2004 SCEC PROJECT 04003:
INCORPORATING ONE-DIMENSIONAL NONLINEAR SITE RESPONSE INTO THE SCEC COMMUNITY MODELING ENVIRONMENT

ANNUAL REPORT

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Proposal Category: Integration and Theory
Focus Areas: Ground Motion and Seismic Hazard Analysis

Budget: $ 5,000
Start Date: 1 February 2004
Duration: 12 months

INTRODUCTION

The SCEC Community Modeling Environment (CME) includes Open Seismic Hazard Analysis (OpenSHA), a web-enabled, open-source seismic hazard analysis code that is being developed jointly by USGS and SCEC (www.opensha.org). One of the goals of the OpenSHA project is to develop a computational infrastructure that allows different SHA components to be plugged into an analysis, so that researchers can evaluate the sensitivity of the hazard to alternative models of various components in an SHA. The current structure of OpenSHA is focused on the geological and seismological inputs into an SHA. To open the OpenSHA framework to geotechnical engineers a site-specific geotechnical site response module is needed.

This project is leveraging funds from the USGS-NEHRP Program to develop an OpenSHA module for geotechnical site response that propagates seismic waves through a one-dimensional soil profile using a newly formulated equivalent-linear approach. This new equivalent-linear method is a frequency domain simulation that uses frequency-dependent soil properties (shear modulus and damping ratio). These properties do not represent any real frequency-dependent material behavior, but rather they avoid the overdamping of high frequencies that has been a problem with equivalent-linear analysis at large rock intensities. Recent research has shown that using frequency dependent soil properties in an equivalent-linear site response analysis provides site response results similar to fully nonlinear analysis (e.g., Sugito 1995, Kausel and Assimaki 2002, Yoshida et al. 2002), which makes this analytical procedure a very powerful tool.

In addition to developing this site response module for time domain input motions, the proposed project will also integrate a random vibration theory (RVT)-based procedure. RVT-based ground motion simulations (sometimes called stochastic simulations) require only the specification of the power spectrum and duration of the input motion, rather than a full acceleration-time history. This feature makes RVT-based site response analysis well-suited for probabilistic seismic hazard analysis (PSHA) because it does not require a suite of input motions. As a result, the site response for each possible magnitude and distance pair in a PSHA can be computed and used to develop site-specific soil hazard curves, which can be used in performance-based design.

The funded work is related to the OpenSHA development of the Seismic Hazard Analysis focus group within SCEC. The geotechnical site response module will be one of the first independent modules for OpenSHA, and therefore will require coordination between the University of Texas (UT) and the OpenSHA teams. Dr. Ned Field of the USGS, team leader for the OpenSHA project, supports the development of this module and is coordinating with the UT team.

PROGRESS

The funds from SCEC have been used to coordinate with the SCEC OpenSHA group to incorporate site-specific geotechnical site response into the OpenSHA modeling environment. One-year of research funding was obtained from the US Geological Survey to support the development efforts. The SCEC funding was used for the PI and a graduate student researcher (Cem Ozbey) to travel to the SCEC Annual Meeting in Palm Springs, CA in September 2004. After the Annual Meeting, additional meetings in Los Angeles occurred between Cem Ozbey and the SCEC OpenSHA researchers, to discuss the details regarding the implementation of our independent geotechnical site response model.

REFERENCES

Kausel, E., and Assimaki, D. (2002) "Seismic simulation of inelastic soil via frequency-dependent moduli and damping," *Journal of Engineering Mechanics*, ASCE, **128(1)**, 34-47.

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Yoshida, N., Kobayashi, S., Suetomi, I., and Kinya, M. (2002) "Equivalent linear method considering frequency dependent characteristics of stiffness and damping," Soil Dynamics and Earthquake Engineering, Vol. 22, pp. 205-222.