

# SimCenter Community Roundtable

## “Liquefaction-Induced Hazards Effects on Buried Utilities”

October 9, 2024

This SimCenter Community Roundtable meeting was organized by the **Working Group on Regional Simulations for Lifelines and Transportation**. In the first hour of the meeting, invited speakers presented advances of our understanding of the seismic performance of buried natural gas pipelines affected by liquefaction. Discussion with attendees followed.

The seismic performance of our buried infrastructure is critical to achieving a resilient nation. Liquefaction-induced ground deformation can damage buried utilities, such as natural gas pipelines and water distribution pipes. Recent advances in developing seismic risk methodologies and open-source software that provide quantitative estimates of seismic risk including the uncertainty range in the risk will be presented. These methodologies and software are required to support risk-informed decision-making by utility companies, their consultants, and regulators. Additionally, the OpenSRA and R2D software provide researchers platforms in which to translate their results into practice.

*Host:* Jon Bray, University of California, Berkeley

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### Presentations and Key Ideas

#### 1. “Liquefaction hazard assessment: PEER-CEC OpenSRA project”

*Presenter:* Tom O’Rourke, Cornell University.

Prof. O’Rourke presented the application of a closed-form analytical model to estimate pipeline strain under permanent ground deformation (PGD) and a probabilistic assessment approach to estimate pipeline failure conditioned on pipeline strain and highlighted that 75% uncertainty is in pipeline failure probability in pipeline critical compression strain. Higher fidelity analysis (e.g., presented by Dr. Ziotopoulou) can reduce the uncertainty in the ground failure mechanism.

#### 2. “A Probabilistic, data-informed framework for regional estimation of liquefaction displacements”

*Presenter:* Domniki Asimaki, California Institute of Technology.

Prof. Asimaki presented a probabilistic modeling workflow that combines site-specific and geospatial methods to estimate liquefaction extent and PGD levels.

#### 3. “Nonlinear dynamic analyses of ground and pipeline failures due to lateral spreading”

*Presenter:* Katerina Ziotopoulou, University of California, Davis.

Prof. Ziotopoulou presented a 2-dimensional nonlinear dynamic analysis of the Bolboa case history in the Northridge Earthquake. The high-fidelity model provides valuable insights on soil failure mechanism, the behavior of different soil units, and the transient strains variation along time. It is also highlighted that uncertainties exist in such high-fidelity models. Future research is needed to evaluate the sensitivity to the extent of the modeled area, cement mortar damage, and strain timing.

#### 4. “Modeling of liquefaction-induced hazards and effects on buried utilities in OpenSRA and R2D”

*Presenters:* Barry Zheng, Slate Geotechnical Consultants, and Jinyan Zhao, SimCenter.

Dr. Zheng and Dr. Zhao compared the pros and cons of the two software, R2D and OpenSRA. They highlighted the softwares’ open-source nature and opportunities to use the software to accelerate other research.

### Discussion Highlights

- What are the most important factors in analyzing pipeline performance in seismic events?

- Accurate modeling of pipeline strain and deformation, considering different tolerances of different pipelines, is critical in the reliable assessment of pipeline seismic performance.
- Relative displacement and the extension of liquefaction at a regional scale are important directions in liquefaction hazard modeling. Site-specific sounding and geological data are essential for advanced numerical models.
- What is missing in current risk software tools?
  - Identify areas of potential corrosion and model the effects of corrosion on pipelines.
  - Consider the improved pipeline capacities of modern pipeline manufacturing and installation techniques.
  - Smart earthquake scenario selections and efficient vulnerability analysis, e.g., surrogate models.
  - Proper characterization of spatial uncertainties, particularly ground water level, which is paramount important in soil liquefaction hazards.
- Interest from the audience:
  - Buoyance force effect on pipeline in liquefaction events.
  - How R2D/OpenSRA different from HAZUS.
- Accelerate industrialization of research
  - Usable and implementable tools without compromising the complexity of advanced modeling need to be developed from research communities.
  - Regular workshop and academic-research events.
  - Release opensource plug-and-play code and data.

### **More Information**

Additional SimCenter Community Roundtable meetings can be found at <https://simcenter.designsafe-ci.org/collaborate/scr/>.