Final Project Summary — PEER Lifelines Program

Project Title—**ID Number**	*Workshop on Uncertainties in Nonlinear Soil Properties and impact on modeling response*—**2B01/2B02**		
Start/End Dates	6/01 – 6/30/04	Budget/ Funding Source	$135,000 / Caltrans
Project Leader (boldface) and Other Team Members	**D.G. Anderson (CH2M HILL), K.H. Stokoe, II (University of Texas at Austin), M. Vucetic (University of California at Los Angeles)**		

1. Project goals and objectives

Evaluate the shear modulus and material damping properties of intact soil samples at small to large shearing strains and from low to high confining pressures.

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 overall benefit from this testing program is to provide additional high quality laboratory test data that can be used to validate existing and develop new soil models which can be used to estimate ground response during seismic events. Additional specific benefits are listed below:

- *The results of these laboratory tests can be used in completing the characterization of sites where in situ shear wave velocities have been collected and where site response calculations are planned as part of a post-Northridge earthquake ground response study; and*
- *Direct comparisons of shear modulus and material damping properties can be made for a limited number of companion specimens tested with DSDSS and RC/TS testing equipment.*

3. Brief description of the accomplishments of the project

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The results of this testing program consist of 15 sets of dual specimen direct simple shear (DSDSS) test results and 25 sets of combined resonant column/torsional shear (RC/TS) test results. Each set of tests includes shear modulus and material damping as a function of shearing strain level. Combined RC/TS results also show effects of confining pressure and testing frequency on modulus and damping.

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

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It is unclear whether these results have been put into use by industry. However, they have been used by Dr. Cliff Roblee, formerly of Caltrans, and by Professor Ken Stokoe, University of Texas, to develop alternate soil models. These models have been presented during an NSF workshop. Participants at the workshop may have used the proposed models in some of their ground response studies.

5. Methodology employed

Tests were conducted using state of the art laboratory testing equipment developed at the University of Texas by Professor Ken Stokoe and his colleagues, and at the University of California at Los Angeles by Professor Vucetic and his Colleagues.

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

This work was conducted within the overall framework of the ROSRINE project. The ROSRINE project involves the evaluation of site response. Others providing support for the ROSRINE project (outside PEER) have included the National Science Foundation, the Electric Power Research Institute, the United States

Geological Survey, the Californian Geological Survey, the Nuclear Power Engineering Corporation (Japan), and the Kajima Corporation of Japan.

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

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Specific recommendations for additional testing were made in the report prepared from this project. These recommendations include the need for a comprehensive evaluation of all ROSRINE information, additional laboratory testing to investigate effects of soil disturbance and uncertainties associated with boundary conditions imposed by current testing methods, in situ testing methods that allowed stiffness and damping to be determined at high shearing strain levels, and further evaluation of the effects of uncertainties on site response.

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

Donald G. Anderson
Laboratory Testing of Nonlinear Soil Properties: I & II
December 2003

Kentaro Tabata and Mladen Vucetic
Results of Cyclic Simple Shear Tests on Fifteen Soils Conducted for PEARL Project and Other Research Purposes
November 2002

Kenneth H. Stokoe, Won Kyoung Choi, Farn-Yuh Menq, and Celestino Valle
Linear and Nonlinear Dynamic Properties Determined by Combined Resonant Column and Torsional Shear Tests
March 2003

The second and third reports listed above are included as appendices to the report prepared by Don Anderson. Vucetic and Stokoe have also published these as UCLA and UT-Austin reports.

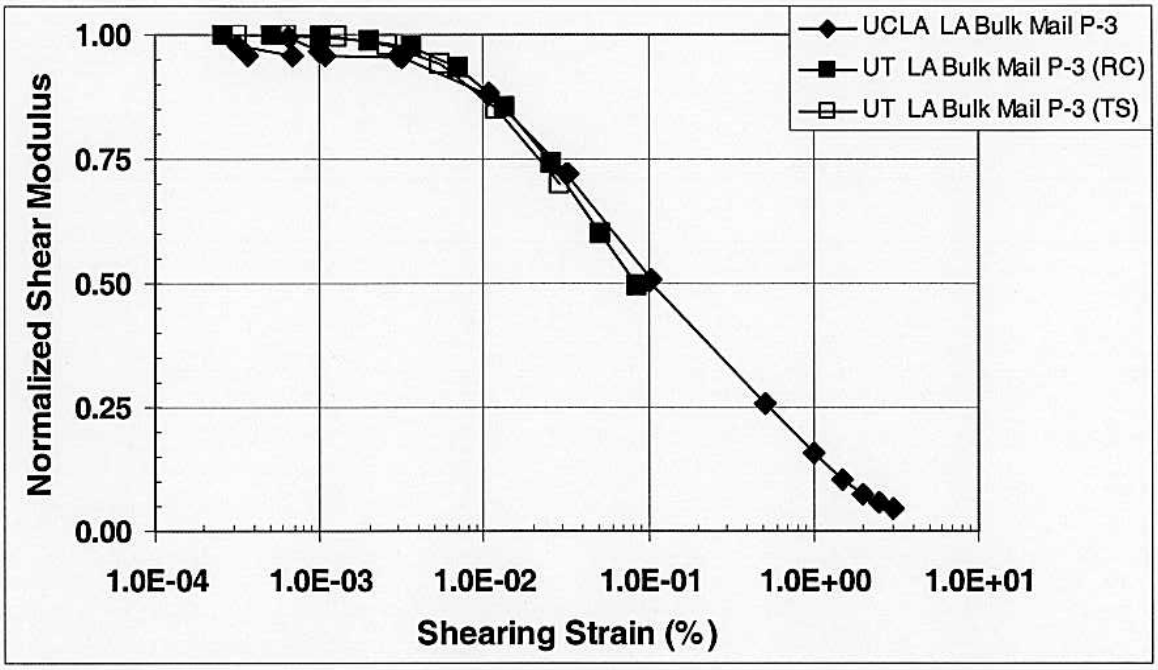

Fig. 3-14 Normalized Shear Modulus Ratio Comparisons (LA Bulk Mail P-3)

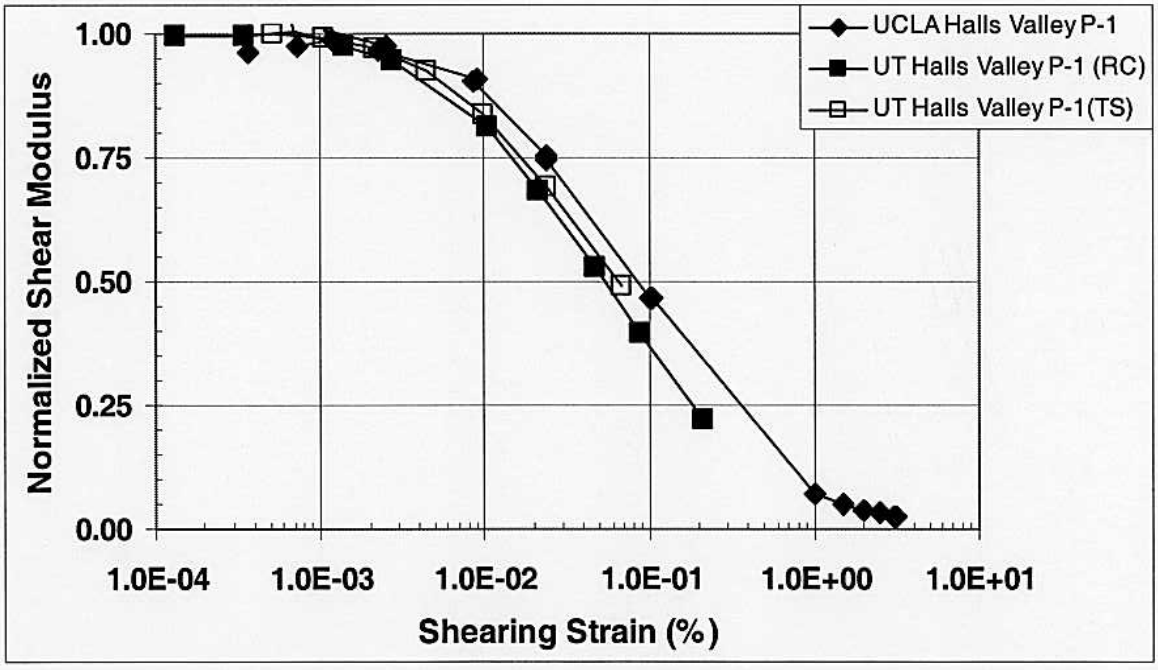

Fig. 3-15 Normalized Shear Modulus Ratio Comparisons (Halls Valley P-1)

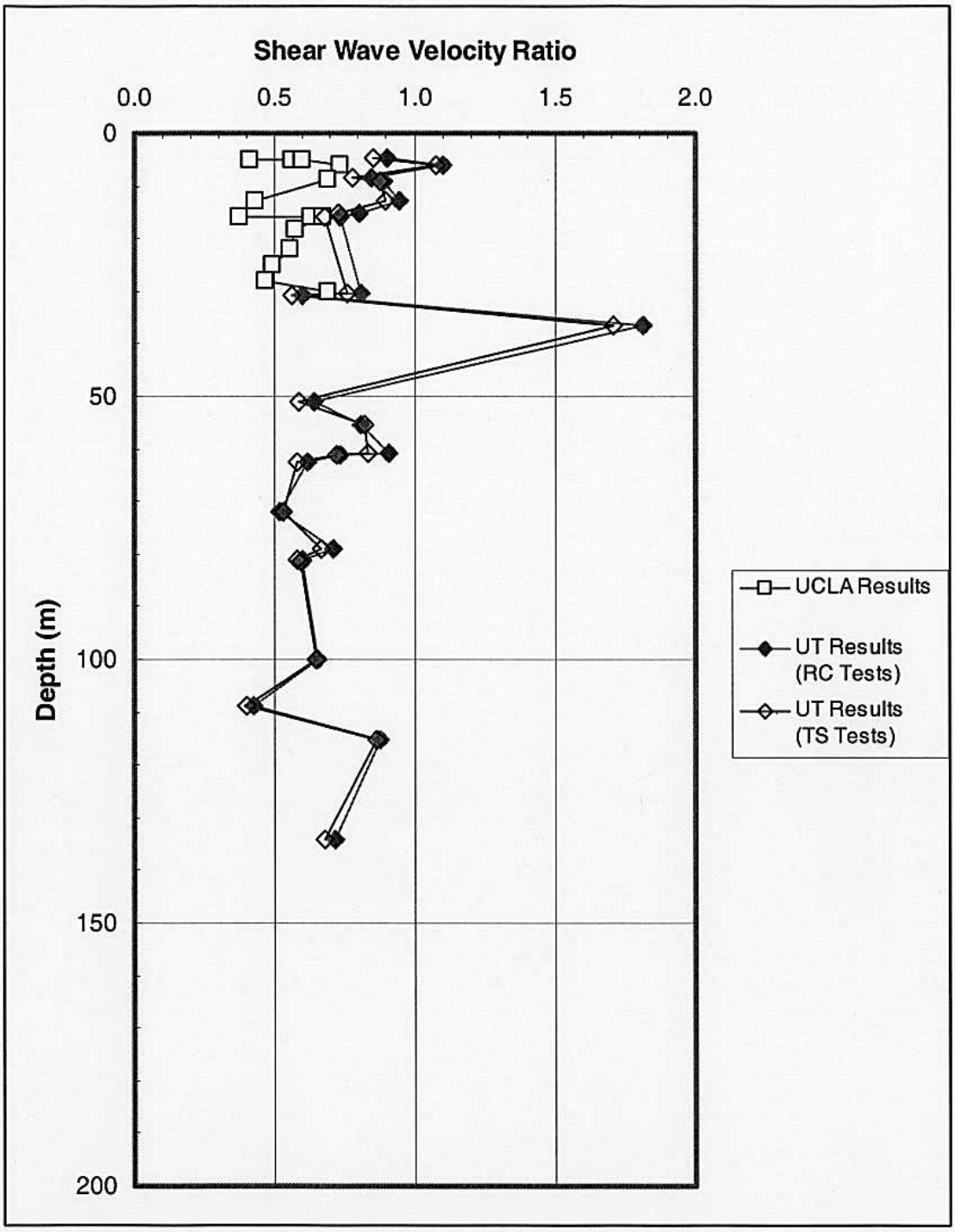

Fig. 3-1 **Comparison of In Situ and UT and UCLA Laboratory Measurements in terms of Velocity Ratio**