The near-field method for soil-structure interaction analysis of building structures resting on shallow foundations

Abstract

Investigations after some historical earthquakes have shown that the geotechnical factors can strongly affect the response of the structures and damage rate during strong ground shakings. The available methods to model the foundation and underlying soil can be classified in two main categories: substructure and direct methods. The direct method has some serious limitations. Using the Equivalent Linear Method (ELM) is an effective approach to simplify the direct method and enhance its efficiency and applicability. Since this method is only applicable for strain levels under approximately one percent, using the equivalent linear properties in the near-field region, where the strain level may be greater than one percent, will not result in accurate results and it is the serious limitation of the ELM. This research proposes new modulus degradation and damping augmentation curves for using in the near-field zone in order to obtain more accurate results with the equivalent linear method. To attain this goal, a set of dimensionless parameters representing the relative properties of structure and soil including the stiffness ratio ($\bar{s}$), the slenderness ratio ($\bar{h}$) and the mass ratio ($\bar{m}$) were selected and a comprehensive parametric study was carried out to determine the near-field zone dimensions and dynamic properties. Then, semi-analytical relations were proposed as functions of the dimensionless parameters to calculate the near-field properties. After that, two sets of 3D examples were considered to evaluate the validity and performance of the near-field method. The first set of examples includes applying certain SSI models to an existing building and comparing with actual observed responses. In the second set of examples, a parametric study was performed with evaluating the nonlinear seismic response of five, ten, fifteen and twenty story moment-resisting frame steel buildings. Two site conditions along with different SSI modeling techniques were considered for this part of study. It should be noted that a nonlinear Winkler model developed by El Ganainy and El Naggar was also applied for both sets of examples to compare performance of the near-field method with another new SSI modeling technique. The results show that the near-field method is a simple yet accurate enough approach for analysis of direct SSI problems and can significantly reduce computational cost.

Key Words: soil-structure interaction, near-field method, shear modulus, damping