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Semi-Analytical Method for Simulating Rotational Ground Motion in Two-Dimensional Heterogeneous Elastic Half-Space

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The seismic waves responsible for shaking civil engineering structures undergo interference, focusing, scattering, and diffraction by the inhomogeneous medium encountered along the source-to-site propagation path. The subsurface heterogeneities at a site can particularly alter the local seismic wavefield and amplify the ground rotations, thereby increasing the seismic hazard. However, due to paucity of direct recordings of rotational motions, little research has been done towards characterizing the amplifications of ground rotations in the presence of subsurface heterogeneities. This study aims to quantify these amplifications in the case of a 2-D heterogeneous elastic half-space excited by plane SH waves. A semi-analytical method based on the perturbation theory is developed to obtain the translational and rotational motions in the spectral domain. In this method, the problem of simulating motion in a heterogeneous medium is reduced to calculating the response of a homogeneous medium subjected to body forces representing the heterogeneities. Since the dynamic response of a homogeneous half-space subject to body forces is easier to synthesize, the proposed method is convenient to implement. The method is tested for accuracy by comparing its solution with that of a spectral finite element-based solver. Furthermore, the method is shown to be stable at high frequencies (up to 10 Hz) as well as when the subsurface heterogeneities are strong (~20%). The method is applied to an example 2-D heterogeneous medium to ascertain the amplifications in the ground rotations.