

Final Project Summary— PEER Lifelines Program

Project Title—ID Number	<i>Calibration of Basin Simulations—1A02/1A02a</i>		
Start/End Dates	10/1/00 – 12/31/02	Budget/ Funding Source	\$200,000 / PG&E/CEC
Project Leader (boldface) and Other Team Members	Jordan/Day (SCEC/SDSU)		

1. Project goals and objectives

Numerical simulations of wave propagation can now be done in three dimensions for models with sufficient realism (e.g., three-dimensional geology, propagating sources, frequencies approaching 1 Hz) to be of engineering interest. However, before numerical simulations can be applied in the context of engineering studies or seismic hazard analysis, the numerical methods and the models associated with them must be thoroughly validated. Task 1A02 focused on the following: (1) Test accuracy of codes in presence of complex earth structure, as represented by the SCEC Reference 3D Seismic Velocity Model (2) Test accuracy and limitations of anelastic attenuation models. (3) Test accuracy of propagating thrust fault source representation. (4) Perform simulations of Northridge earthquake.

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 project provided an essential foundation for simulation-based ground motion estimation in urban sedimentary basins.

3. Brief description of the accomplishments of the project

Six new test problems were designed and carried under Task 1A02. Together, these test simulations complement an additional 4 which were carried out as part of the initial phase of the project (Task 1A01). They document very close agreement among the codes for perfectly elastic problems, and for anelastic problems over the frequency range in which the prescribed Q model is well represented by the respective codes. At the low and high frequency ends of the prescribed frequency band, those methods employing a broadband attenuation scheme agree closely among themselves and with the analytical solution, while significant departures from the analytical solution are evident for other methods.

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

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5. Methodology employed

Five different earthquake ground-motion simulation codes were tested. Of these, four are finite difference (FD), and one is finite element (FE). All of the FD codes use uniform, structured grids, with staggered locations of the velocity and stress components and fourth-order accurate spatial differencing of the elastodynamic equations. The codes were independently programmed. The main variations among them include: degree of computational parallelism, type of memory management (e.g., main-memory contained operation versus roll-in/roll-out from disk), free-

surface boundary condition formulation, absorbing boundary formulation, material interface representation (e.g., type of averaging of material properties in vicinity of properties gradients or interface), and source formulation.

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

The PI and several of the co-PIs conducted related SCEC research, including developmental work on the codes that were the subjects of this validation study.

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

Application of the methods to estimate basin amplification effects on seismic ground motion.

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

Authors: S. M. Day, J. Bielak, D. Dreger, S. Larsen, R. Graves, A. Pitarka, and K. B. Olsen

Title: Tests of 3D Elastodynamic Codes

Date: October 10, 2003

9. Figures

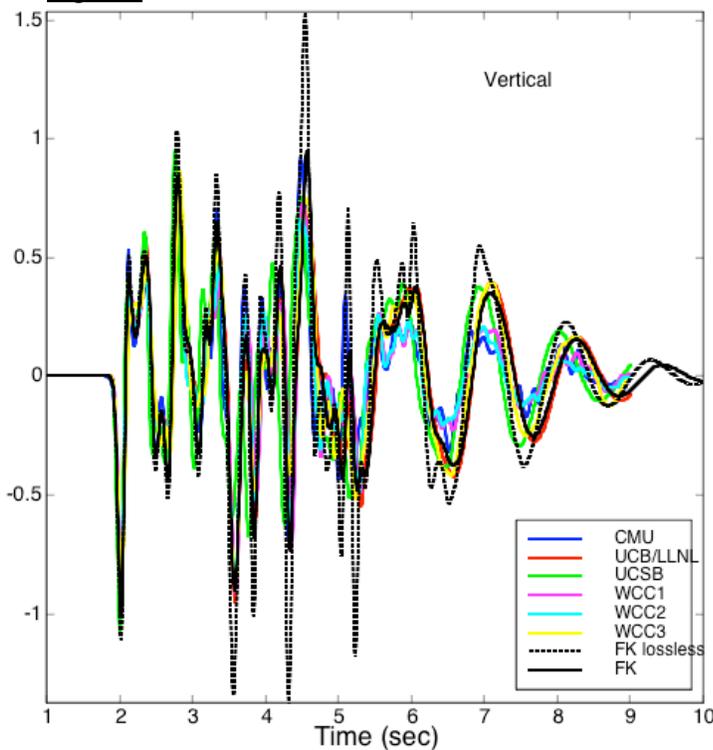


Figure 1. Comparison of FE and various FD codes for point-source problem with anelastic attenuation, showing good level of agreement among methods.

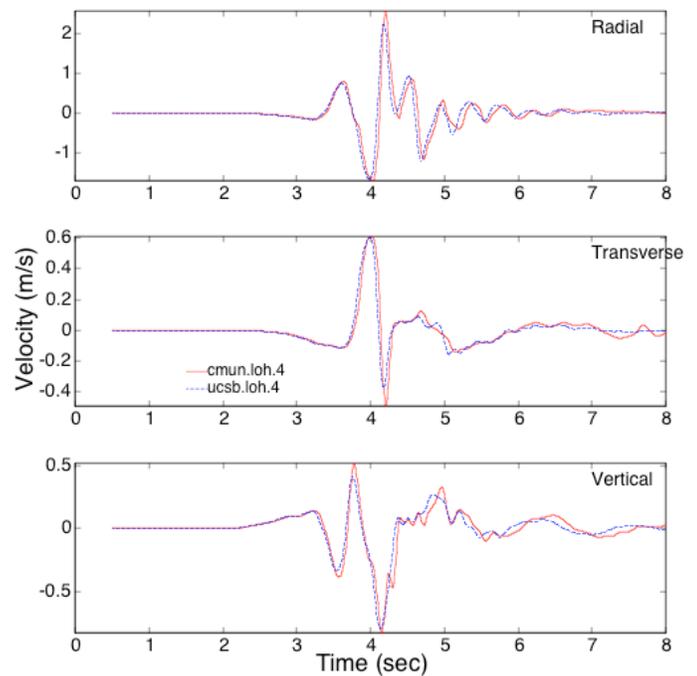


Figure 2. Comparison of FE (red) and FD (blue) solutions for propagating thrust fault source in layer-over-halfspace model.