Updated Simplified Equations for Estimating Kinematic Soil-Structure Interaction Effects in Nuclear Power Plants

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A commonly used practice to evaluate the extent of soil-structure interaction (SSI) effects in structures is the substructure method which suggests two phenomena, namely kinematic and inertial effects mainly control the motion at the foundation level (FM). The kinematic SSI effects consider the impact of stiffness of a massless foundation on the deviation of the FM from free-field level motion (FFM), and the inertial SSI effects represent the impact of the structure's inertia on the further modification of the FM compared to the FFM. It is worth noting that as a result of reductions in FM relative to FFM, the incorporation of kinematic SSI effects into engineering design has been an appealing practice. The current state of practice in assessing the kinematic SSI effects is based on available simplified methods in design guidelines such as ASCE/SEI 41-17, which have been developed for regular buildings with limited foundation sizes that are embedded at shallow depths. This aspect limits their applications toward seismic assessment of nuclear facilities as the nuclear energy-related structures typically feature large-sized and deeply embedded foundations.

The objective of this research was to propose an update to the current simplified code-based formulations in ASCE/SEI 41-17 for estimating kinematic SSI effects for applications to structures with large and deeply embedded foundations.

The proposed sets of equations have been empirically calibrated using a comprehensive dataset of recorded earthquake motions at five instrumented nuclear power plant sites in Japan, comprising 37 instrumented structures and adjacent geotechnical downhole arrays. The recorded data were used to quantify kinematic effects in terms of the ratio of response spectra (*RRS*) between the FM and FFM.

This presentation discusses the updated equations by comparing them to the results obtained based on ASCE/SEI 41-17 equations and the differences are quantified using residuals.

The results clearly illustrate that the use of ASCE/SEI 41-17 equations can result in higher FM in nuclear energy-related structures, hence are conservative. However, the proposed equations in this study would yield a more accurate estimate of FM in this type of structure.

The presentation concludes with reviewing some of the key highlights of the updated equations, although still being limited to the horizontal translational motions; discusses potential introductions in ASCE 4-16, and provides examples of future experimental research directions in the area of kinematic SSI.