Presentation of the Near Field Method and Semi-Analytical Models for Analysis of Soil-Structure Interaction and the Maximum Responses of Adjacent Structures during Earthquakes

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Abstract

In design of low rise structures the effects of soil-structure interaction are often ignored. However, these effects are considerable for heavy structures such as skyscrapers or multi-level highway structures. The existence of this interaction phenomenon can also be extended to the adjacent buildings. For example, in an area congested with many nearby tall buildings, to account for the proximity effects of adjacent buildings will become critical. Previous few studies conducted in this area, were limited to 2D finite element plain-strain models. While assuming plain-strain for foundation soil may be valid, for a building structure with limited dimensions in plan this assumption could be erroneous.

In this thesis, the effects of soil-structure interaction and structural adjacency on the response of structures are studied. Also, a simple and effective method for soil modeling in the analysis of soil-structure interaction and adjacent structures is presented. 3D models of 5, 10, 15 and 30 Story building structures on strip, matt and group piles are used. The foundation soils are assumed to be 25 m layered sand and 45 m layered clay. The site classification for both of these soils is type III (corresponding to the Iranian Code of Practice for Seismic Resistant Design of Buildings). Dynamic analyses are performed under seven horizontal components of actual earthquakes.

For structural modeling, beam element is used for frames and piles. Shell elements are used for rigid diaphragm and pile caps. Solid 3D element with 8 nodes is selected for direct finite element modeling of soils. Structural elements are assumed to behave linearly in general and nonlinearly in critical cases. To account for soil nonlinearities, the equivalent linear approach is assumed for soil behaviour. This method is effective, fast and sufficiently accurate for analysis of large scale soil media. Also, in critical states, plastic modeling is done for the near field soil. Results show that the soil-structure interaction (SSI) increases the lateral displacement response of moderate, tall and very tall structures (up to 24% in roof and 98% in first Story of structures), and decreases the lateral displacement of short structures (12% in average). For shear force responses of structures in stories, SSI decreases the response in all cases (up to 30% in the first Story and 50% in roof levels). In structural adjacency cases, results show that the adjacency increases the lateral displacements of stories (up to 80% in first Story for shorter structure and 30% in first Story for taller structure) and decreases the shear forces of stories (up to 75% in roof for shorter structure and 20% in roof for taller structure). It is expected that for two adjacent structures, as they are closer, the interaction response of the structures is higher, and for deep site cases the variation of response of the structures are more extensive. Finally, for presentation of applicable and useful results from this study, several semi-analytical formulations are developed.

Keywords:

Soil-Structure Interaction, Structural Adjacency, Equivalent Linear Method, Near Field Method, Story Lateral Displacement, Story Shear Force.