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EVALUATION OF THE IMPEDANCE FUNCTIONS OF RIGID AND FLEXIBLE FOUNDATIONS FOR HETEROGENEOUS SOILS

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The substructure method for the dynamic soil-structure interaction (SSI) analyses, in general, requires an impedance function, which represents the frequency-dependent dynamic reaction of soil media that surrounds/supports the structure. However, present literature on impedance functions is mostly confined to solutions for rigid and regular-shaped foundations resting on (embedded in) homogenous soils. To address this knowledge gap, we describe herein a generalized numerical approach to extract the impedance functions for rigid or flexible foundations with arbitrary geometry embedded in arbitrarily heterogeneous soil media.

We obtain the solution to the (forward) wave propagation problem through the standard finite element method. The Perfectly-Matched-Layers (PML) are employed as the wave absorbing boundary conditions (WABCs) to account for the nominally semi-infinite extent of supporting soil medium. We use a time domain wave solver to compute the impedance functions. That is, we first compute the soil reactions on the foundation boundary initiated by a known displacement pulse signal that has a broad frequency spectrum. Then, by using the Fourier transform, we arrive at the time-harmonic wave solution and compute the impedance function. In particular, for a flexible foundation, we propose to obtain a reduced-order impedance function matrix, of which basis vectors are comprised of mode shapes of the flexible foundation.

We verified this method by comparing its results against impedance functions of various rigid surface and embedded foundations for which there are readily available analytical solutions. We also explored the best excitation signal type to extract the impedance functions and the effects of the proximity of PML to the foundation boundary on accuracy. The numerical experiments show that our proposed modal expression of the impedance function of a flexible foundation significantly reduces the computational cost of dynamic soil-structure interaction analyses with controllable accuracy.