Final Project Summary — PEER Lifelines Program

Project Title—**ID Number**	*Physically Based Source Input for Strong Ground Motion Simulation*—**1C08**		
Start/End Dates	6/01/02 – 5/31/03	Budget/ Funding Source	$63,262 / PG&E/CEC
Project Leader (boldface) and Other Team Members	**Beroza (Stanford) Guatteri (Stanford – now at Swiss Re)**		

1. Project goals and objectives

The goal of this project is to develop a library of rupture models for scenario earthquakes that are consistent with the scaling and spatial variability of slip determined for past earthquakes and with simple notions of the physics of earthquake faulting.

2. Benefits of the results of this project to develop technologies and protocols to mitigate the vulnerability of electric systems and other lifelines to damage directly and indirectly caused by earthquakes. Also, benefits to develop assessment techniques to evaluate damage to electric systems caused by earthquakes and to assess fiscal impacts due to the loss of electric service to the community.

The output of the project is being used to simulate seismograms from large earthquakes. These are in turn being used as input to the modeling component of the Next Generation Attenuation project under the PEER Lifelines Program.

3. Brief description of the accomplishments of the project

We carried out dynamic rupture modeling using the boundary integral method (BIM) algorithm [*Quin and Das*, 1989]. The pseudo-dynamic source model we developed is based on the output of this dynamic rupture modeling algorithm. We have demonstrated that we can accurately reproduce the effects of the free surface and horizontal layering in dynamic rupture modeling within the framework of the BIM using approximations that are valid for vertical faults. This was presented at a PEER/Lifelines workshop. We have also developed a library of source models for scenario strike-slip earthquakes. This was presented at the March quarterly PEER/Lifelines Workshop. A paper on the approach has been submitted to *BSSA* for publication [Guatteri, M., P. M. Mai, and G. C. Beroza, A Pseudo-Dynamic Approximation to Dynamic rupture Models for Strong Ground Motion Prediction, *Bull. Seismol. Soc. Am.,* (in press), 2004]

4. Describe any instances where you are aware that your results have been used in industry

None known.

5. Methodology employed

We have used a spatial random field model developed by *Mai and Beroza* [2002] to create realizations of scenario earthquakes. From these we create dynamic models that are consistent with them using the method of *Guatteri et* al. [2003] based on a modified boundary integral formulation. These inputs are used as a basis for predicting an approximate, physically consistent source model (*viz.*, the pseudo-dynamic approximation).

6. Other related work conducted within and/or outside PEER

We had funding from SCEC to work on the initial development of this model. We have also used it to develop seismograms in the extreme near field for a project funded by the NSF sponsored US-Japan Urban Earthquake Hazards Program.

7. Recommendations for the future work: what do you think should be done next?

Our approach was developed for earthquakes in the magnitude range of 6.5 to 7.2. We have extrapolated it to earthquakes as large as magnitude 8.2. This extrapolation is problematic for several reasons, so a project to extend and validate our method for larger earthquakes would be a natural next project. Also, if the hybrid NGAH project gets underway, then pseudo-dynamic modeling would be a natural way to treat the source as the starting point for simulating strong ground motion.

8. <u>Author(s), Title, and Date</u> for the final report for this project

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1C08: "Physically Based Source Input for Strong Ground Motion Simulation"
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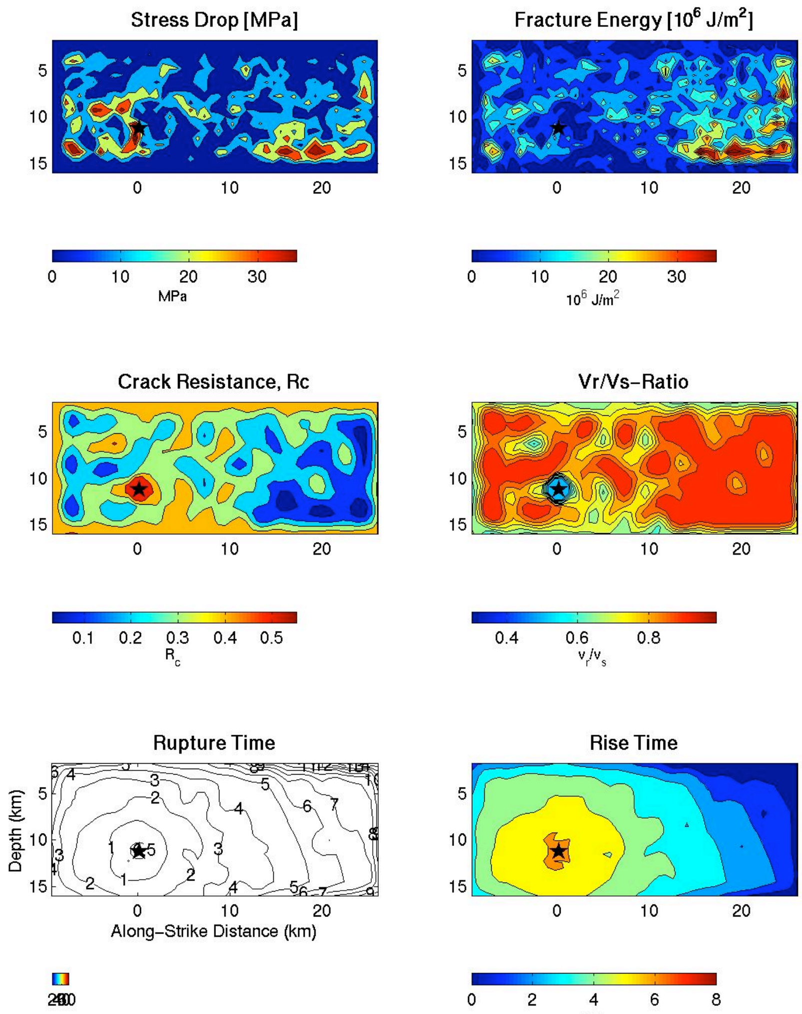

Figure 1: Example representing the pseudo-dynamic procedure [. The starting point is a slip realization generated as a spatial random field [Mai and Beroza, 2002], which yields a corresponding stress drop distribution computed using the method of Andrews [1981] shown in the upper left panel. Upper right panel shows a fracture energy distribution determined in such a way the the average rupture velocity is subshear. The crack resistance (middle left) determines a direct mapping to an approximate local rupture velocity (middle right). Rupture time (lower left) is determined from this and rise time is estimated based on the overall dimensions of the slipped region.