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What Spatial Area Influence Seismic Site Response: Insights Gained from Non-invasive Testing and Multi-dimensional Ground Response Analyses at Borehole Array Sites

by

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ABSTRACT

Numerical earthquake wave propagation simulations, known as ground response analyses (GRAs), are commonly performed in an attempt to estimate the site-specific, frequency-dependent amplification of seismic waves (i.e., site effects) as they travel from a reference bedrock condition up through soil layers to the ground surface. The importance of accurately predicting site effects as a means to evaluate design loads for engineering infrastructure projects in seismically active regions cannot be overstated. While one-, two-, and three-dimensional (1D, 2D, and 3D) GRAs have been developed to simulate the complexity of the subsurface and seismic wave propagation patterns, the overwhelming majority of GRAs are presently performed using only 1D simulations of vertically propagating, horizontally polarized shear waves. This is concerning, as recent studies have revealed that, on average, recorded ground motions at more than 50% of borehole array sites are poorly modeled using 1D GRAs. While 2D and 3D GRAs are theoretically plausible, they remain largely inaccessible in research and practice due to a lack of adequate and affordable site characterization methods that can be used to develop 3D subsurface shear wave velocity (Vs) models down to depths required for ground response studies (i.e., engineering bedrock). Furthermore, there is a lack of information about how large of an area influences seismic site response, leaving researchers and practitioners to simply guess about how large their subsurface numerical models should be. This presentation will detail a new geostatistical approach based on horizontal-to-vertical spectral ratio (HVSR or H/V) measurements that can be used for building large and deep pseudo-3D Vs models as a means to rationally account for spatial variability in seismic GRAs. The efficacy of various strategies used to account for spatial variability in 1D, 2D, and 3D GRAs will be discussed in the context of several case histories based on recorded ground motions a borehole array sites.

ABOUT THE SPEAKER

Dr. Cox is a Professor in the Civil and Environmental Engineering Department at Utah State University (USU) and the founding director of the new Utah Earthquake Engineering Center. Prior to joining Utah State, he served on the faculty of The University of Texas for eight years and The University of Arkansas for six years. Dr Cox specializes in issues related to seismic design and in-situ site characterization for major civil infrastructure projects and critical nuclear facilities. His research efforts combine experimental field testing with computational analyses for subsurface imaging purposes and multi-dimensional seismic wave propagation simulations. He has led teams deployed to collect seismic site characterization data at ground motion recording stations, soil liquefaction sites, and structural failures following significant earthquakes in the U.S. and around the world (e.g., Ecuador, Haiti, Japan, New Zealand, Peru, Turkey). Dr Cox is a recipient of the prestigious Faculty Early Career Development (CAREER) award from the U.S. National Science Foundation and the Presidential Early Career Award for Scientist and Engineers (PECASE), which he received in a ceremony at the White House from President Barack Obama. He has authored over 150 peer-reviewed publications and has taught eight different courses at the undergraduate and graduate levels at three different universities.