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Numerical Simulations and Validation of a Rocking Foundation Model for Seismic Loading

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Abstract

The objective of this study is to develop a numerical model for rocking shallow foundations supporting shear wall and bridge pier structures and to validate the numerical model using centrifuge experimental results. OpenSees finite element framework was used to build the numerical model, where a Contact Interface Model (CIM) was used to model the rocking behaviour of soil-foundation system and the structural components were modelled using elastic beam-column elements. The numerical model was first developed using soil properties obtained from theoretical and empirical relationships and validated using the cyclic moment-rotation results of foundations obtained from centrifuge experiments. The numerical model was then used to calculate seismic energy dissipation in soil during rocking, peak rotation of foundation during shaking, and tipping-over stability ratio of rocking systems for the same base accelerations of earthquake motions used in centrifuge experiments. Numerical model predictions for seismic energy dissipation of rocking foundations as a function of Arias intensity of the earthquake motion and peak rotation of rocking foundation as a function of peak ground acceleration of the earthquake motion compare reasonably well with the corresponding experimental results (with mean absolute percentage errors of 0.5 to 0.6). For 24 out of 26 centrifuge experiments considered, the tipping over stability ratio obtained from both the numerical simulations and experimental results vary between 0.85 and 1.0, demonstrating (i) the excellent stability of rocking systems against tipping over failure and (ii) the numerical model's ability to capture the tipping over stability of rocking systems.

Keywords: Rocking foundation, Contact interface model, Seismic energy dissipation, Peak rotation, Tipping-over stability