Research Highlight

Development of the PEER Simulated Ground-Motion Database (PEER-SGD) for Performance-Based Earthquake Engineering

TSRP Topic: R1 – Regional-scale Simulation of Networks

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Start-End Dates:
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Abstract
The development of site-specific earthquake ground motions for application in engineering risk assessments continues to be one of the most challenging and uncertain elements in Performance-Based Earthquake Engineering (PBEE). While major progress has been made in the development of empirically-based ground-motion models, the ability to understand and characterize site-specific ground motions and the site-to-site variability of ground-motions remains elusive. Recent advancements in understanding the physics of earthquake processes, increased performance of high-end computer platforms, and the development of advanced computational workflows are combining to provide transformational computational ecosystems for simulation-based earthquake hazard and risk assessments. This project focuses on providing necessary foundational elements that will position the PEER community to fully exploit the utilization of emerging regional simulations in PBEE. In June 2021, PEER held the *International Pacific Rim Forum on Regional-Scale Simulations of Earthquake Ground Motions and Infrastructure Response for Performance-Based Earthquake Engineering*. The Forum brought together over 250 international participants to discuss the current status of regional-scale simulations and the remaining challenges to full exploitation of simulations. A number of participant polls were executed during the Forum to help establish consensus community views on the most pressing needs for transitioning regional-scale simulations into broader research and engineering practice. In response to the question, "*What would be most helpful in promoting the utilization of simulated ground motions in your research or professional practice*?" the leading answer was "*The availability of a database of simulated motions with open-access to the community.*" Making representative simulated ground motions available for community access will be essential to enabling the transition of simulated ground motions from a limited group of specialists to the broader research and practitioner communities. The principal objective of the current project, which will highly leverage

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on-going simulation work and recent software developments from other projects, is to develop the first realization of a PEER-SGD framework.

Deliverables

The project team will work in close coordination with the newly formed PEER *Database of Simulated Ground Motions* Technical Committee to define the database architecture, protocols and metadata requirements for an effective and efficient database for PBEE applications. To accommodate the large datasets that will be necessary to exploit the full value of dense simulated ground motion data, the database must be designed to be inherently scalable in size. In addition, the database must be capable of including a number of realizations for each scenario earthquake event in order to capture the breadth of potential ground motions as a function of a specific fault rupture evolution. The project team will work with PEER's information technology (IT) staff to stand-up an initial version of the SGD using existing dense regional ground motion simulation data for the San Francisco Bay Area created under a U.S. Department of Energy funded project. Specific deliverables will include a report documenting the SGD architecture and implementation, a first web-accessible dataset of simulated ground motions, and conference and journal publications describing the developments.

Research Impact

The development of an effective and efficient database of broad-band simulated ground motions will provide a nucleating capability for a broad group of researchers and practitioners to both explore and exploit simulated ground motions at unprecedented spatial density. There will be multiple opportunities for utilization of the simulated data ranging from selection of synthetic ground motion waveforms with desired attributes, for example simulated records containing near-field pulse-like motions, to augment measured earthquake waveforms within traditional hazard definitions (e.g. ASCE 7-16), to more advanced direct application of simulated motions in infrastructure nonlinear response history analyses. The ability to access dense motions will provide a new resource for exploration of the regional effects of spatially variable ground motion input for distributed transportation, energy and water systems, and to evaluate the effects of complex, three-dimensional site response, as opposed to traditional one-dimensional site response idealizations. Such datasets can provide new knowledge, help advance the understanding of complex earthquake phenomenon, and supplement the existing measured earthquake database, particularly for features that are not well constrained by the sparse database of measured motions, for example characterization of the spatial variation of near-fault motions. Most importantly, this work will help provide a core element for PEER community engagement that can be expanded upon as regional-scale simulation capabilities continue to advance.

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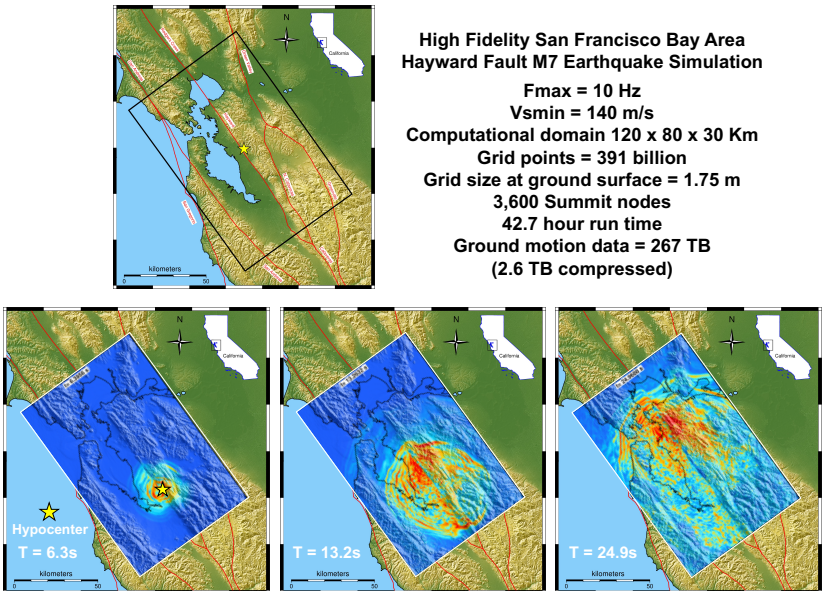
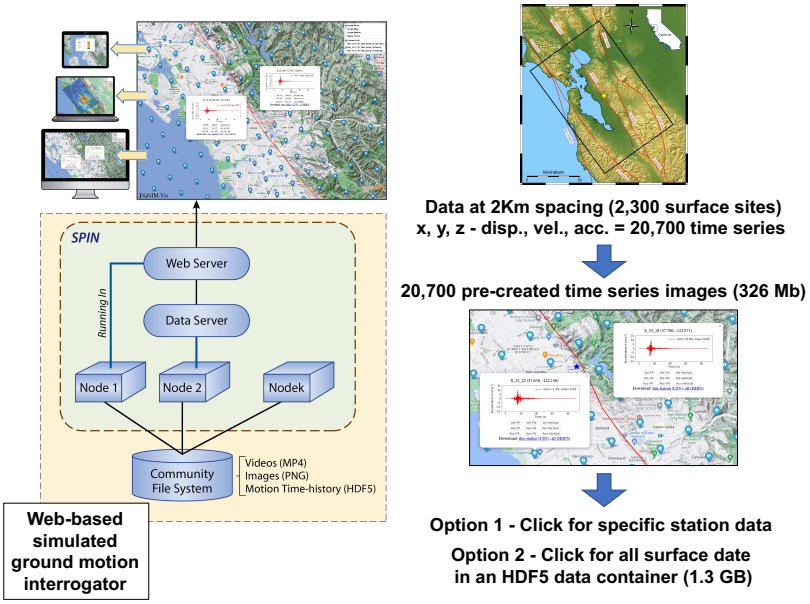
Project Images



a) A representative dataset consisting of physics-based, broad-band, regional-scale ground motion simulations of the San Francisco Bay Area for a M7 Hayward fault earthquake.



b) An in-development interactive web-based system for display, interrogation, and selective download of simulated ground motion data.

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