DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Geotechnical/ Structures

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Project Title: Earthquake Ground Motion Hazard Characterization

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Pacific Earthquake Engineering Research Center (PEER) – Lifelines Program 3

A partnership of government agencies and private companies focused on common interest research to better characterize earthquake hazard in California.

WHAT WAS THE NEED?

California, located at the margin of the Pacific and North American tectonic plates, is the most seismically active region in the US. Past earthquakes have shown that earthquake ground motion is highly variable. Improving our ability to predict ground motion, particularly high levels of motion, allows seismic mitigation spending to be better targeted on the most vulnerable locations.

Earthquakes also cause damage in the form of ground failure and tsunami inundation. Large displacement offsets often occur across faults severely damaging bridges that span them. Loose saturated soil can undergo dramatic strength loss when moderately shaken in a process called liquefaction. Liquefaction has been a major cause of damage in past earthquakes as the weakened ground causes large foundation settlement or large lateral ground displacement that pushes sideways into bridges. Tsunamis threaten coastal bridges with potential wave heights in excess of 30 feet.

WHAT WAS OUR GOAL?

The primary objective was to develop practical engineering models, methods, design tools, and guidelines that better characterize potential hazards and how to mitigate them.

WHAT DID WE DO?

A common-interest earthquake research partnership was created that aims to better predict earthquake ground motion, liquefaction, ground deformation, tsunami hazard and improve structural analysis of earthquake loading. Projects related to earthquake ground motion primarily focused on improving ground motion models for subduction type earthquakes. These projects focused on building a community database of subduction ground motion data and then using that data to develop improved prediction models for shaking intensity. Deep sedimentary basins are known to amplify shaking intensity. A project was initiated to look at how well current ground motion models do at predicting this amplification and explore methods that might improve those predictions. Another project was created to evaluate a range of near-fault directivity models that were recently developed under an earlier research program. The study evaluated the similarities and differences between models and recommended two models for implementation in future ground motion models.

Liquefaction related research focused on the creation of a community database under the Next Generation Liquefaction (NGL) program. This relational database has been populated with roughly 80% of existing case-histories of liquefaction triggering. Extensive lateral spreading case-histories have also been added including a new case-history of a tailing dam failure. To support future liquefaction modeling efforts a series of short reports by recognized experts on various liquefaction issues were developed.

Structural related research generally focused on practical issues of ground motion use. One project focused on how to improve the convergence of numerical bridge models so that use of poorly constructed models would not be erroneously interpreted as a bridge collapse. Another project focused on making spectral matching software easier and more reliable to use. Finally, a workshop of invited experts was held to provide their opinions on suitable fragility curves for bridge columns.

WHAT WAS THE OUTCOME?

One of the most notable successes of the Lifelines-Partnership was the development of new subduction event ground motion models through the NGA-Subduction program. Several new models were developed, all considered to be a major step forward relative to previous models. These new models have been adopted by the USGS for their next generation of national seismic hazard maps. Other immediately deployable items include a spectral matching tool for earthquake records to be used as input into structural models and a tsunami hazard data viewer to assist design engineers.

The program also successfully created databases of liquefaction case-histories and fault rupture displacement. These databases represent major accomplishments since they store very complex data in a very flexible, usable way. The fault rupture database is notable in that it includes ground displacement information measured off the main fault trace. Both datasets will be the center of future efforts to build engineering models of liquefaction triggering, lateral spreading, and fault offset hazard.

WHAT IS THE BENEFIT?

New or improved design methods and tools were developed that help bridge the gap between best science and practical engineering. The cost of performing this research was shared with other Lifelines providers as we have a mutual interest in better understanding seismic hazards. The net benefit to California is more reliable infrastructure and cost effective seismic mitigation.

IMAGES

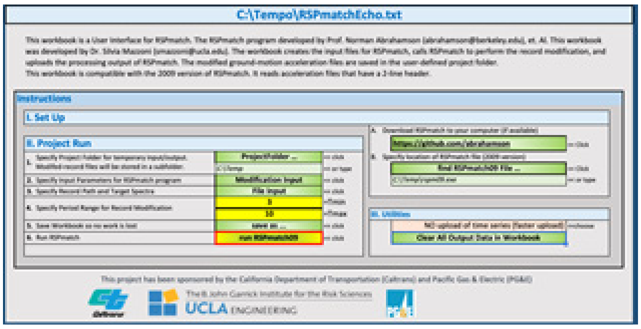

Image 1: RSP Match user-interface

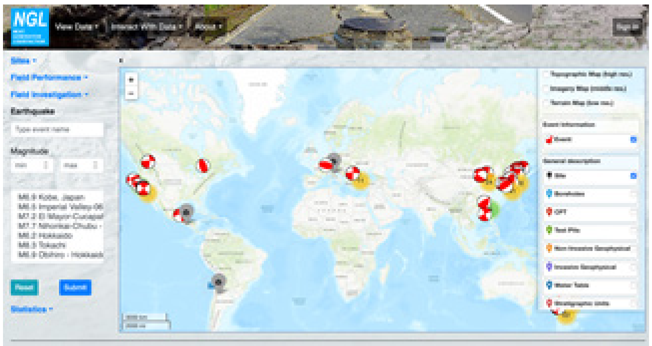

Image 2: NGL database interface