SimCenter Community Roundtable
"Regional earthquake testbeds: advancing data and models"
April 15, 2025

This SimCenter Community Roundtable meeting was organized by the **Working Group on Regional Simulation of Earthquakes**.

This roundtable examined how regional testbeds can drive the development and implementation of data and models to perform high-fidelity simulations of earthquake impacts and recovery in large urban areas. The roundtable featured presentations that delved into ongoing efforts to develop detailed inventories of buildings and infrastructure, multi-resolution surrogate models that estimate response and damage to buildings and infrastructure, and advanced topics in regional simulations, including uncertainty quantification, multi-hazard simulations, and recovery modeling. The presented research and developments leverage SimCenter tools, such as BRAILS++ and R2D, the SimCenter's San Francisco Bay Area testbed, and other testbed initiatives. We expect the discussions will promote research collaboration and benchmarking using earthquake scenario studies and model validation using post-earthquake observations.

Host: Gregory Deierlein, Stanford University

Presentations and Key Ideas

1. **"Testbed Experiences and Lessons"**
   Presenter: Elaina Sutley, University of Kansas.
   This presentation provided a structural review of testbed development efforts within the natural hazards engineering community. Beginning with a formal definition of testbeds, statistical breakdowns of the recent publications are provided for different target hazards and systems. Prof. Sutley also discussed key requirements for a successful testbed, including the need to address data security concerns, develop best practices for validation, and promote stakeholder engagement.

2. **"New Zealand as a Testbed"**
   Presenter: Liam Wotherspoon, University of Auckland.
   This presentation introduced an ongoing nationwide decadal effort in New Zealand to develop a multi-hazard, multi-disciplinary testbed framework. Emphasis was placed on bridging research and practice through mission-led research and coordinated collaborations. Prof. Wotherspoon also discussed the importance of developing nationally consistent datasets and locally adaptive component models.

3. **"SimCenter Regional Simulation Testbeds"**
   Presenter: Adam Zsarnóczay, Stanford University, NHERI SimCenter
   This presentation conveyed the SimCenter's objectives in developing community-driven testbeds, including reproducible simulations, reuse of shared data, and quality assurance. Dr. Zsarnóczay highlighted the role and challenges faced by SimCenter in serving as a platform to coordinate the community's collaborative efforts in co-developing the testbeds.

Discussion Highlights

- <u>What is meant by the term "testbed architecture"?</u> Testbed architecture relates to the process by which datasets and models are acquired and assembled. The architecture depends on the testbed's purpose, data availability, tool accessibility, and tool evolution over time. Clearly communicating the architecture is essential, as changes in its details can affect key insights derived from the testbed, such as risk prediction and the identification of critical components.

- Lifespan of testbed: Communicating the architecture is important to ensure the testbed can be maintained over its intended lifespan, especially once it is handed over to stakeholders. Moreover, it's important to recognize that future testbed users may apply it differently and for a different purpose than those envisioned in the original testbed development.
- Role of AI in testbed: There are growing opportunities to apply AI in the development and application of testbeds, as evidenced in BRAILS++ and other SimCenter tools. These include identifying data, filling gaps within datasets, and even extending to the use of large language models as a substitute for survey responses.
- Developing a testbed for data-scarce regions: The first step in developing any testbed, but especially one in a data-scarce region, is understanding "how much data is enough data" to make the intended informed decisions. When remote data access is limited, visiting sites in person and building relationships with local communities can be an effective (and only feasible) approach to collecting important inventory and other data. However, creating such partnerships often involves communication and other challenges. While this effort can be complicated and demanding, it is worth pursuing to move beyond convenient scientific assumptions.
- Handling uncertainty in inventory: Uncertainty in the built environment (e.g., features of specific buildings and the choice of fragility and vulnerability curves) has a significant impact on predicted risk, although this may even out when aggregated at a regional scale. While biases arising from uncertainties in the asset inventories (buildings, bridges, other infrastructure) are unavoidable, we can still aim for consistency in modeling to make relative comparisons between different scenario outcomes.
- Broader impact of testbed: It is rewarding to see improvements in partner agencies' capabilities to utilize regional natural hazards risk predictions, such as by hiring data scientists and GIS experts who can interpret the results or by developing new work programs related to these efforts. There are distinct differences between providing simulation tools and providing simulation results as the ownership of the simulation shifts.

More Information

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