Comparison of Dispersion-Based and Full Waveform Inversion of Surface Waves To Evaluate the Spatial Variability of Liquefaction Triggering

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Liquefaction triggering is typically evaluated based on penetration resistance from methods such as the standard penetration test (SPT) and the cone penetration test (CPT). These methods provide detailed stiffness information at a point-location within a site. However, they cannot effectively account for the spatial variability inherently present in natural soils without implementing multiple measurement locations, which drastically increases costs. Alternatively, shear wave velocity (V_S) liquefaction triggering approaches have the potential for more effective assessment of natural stiffness variability due to the rapid deployment and broader spatial coverage of geophysical arrays used for surface wave testing. Typically, the waveforms acquired from surface wave testing are analyzed within a dispersion-based framework. The raw waveforms are processed using a wavefield transform and a characteristic dispersion curve is extracted that is assumed to represent the conditions at the middle of the array. An inversion process is then implemented that matches the field dispersion curve with a theoretical dispersion curve acquired from forward modeling of an idealized flat-layered model. This process introduces spatial averaging that may render the resulting V_S profile ineffective for liquefaction triggering in spatially variable soils. Recently, there has been increasing interest in full waveform inversion (FWI) of surface waves within the geotechnical community. FWI skips dispersion processing and attempts to directly match the signals acquired at the receivers by numerically modeling the wave propagation through the domain. This paper compares the extent with which spatial variability of liquefaction triggering is accurately evaluated from V_S estimates developed using a dispersion-based and a full waveform inversion (FWI) approach. The spectral element method (SEM) was used with a spatially correlated Gaussian random field generator to model wave propagation through a domain exhibiting appreciable natural soil variability. The results demonstrated that a FWI approach outperforms the typical dispersion-based MASW approach in this application.

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