Final Project Summary — PEER Lifelines Program

Project Title—**ID Number**	*Experimental Model for Rupture Directivity Effects*—**1D01**		
Start/End Dates	05/01/00 – 8/30/03	Budget/ Funding Source	$121,877 / Caltrans
Project Leader (boldface) and Other Team Members	**Brune/ Anooshehpoor (UNR)**		

1. Project goals and objectives

Understanding earthquake rupture dynamics, especially forward rupture directivity, is crucial in determining the seismic hazard for critical structures located near major active faults. Numerical models currently in use have too many unconstrained parameters to allow confidence in predictions, and may not even be realistic from a physical point of view. The overall objective of this project is to use foam rubber modeling experiments to provide constraints on parameters that control rupture dynamics, and consequently, forward directivity effects.

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.

This project has the potential for better understanding of the rupture process and ground motion effects in the near field, and validation of simulation methods which can be applied to a wide variety of cases and eventually provide realistic forward simulations for time-history based design. Developing an in-depth understanding of this particular physical (and thus physically realistic) model allows us to greatly improve our understanding of the various modeling parameters involved, and consequently improve our understanding of the true seismic hazard near large active faults.

3. Brief description of the accomplishments of the project

Data from experiments simulating unilateral strike-slip motion agreed well with 3D numerical simulations of the shape, duration, and absolute amplitude of the direct acceleration pulses. Directivity was evident in both peak accelerations and pseudo-spectral accelerations, the amplitude of the fault-normal component of acceleration generally larger than the associated fault-parallel component. Waveforms agree with an empirical directivity model for earthquake strong-motion spectra at long periods. We investigated the effects of shallow weak layer on the near-fault ground motions by introducing plastic strips of different widths on the fault plane, near the surface. Accelerations recorded on or close to the weak layer show significant reduction in amplitudes, even though the total slip is similar to the case without a weak layer (increased slip rise-time). Surface acceleration amplitudes decrease rapidly with increasing depth of the weak layer. We also recorded results from a variety of anti-asperity (weak patch) models.

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

Not aware of any.

5. Methodology employed

The strike-slip model consists of two large blocks of foam rubber, one driven horizontally past another by a hydraulic piston (Fig. 1). As the upper block is forced to slide over the lower block, the strain in the blocks increases until the stress at the interface exceeds the frictional resistance and a stick-slip event occurs over the entire fault plane.

Fig. 1 (left) shows the locations of the sensors. There are 76 recording channels, of which 35 are on the fault plane and 41 on the free surface. Fig 2. (right) shows a stick-slip event recorded on all 76 channels.

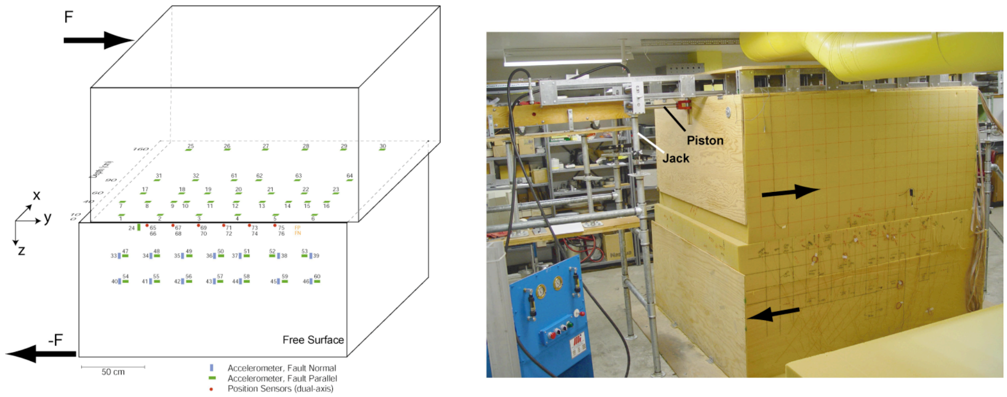

Figure 1: A photograph of the foam rubber model of strike-slip faulting (right) and a diagram showing the type and location of the sensors.

The numbers next to each trace match those in Fig. 1. The first 64 traces are accelerations and the last 12 displacements. Plots on the left side of Fig. 2 show fault-parallel and fault-normal components of ground motions on the surface along two profiles parallel to the fault trace at distances of 25 and 45 cm. Increasing acceleration amplitudes at stations in the rupture direction indicate a strong forward directivity. Note that the fault-normal components are generally larger than the corresponding fault-parallel components.

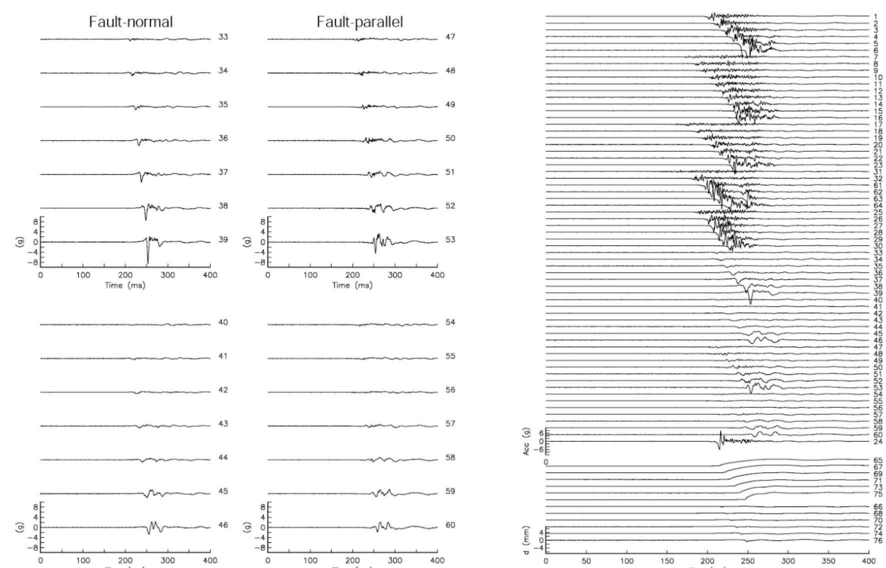

Figure 1

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

There is not similar work outside PEER, but within PEER, data was used for comparison with simulation methods, 1D02 project.

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

Further studies of more complex asperities on the fault and use of a layered model to study rupture dynamics and the resulting strong ground motions.

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

Rasool Anooshehpoor and James N. Brune, Study of Rupture Directivity in a Foam Rubber Physical Model, July 2004.