

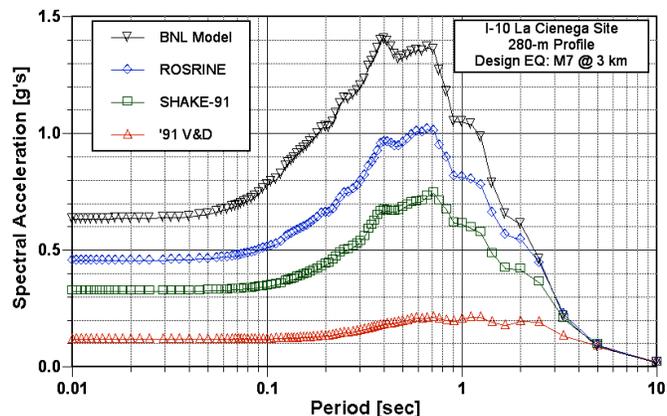
Final Project Summary — PEER Lifelines Program

Project Title—ID Number	<i>Workshop on Uncertainties in Nonlinear Soil Properties and Impact on Modeling Response</i> -- Project 2B03		
Start/End Dates	6/1/00 – 4/30/04	Budget/ Funding Source	\$30,000 / Caltrans
Project Leader (boldface) and Other Team Members	Riemer (UCB) ; committee included E. Rathje, D. Anderson, C. Roblee		

1. Project goals and objectives

This project provided supplemental funding for an NSF Workshop focusing on identification of key sources of uncertainty surrounding the non-linear dynamic properties of soils, and evaluating the role of this uncertainty in the context of other factors in performing Site Response Analysis (SRA).

It is well established that uncertainties exist in nonlinear soil property determination. These uncertainties result from a number of sources, including inherent variations in nonlinear soil properties, soil sample disturbance, equipment testing effects, and in situ stress state/stress history. There are also a variety of soil models in use for predicting site effects, which can lead to substantial variation in predicted motions in some cases (see figure, after Silva).



The primary goals of the project were:

- Evaluation of the levels of uncertainty and bias in nonlinear soil property determination, and the types of testing and modeling that best address this issue.
- A better understanding of the current and future needs for soil modeling, and how these needs are related to the prediction of ground response and soil-structure interaction.
- A consensus between the *Testers* and *Modelers* on the types of development that should occur in each of their respective areas, through improved communication.
- Guidance to funding agencies on areas of research that are likely to achieve the most progress in the overall area of soil response and soil-structure interaction modeling.

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.

High levels of uncertainty in the likely ground motions at the site of any major component of a Lifeline system will necessarily lead to either very conservative (and expensive) design or retrofit of the structure,

or the assumption of considerable risk. Reduction of this uncertainty is complicated by the fact that there are multiple sources contributing, including the inherent variability of the seismic activity, bias and scatter in the evaluation of soil properties, and simplifications in the modeling and analysis used to predict site response. This Workshop brings together experts to begin untangling these various sources, evaluate their relative importance, and propose avenues of research that can best identify and reduce the most important sources of the uncertainty. As the research is performed, and the dominant sources of the uncertainty are better characterized, the ground motions will be predicted with greater confidence, and thus the costs of developing or retrofitting key Lifelines facilities can be reduced.

3. Brief description of the accomplishments of the project

The Workshop itself was held on March 18 and 19, 2004, at the PEER Center in Richmond, and was attended by some 44 participants from around the world, include three from overseas. All participants were required to write “opinion papers” laying out their perspectives on key questions in the field of site response analysis, and were selected based on the relevance of their research or experience in practice, with care taken to provide a balance among experimentalists, constitutive modelers, code developers and practicing engineers.

The products of the Workshop include:

- opinion papers and plenary papers of the individual participants,
- plenary presentations made by the invited speakers on the first day,
- reports made by the eight breakout session groups on the second day,
- summary report synthesizing the discussions and conclusions reached.

These materials will all be available on the project web site (most are already there):

<http://peer.berkeley.edu/lifelines/Workshop304/index.html>

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

As the Workshop was primarily concerned with identifying key issues for quantifying sources of uncertainty and key areas for further research, there are not yet specific cases in practice that have been impacted. However, the inclusion of practicing engineers in the Workshop formed an important “reality check” on the ideas proposed by researchers at the workshop, while also establishing a direct path by which future developments can be incorporated by these individuals in industry.

5. Methodology employed

The organizing committee for the Workshop was active through frequent teleconference calls to identify appropriate speakers and other Workshop participants, develop and revise the agenda to best meet the goals of the Workshop, and prepare the participants through solicitation and posting of preliminary materials on the Project web site.

The first day focused on plenary sessions, with 11 invited presentations covering specific issues within the field of site response analysis. These presentations provided the group with a common background on the current issues from different perspectives, and stimulated excellent plenary discussions on the relative importance of various factors in contributing to accurate site response analysis. The second day was organized around eight “break out” sessions, in which smaller groups of participants met to work out responses to specific questions, including prioritization of future research to most effectively improve

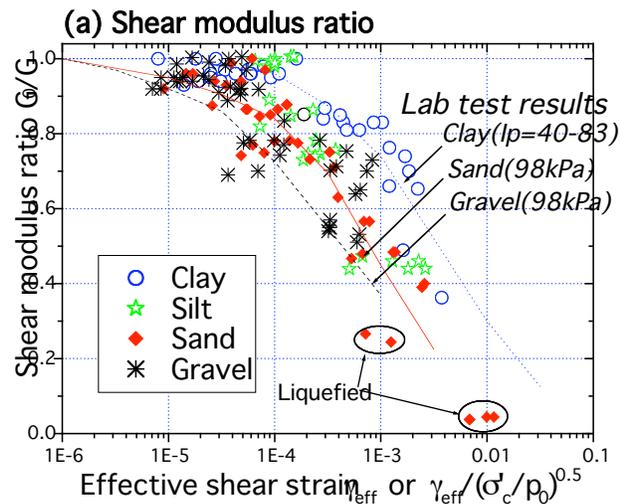
response analysis. The conclusions of each group were summarized individually by the members, and are provided in the Workshop documentation.

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

PEER Lifelines Project 2B01/02 involved extensive testing of high quality soil samples obtained as part of the ROSRINE program in Southern California. As such, it provided direct comparisons of dynamic properties as determined through Resonant Column, Torsional Shear, and Double Specimen Direct Simple Shear testing methods. While this provided some measure of the variability in properties associated with different methods, the current Workshop establishes a framework for evaluating the importance of these variabilities, particularly in comparison with other sources of uncertainty.

Outside of PEER, there is a strong interest in many of the same issues surrounding uncertainty in soil response analysis, particularly in seismically active regions of the world. This emphasizes the importance of developing international consensus on issues such as benchmark cases for validation of models and codes, and including international researchers to participate in database development.

(Kokusho, 2004)



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

One of the primary goals of the program was the identification and prioritization of both short term and longer term research needs. Some of the most pressing needs identified included: quantification of the uncertainty in site response from all sources; characterization of soil response at larger strains (especially for non-linear models and pore pressure softening); rigorous benchmark testing of available non-linear models; calibration of available models with high quality array data and centrifuge data; field methods of measuring stiffness and damping over wide strain ranges, to tie together lab testing with Vs methods; development of a public database of high quality data for calibration of constitutive models; and the need to augment available data on a broader range of soils (eg. silts, gravels and other commonly encountered materials).

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

The final report is not yet completed, but is anticipated in November 2004. The title will be:

International Workshop on uncertainties in nonlinear soil properties and their impact on modeling response