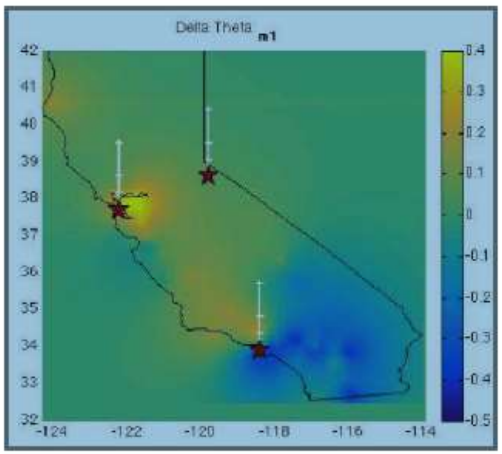
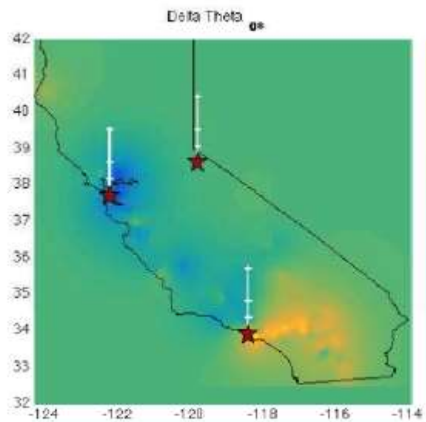
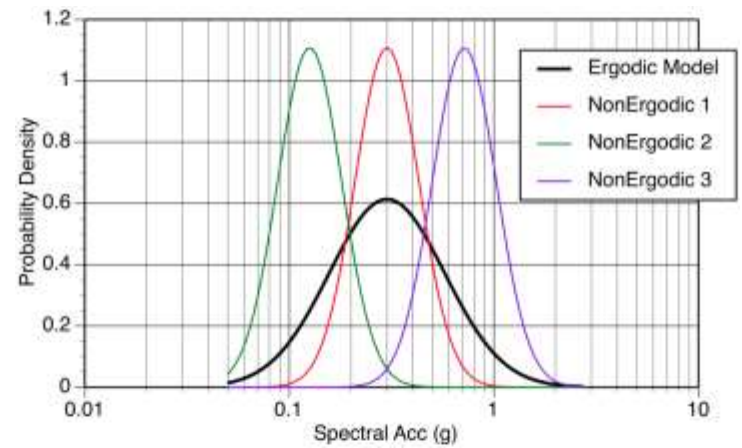
Sample Projects

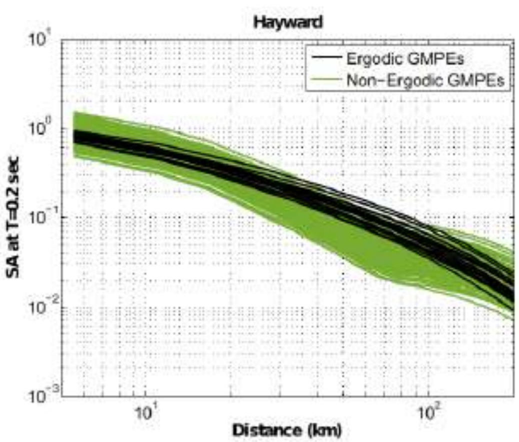
Non-Ergodic Ground Motion Models

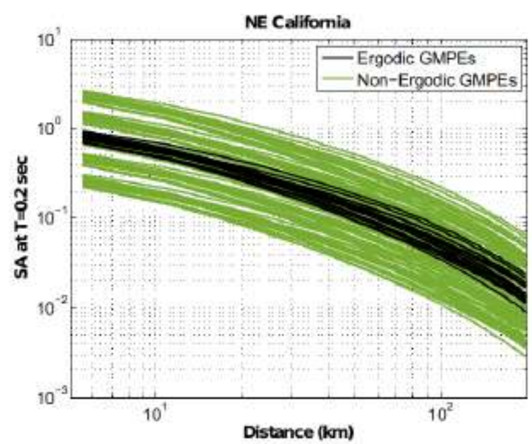
Prof. Norm Abrahamson, UC Berkeley/Davis

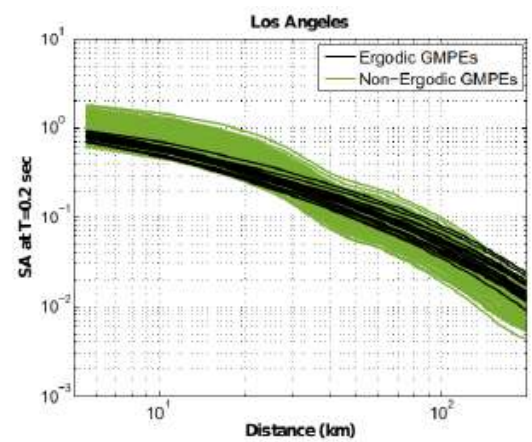












A key change in the direction of geo-hazards research

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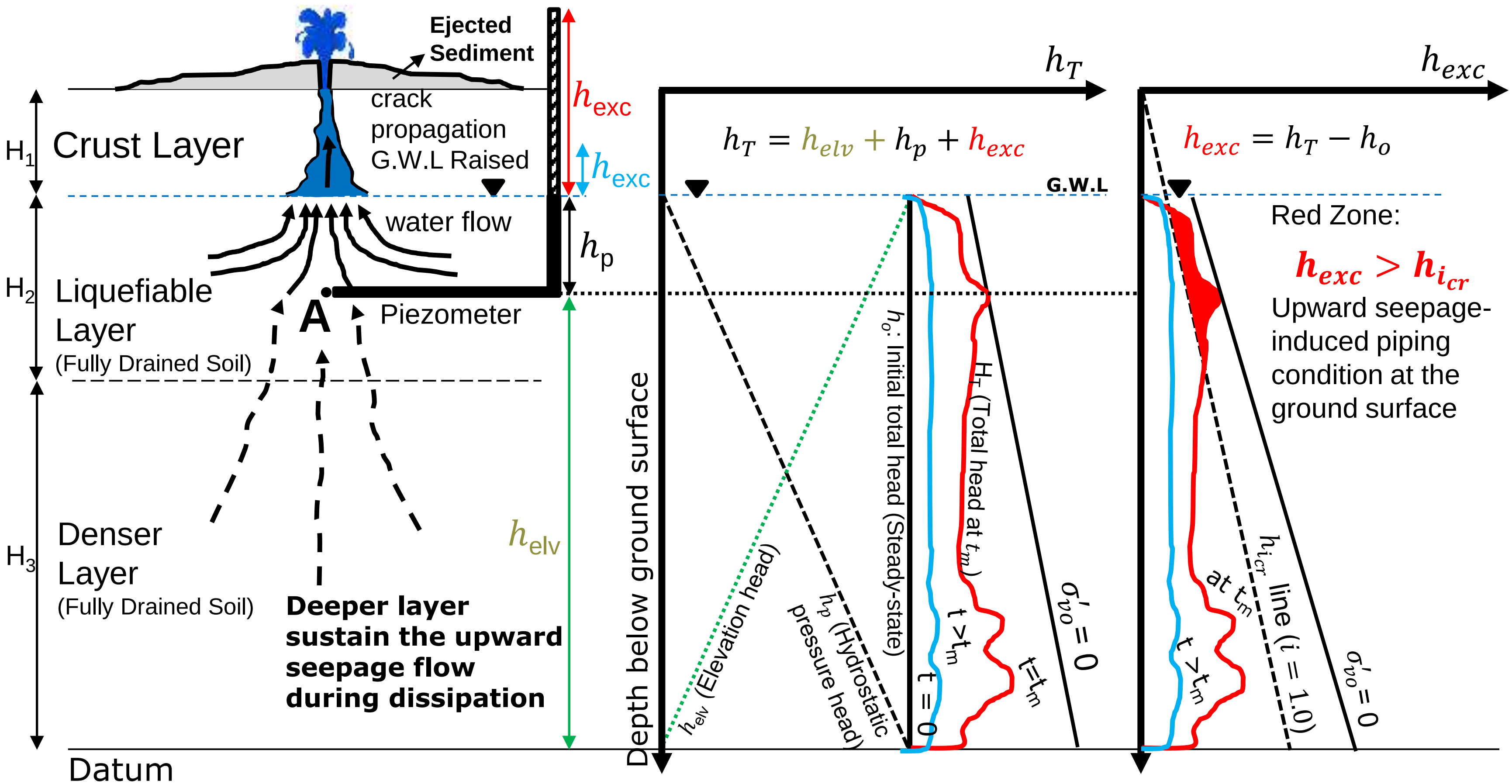
Liquefaction Estimation

Jon Bray, UC Berkeley



(a) Typical Soil Profile (b) h_T, Total Head (m) (c) h_{exc}, Excess Head (m)

Improved procedures for liquefaction manifestation estimate

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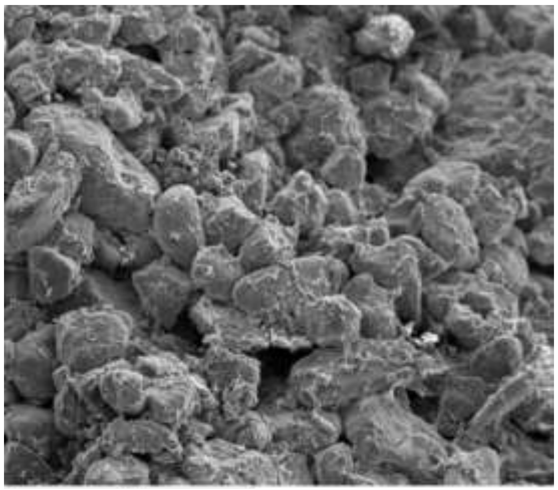
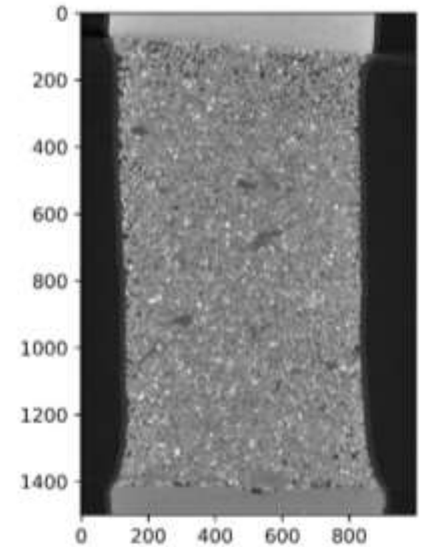
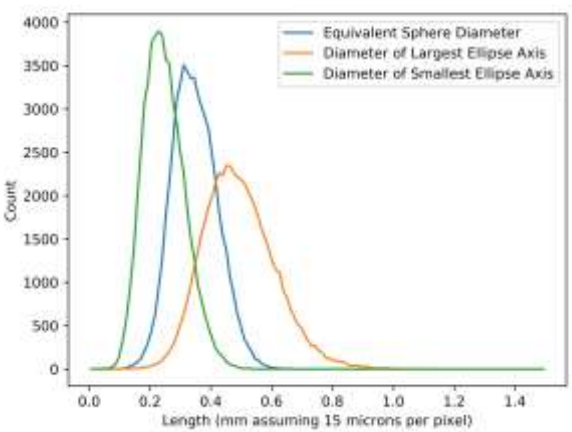
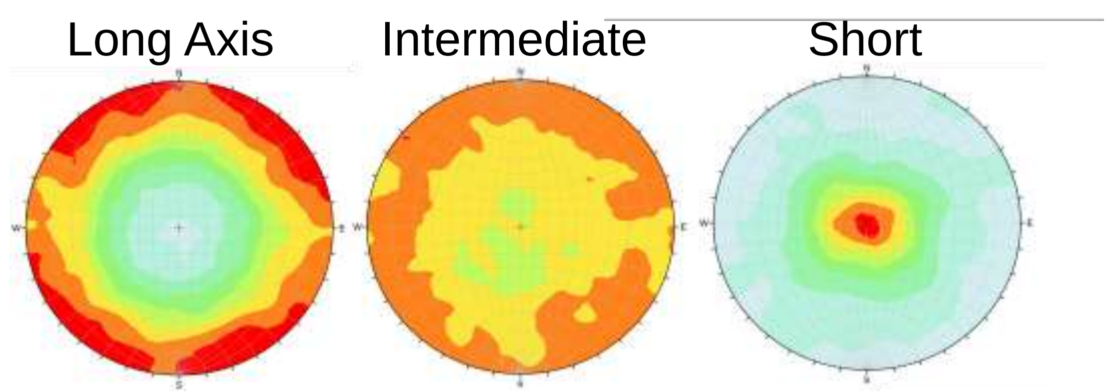
DEM Modeling of Granular Deposits

Prof. Nick Sitar, UC Berkeley









Effect of fabric & validation by DEM modeling

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Inclusion of Uncertainty in RC Bridges

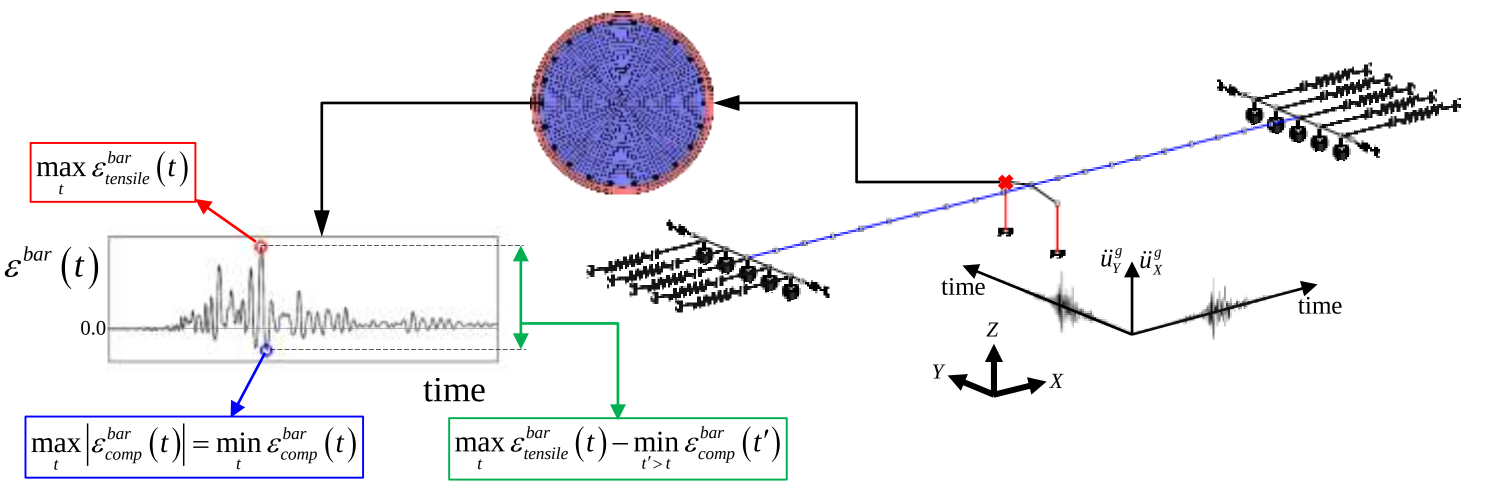
Prof. Joel Conte, UC San Diego

For $col\ j,\ (j \in [1,\cdots,N_{col}])$ of FE model realization corresponding to $\boldsymbol{\Theta} = \boldsymbol{\theta}^{(i)},\ \ i \in [1,\cdots,N_S]$

Limit-state (*LS*)	Associated *EDP*
Concrete cover crushing for a single column	$EDP_1^{col\ j,(i)} = \max_{bar}\left(\max_t \left\lvert \varepsilon_{comp}^{bar,(i)}(t)\right\rvert\right)$
Longitudinal rebar buckling for a single column	$EDP_2^{col\ j,(i)} = \max_{bar}\left(\max_t \varepsilon_{tensile}^{bar,(i)}(t)\right)$
Longitudinal rebar fracture for a single column	$EDP_3^{col\ j,(i)} = \max_{bar}\left(\max_t \varepsilon_{tensile}^{bar,(i)}(t) - \min_{t'>t} \varepsilon_{comp}^{bar,(i)}(t')\right)$

Demand Hazard Integral:

$$\nu_{EDP_k^{col\ j}|\boldsymbol{\Theta}=\boldsymbol{\theta}^{(i)}}(\delta) = \int_{IM} P\left[EDP_k^{col\ j} > \delta \mid IM = x, \boldsymbol{\Theta} = \boldsymbol{\theta}^{(i)}\right] \cdot \left\lvert d\nu_{IM|\boldsymbol{\Theta}=\boldsymbol{\theta}^{(i)}}(x)\right\rvert$$



Modeling, parameter & parameter estimate uncertainties

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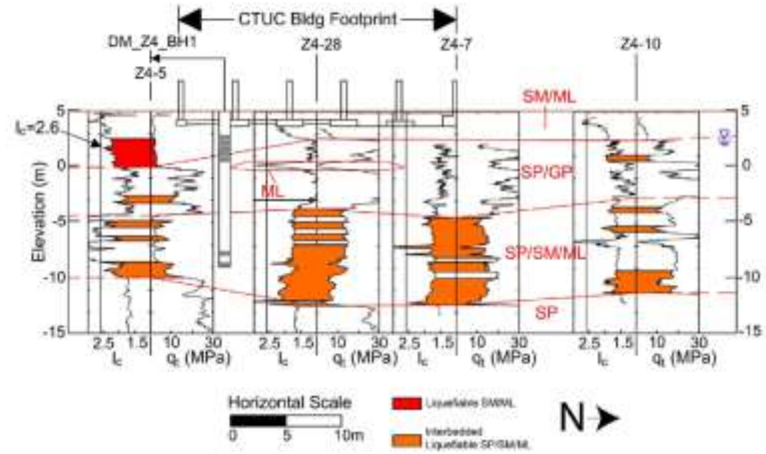
Shake Table Tests on Liquefiable Soils

Prof. Ramin Motamed, Univ. Nevada, Reno



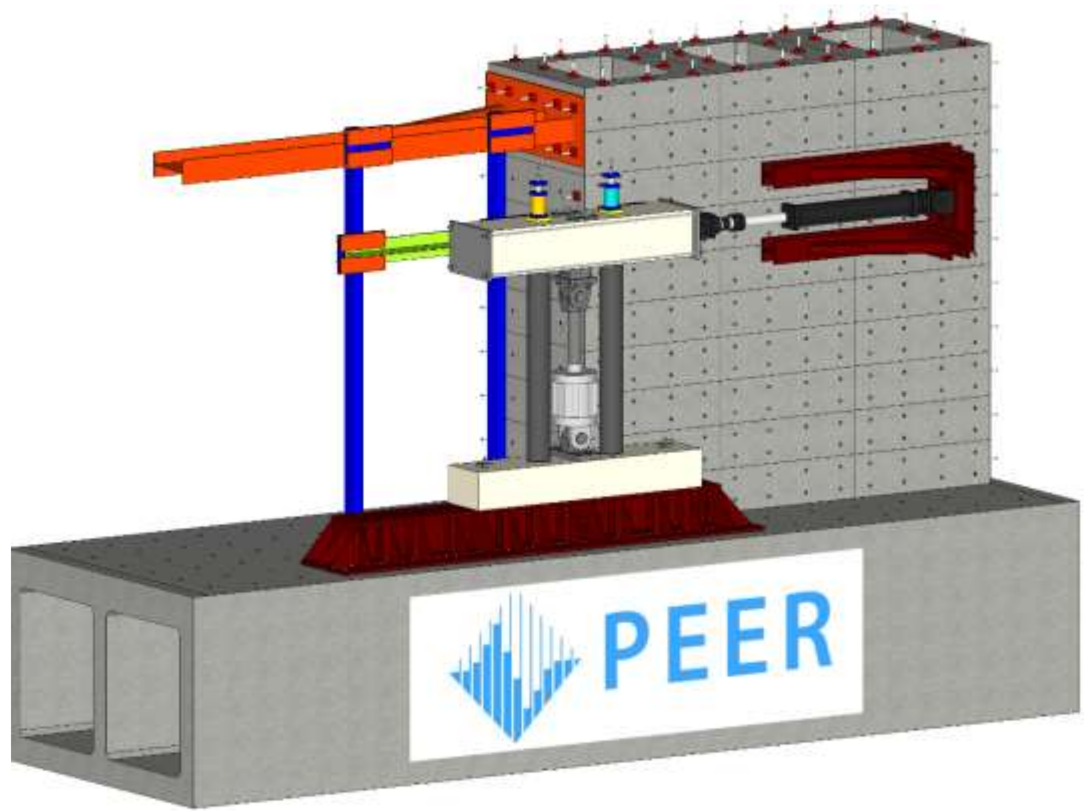
Experimental investigation of shallow foundations

Resilient Bridge Design: Hybrid Simulation

Prof. Khalid Mosalam, UC Berkeley

Shaking Table Tests [Nema, 2018]

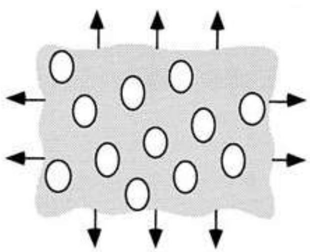
Current Hybrid Simulation Setup



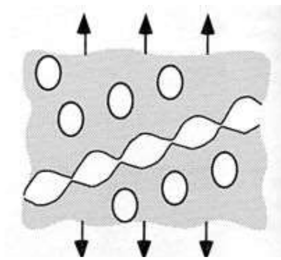
Validation of new HS method & extension to full bridge systems

Earthquake Duration Effects

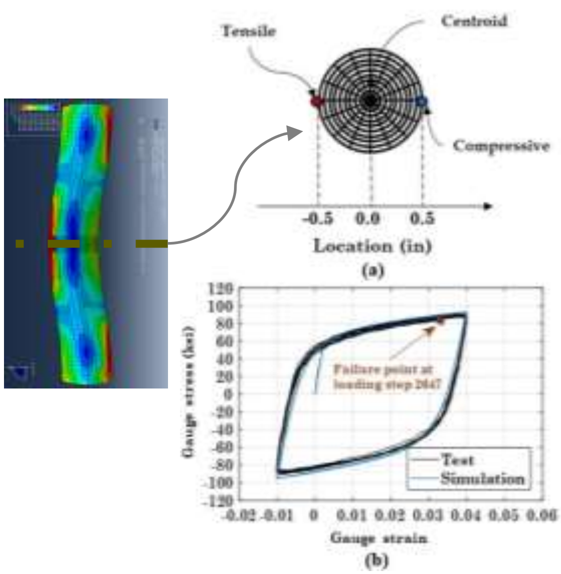
Prof. Greg Deierlein, Stanford; Prof. Mohamed Moustafa, UNR

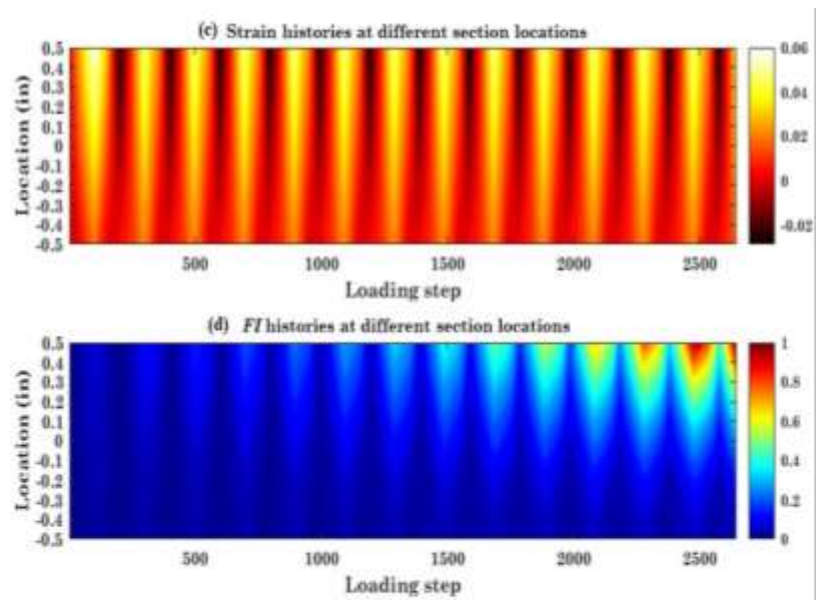


Void growth
(captured by C)



Void coalescence
and shrinkage
(captured by λ & β)

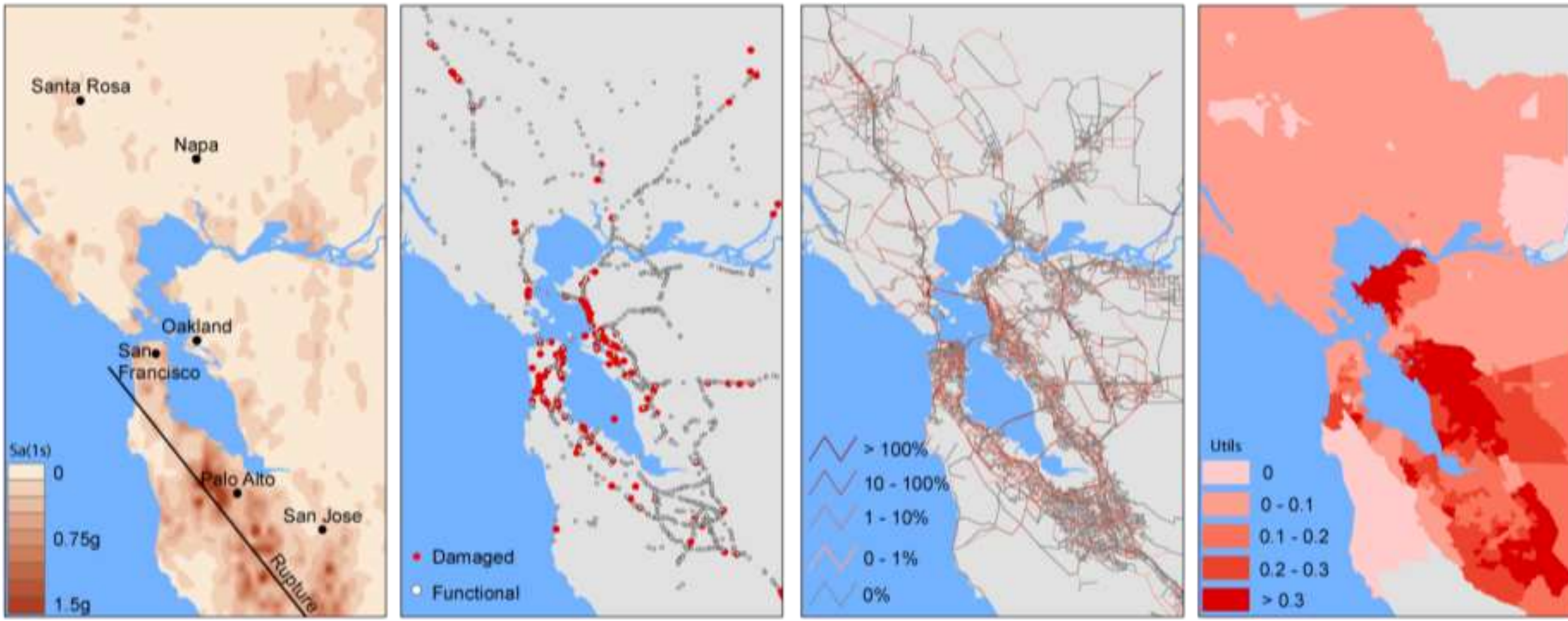




A key change in the direction of geo-hazards research

Resiliency at Network Level

Prof. Jack Baker, Stanford



Step 1: Ground-motion intensity

Step 2: Component damage

Step 3: Network performance

Step 4: User impacts

Contribution to community resiliency

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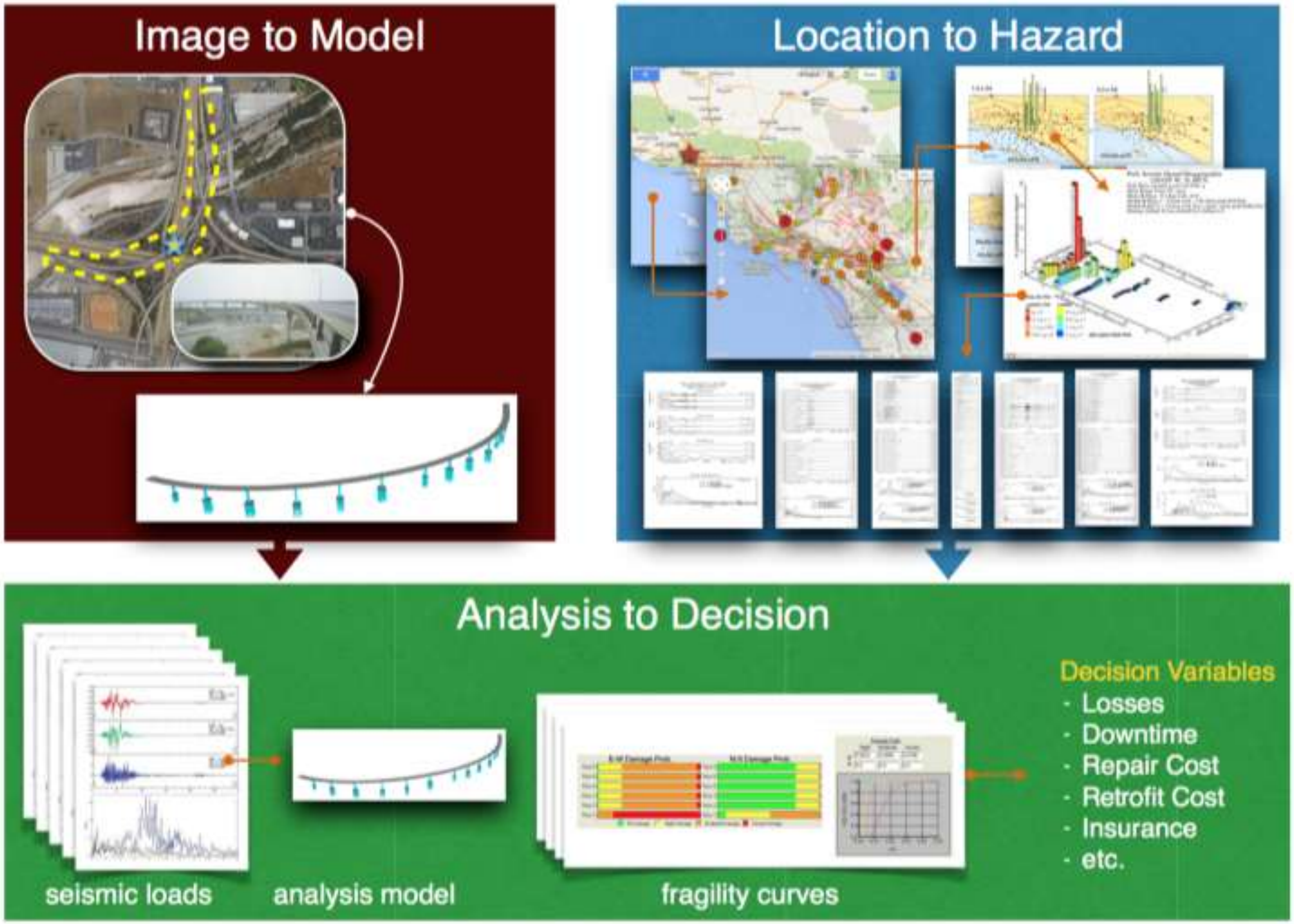
Regional Seismic Risk Assessment

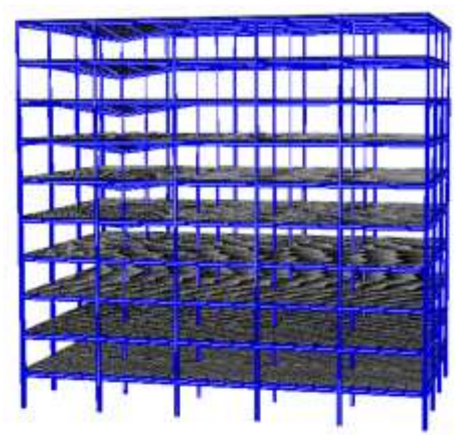
Prof. Ertugrul Taciroglu, UCLA

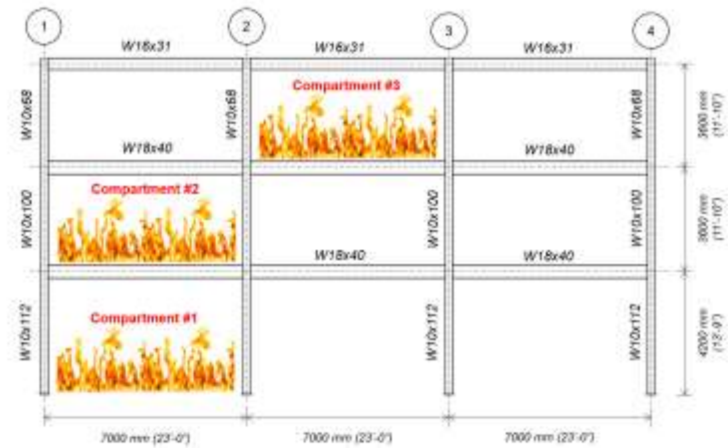


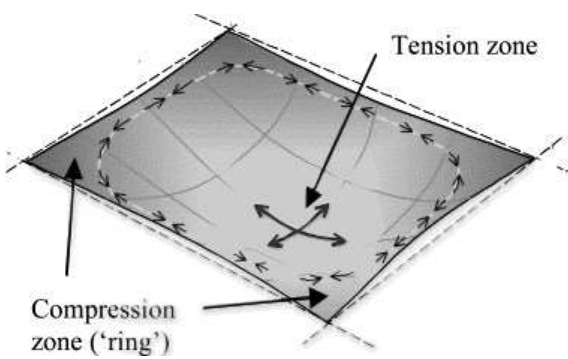
Contribution to modeling on the regional scale

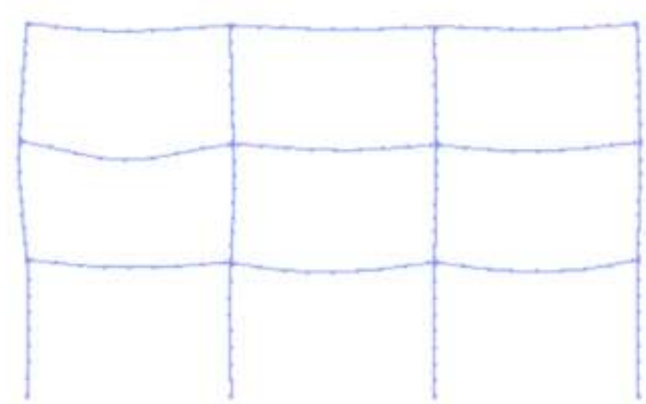
Fire Performance of Industrial Facilities

Prof. Erica Fischer, Oregon State University





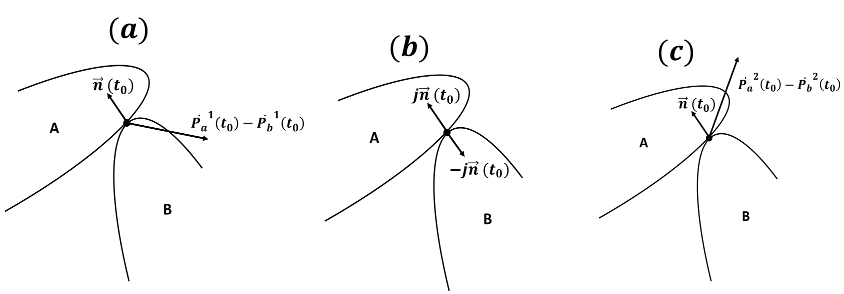




Development of 3D models in OpenSEES

Tsunami Debris & Loads

Prof. Patrick Lynett, USC



$$v_{rel} = \left(\dot{p_a}(t_0) - \dot{p_b}(t_0)\right) \cdot \vec{n}(t_0)$$

$$v_{rel}^1 = -\beta v_{rel}^2 \quad 0 \leq \beta \leq 1$$

$$j = -\frac{-(1+\epsilon)v_{rel}^1}{\left(\frac{1}{M_a} + \frac{1}{M_b} + \vec{n}(t_0) \cdot \left(\frac{r_a\, x\, \vec{n}(t_0)}{(I_{zz})_a}\right) x\, r_a + \vec{n}(t_0) \cdot \left(\frac{r_b\, x\, \vec{n}(t_0)}{(I_{zz})_b}\right) x\, r_b\right)}$$

Developing better models for estimation of Tsunami loads

Thank You

A complete list of ongoing & past projects including research highlights can be found in:

https://peer.berkeley.edu/research/transportation-systems/projects