Wednesday, 3/15/2017

9:45–11:15 a.m.

Seismic Parameters 4

Chairs: Adrian Rodriguez-Marek, Virginia Tech; Ashly Cabas-Mijares, Virginia Tech

Topography Effects Are Not Dominated By Ground Surface Geometry: A Site Effects Paradox

Kami Mohammadi and Domniki Asimaki, California Institute of Technology

The material properties and the geometry of near surface soil layers, known as local site conditions, can significantly change the input seismic motion compared to the simple case of homogeneous linear elastic half-space. Our recent studies have shown that the effects of topography coupled to site response can lead to ground motion aggravation larger than the superposition of site and geometry amplification. These soil-topography coupling effects arise from seismic waves trapped in the near surface soil layers, are amplified or deamplified as a consequence of stiffness contrast, and are further modified due to scattering caused by irregular interface and ground surface. In this study, we investigate the coupling effects for 2D idealized convex features through a systematic analysis. The resulting trends, which are presented in the form of dimensionless amplification factors, clearly demonstrate the nonlinear nature of coupling effects, which cannot be predicted by modifying simulations of topography effects on rock by 1D site amplification factors, a posteriori. We then quantify these coupling effects through 3D site-specific analyses at selected strong ground motion stations in California, which yield more realistic amplification patterns (using 1 arc-second DEM extracted surface topographies and measured Vs profile). The results of coupling effects provide a basis as to how it can be incorporated in the proposed design motion of seismic code provisions.

Effect of Sudden Shear Wave Velocity Contrast at Shallow Layer Interfaces on Seismic Site Response for Charleston, S.C.

Md. Ariful H. Bhuiyan, S&ME Inc.; Nadarajah Ravichandran and Ronald D. Andrus, Clemson University; Shimelies Aboye, Tetra Tech

In practice, seismic site response analysis is often conducted with the entire soil profile being divided into a number of sub soil layers and site-specific parameters, such as shear wave velocity (VS), damping and modulus reduction, are assumed to be constant within the extent of each layer. In this study, the effect of large contrast in VS at shallow layer interfaces on the computed surface response is investigated considering the geologic and seismic settings for the Charleston, SC area. The VS profiles with sudden contrast at shallow depth were smoothened systematically using various hypothetical gradients to obtain derived Vs profiles. The computed responses from the original and the derived profiles were then compared. The hypothetical profiles produced lesser shear strains and greater surface accelerations as compared to the corresponding original profiles with significant VS contrast. Therefore, such simplification of VS profiles should be avoided in site response analysis, unless they represent actual geologic conditions.

Site-specific Dynamic Analysis 1-D vs. 2-D

Jianchao Li and Bashar S. Qubain, GeoStructures Inc.

When the subsurface profile at a given site cannot be simplified as horizontal layers or the depth to bedrock varies across the profile, validation of a typical 1-D soil column analysis is desirable in calculating the site-specific response spectrum. This point is illustrated through a detailed analysis of a multi-story building project site underlain by very soft marine clay deposits. The subsurface profile and the corresponding dynamic soil parameters are determined through field exploration, geophysical testing, and laboratory testing. Consequently, a 2-D dynamic finite element analysis is performed to provide insight into the effects of a sloping rock. The results indicate that the short period response across the sloping rock is substantially magnified in the 2-D analysis. The 1-D soil column underestimates the short period amplification factor of the spectral acceleration Fa while the 1-sec period amplification factor Fv generally increases with the thicker soil profile. The boundary effects of a 2-D analysis are also discussed.

Weathered Zone Effects: Central and Eastern North America Site Response

Morgan Eddy, Steele Foundation LLC; Guney Olgun, Adrian Rodriguez-Marek, and Martin Chapman, Virginia Tech

This study quantifies uncertainty in Central and Eastern North America (CENA) Reference Rock (RR), Weathered Zone (WZ), and resulting earthquake ground surface site response predictions. The assumptions used for modeling the WZ have an effect on the predicted ground surface response. Random modeling of the RR and WZ is implemented using a simple Taylor Series expansion. Equivalent linear site response analysis is performed with a synthetically generated motion and includes the site attenuation parameter, kappa (κ), for modeling site damping. Probabilistic site response spectra and ratios of response spectra are presented. This study introduces a simple method for quantifying uncertainty in ground surface response while capturing RR and WZ variability.

Metrics for Comparison of Acceleration Time Histories

Mourad Zeghal and Nithyagopal Goswami, Rensselaer Polytechnic Institute; Majid Manzari, George Washington University; Bruce Kutter, University of California, Davis

A decomposition is used to express the mean squared deviation, quantifying the dissimilarities between time histories of input (or response) quantities of multiple replicas of a soil system centrifuge test, as a unique aggregate of three discrepancy measures associated with shape, phase and frequency-shift. The shape measure quantifies the deviations associated with dissimilarities in form and amplitude. The phase measure estimates the deviations associated with differences in phase angle. The frequency-shift measure quantifies the deviations associated with differences in frequency components. These measures are illustrated using simple synthetic motions and used to assess the discrepancies among six replicas of centrifuge input motion achieved at six different facilities. The conducted analysis shows that the proposed decomposition accurately quantifies the different types of discrepancies between time histories.