Issues related to nonlinear soil behavior and relationship to seismic site response assessment, a position paper

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Introduction

This paper addresses some of the questions that will be discussed in this workshop. The discussion is presented within the context of the proposed breakout sessions

BO#1 View from Practice: Adequacy of Current Design Models: *How are site effects addressed in engineering practice? When are generic versus site-specific soil properties used? What are the limitations of current models?* &
BO#7 Testing Needs for Applied and Advanced Models

The challenges faced by engineering practice in performing site response analysis mirror challenges encountered in using many advanced analysis tools for static as well as dynamic response of geotechnical structures. In general at a given site very limited site specific in situ and laboratory tests are performed. Basic information such as shear wave velocity profiles for deeper layers are often missing. The use of advanced modeling tools is hampered by the lack of sufficient data on soil behavior. Therefore, one resorts to either using generic soil properties or very simple models that do not require much information.

In general development of advanced modeling tools has been unmatched by advances in in situ or laboratory soil characterization. Many available models require information that is difficult to obtain from commonly available laboratory tests. There is a general need for new testing devices and methodologies that are able to provide the complex soil behavior information needed for these advanced modeling tools. In the absence of such devices the use of advanced modeling tools is likely to remain limited to the research realm. Even there it would be limited to few researchers familiar with the development of that specific model.

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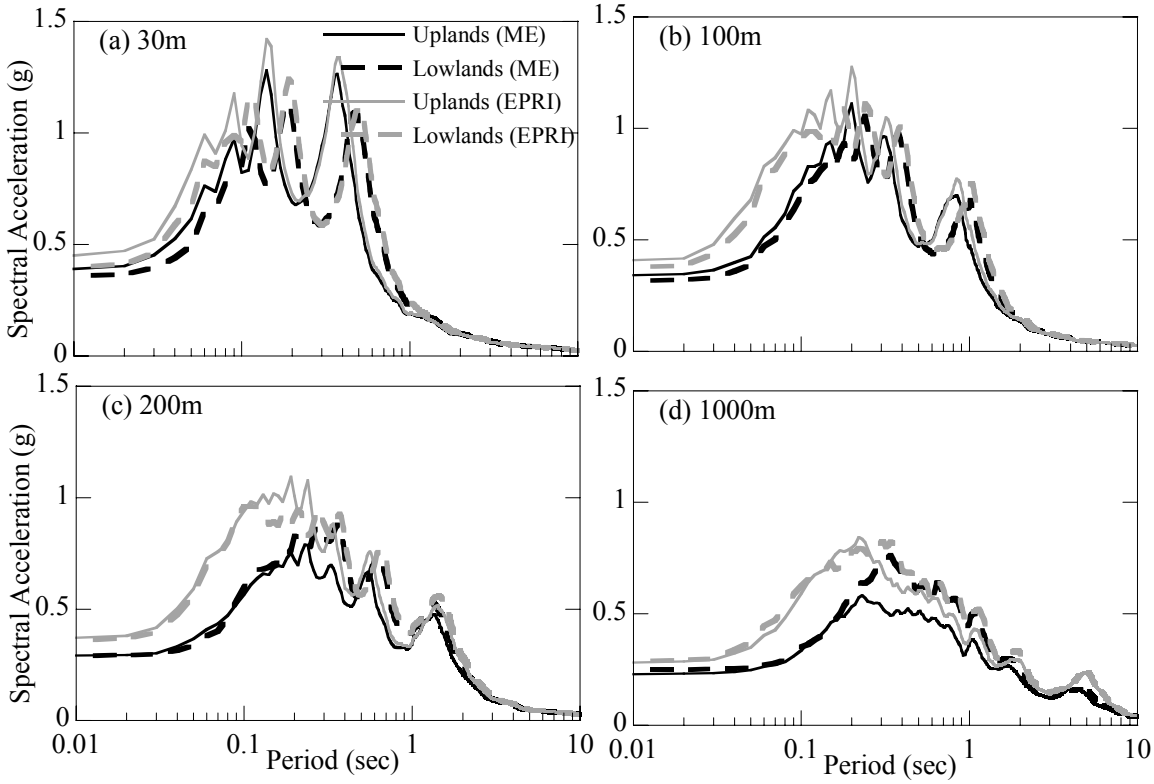
BO#2 Adaptations Needed for Use in Performance-Based Framework. *How can uniform hazard probabilities be maintained in site response analysis?*

Current procedure for including site effects in uniform hazard response spectra such that used in NEHRP does not preserve the probabilistic nature of the spectra. This is a result of using site factors that are derived deterministically.

This issue is partly addressed in a recent doctoral thesis by Park (2003) at the University of Illinois at Urbana-Champaign. A new probabilistic seismic hazard analysis (PSHA) procedure, PSHA-NL, is developed that integrates a conventional PSHA with site response analysis. In the PSHA analysis ground motion time histories instead of ground motion parameters are generated at an equivalent hard rock site. The aggregated ground motion response spectra provide the desired uniform hazard response spectrum. Equivalent linear and nonlinear site response analyses are performed using the individual motions. The computed surface motions are then aggregated to develop a uniform hazard response spectrum. This procedure preserves the probabilistic nature of the analyses while accounting for site effects. The figure below illustrates some of the results obtained for analyses in the Mississippi Embayment in the New Madrid Seismic Zone.



Site response analysis in the Mississippi Embayment. Comparison of UHRS (2% in 50 years) for Site 1 using various combinations of Uplands and Lowlands profiles and ME and EPRI soil properties. *After Park D. Estimation of non-linear seismic site effects for deep deposits of the Mississippi embayment. Ph.D. Thesis, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign. 2003; 311p.*

BO#5 Desired Model Form(s) for New Models *Can self-consistent basic and advanced models be developed?*
BO#8 Incorporating Nonlinear Soil Data into NEES *What NEES experiments would best assist in soil model development?*

A new approach for developing self evolving models from field and experimental data has been proposed and developed by Ghaboussi et. al (1998) and Hashash et. al (2003) This approach takes maximum advantage of available instrumentation to develop material constitutive models that when used in a numerical analysis reproduce observed system response. The material constitutive behavior is unknown apriori. This approach shows significant promise to better integrate experimental results with numerical models. The approach is currently being applied to extraction of soil behavior from vertical array data.

Ghaboussi, J., Pecknold, D. A., Zhang, M., and Haj-Ali, R. (1998). "Autoprogressive training of neural network constitutive models." International Journal for Numerical Methods in Engineering, 42(1), 105-126.

Hashash, Y. M. A., Marulanda, C., Ghaboussi, J., and Jung, S. (2003). "Systematic update of a deep excavation model using field performance data." Computers and Geotechnics, 30, 477-488.