Full Waveform Inversion in Seismic Site Characterization: Evaluation of Natural Spatial Variability of Subsurface Soil Stiffness

By: Siavash Mahvelati, Joseph T. Coe, and Alireza Kordjazi

Seismic hazard analysis (SHA) provides a quantitative estimate of the level of ground shaking anticipated at a particular site. A critical aspect of a SHA is the determination of the peak ground acceleration (PGA) and design response spectrum. These parameters can highlight whether amplification is expected at a site for a particular seismic event. They also depend significantly on the site-specific in situ dynamic properties of the soils and underlying bedrock. Site characterization to classify these properties is often accomplished by using geophysical methods since they provide a direct assessment of shear stiffness. Surface wave testing methods have been increasingly used for this purpose since their development starting in the 1950's. However, typical surface wave processing implements a wavefield transform that converts the acquired waveforms into a dispersion image. A characteristic dispersion curve is then extracted to represent the site conditions within the spatial extent of the receiver array. The subsequent inversion process matches this field dispersion curve to theoretical curves from forward modeling using idealized models with flat stratigraphy. The wavefield transform and subsequent idealized inversion stratigraphy can prevent an accurate assessment of soil/rock stiffness spatial variability. The goal of this study was to explore the extent to which a full waveform inversion approach that bypasses dispersion processing can better evaluate natural spatial variability of subsurface stiffness and potential site amplification hazards at a site. This was accomplished numerically by modeling wave propagation through a site generated with spatially correlated Gaussian random fields. The results showed that natural stiffness spatial variability can result in the subsequent dispersion image not representing actual conditions beneath the receiver array. Such uncertainty may influence more localized measurements of site behavior, but does not significantly affect global averages such as the average shear wave velocity in the upper 30 meters (V_{S30}).

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