SEISMIC STRUCTURAL RESPONSE OF STEEL FRAMES CONSIDERING SOIL-FOUNDATION-STRUCTURE INTERACTION

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Prescribed response spectra have been proposed by seismic design codes to consider the effect of both soil and superstructure parameters as well as the seismic zone in evaluating the earthquake equivalent static force. The codes also take into account Soil-Foundation-Structure Interaction (SFSI) by modifying the natural period and associated damping of the corresponding Fixed-Based (FB) system. Although it is believed that considering SFSI is beneficial and can cause reduction in the response of structures, such belief should be supported by several comprehensive investigations to be considered diversely valid for various structures and soils.

Through last decades several studies have been conducted to survey the effect of SFSI on the structural response. Moghaddasi et al. (2011a, 2011b) investigated the influence of foundation flexibility on the structural seismic response. Using robust Monte-Carlo simulation, the authors addressed uncertainties in ground motion characteristic as well as structural systems. Performing two-dimensional plane strain finite element seismic SFSI analyses, the influence of different subsoils (dense and loose sand), buildings height, and the frequency content of the earthquake have been investigated on amplification, acceleration response and stress propagation on the soil-foundation interface (Matinmanesh and Asheghabadi, 2011). Torabi and Rayhani (2014) studied nonlinear foundation–soil coupled response under seismic loadings for a soft clay soil using finite element method. In addition, some investigations have been performed to illustrate the effect of superstructure, foundation and soil by allowing the rocking of baseplate/foundation that can be used in seismic response improvement of steel structures (Nouri et al., 2016; Vetr et al., 2016, 2012).

In the present paper, the response of a three-dimensional moment-resisting steel frame which is subjected to three devastating earthquake applied in the similar investigations (Nouri et al., 2017) has been studied numerically. The soil under foundation is modeled adopting "Cone Model" developed for foundation dynamics (Wolf, 1998). The soil model properties for different ground types is shown in Table 1 according to the Iranian Standard No. 2800, 4th edition (BHRC, 2014).

Table 1. Soil material properties (beneath the foundation).

Type	Description	Density (kg/m^3)	Shear Wave Velocity (m/sec)
I	Rock	2700	900
II	Very dense sand or gravel	2100	500
III	Moderately dense sand or gravel	1800	250
IV	Loose sand	1200	30

The frame's base shears have been compared for both SFSI and FB models subjected to Tabas earthquake (longitudinal component), in the case of loose sand, i.e. type IV in Table 1, as shown in Figure 1.

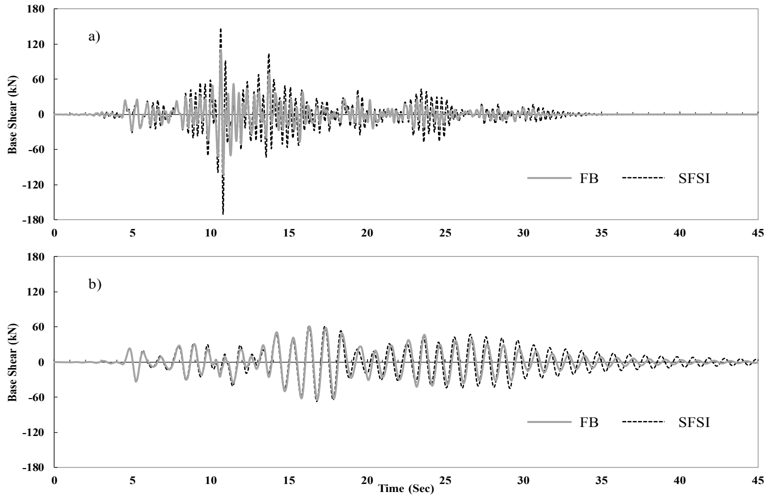

Figure 1. Base shear of three-dimensional frame on the loose sand (type IV) subjected to Tabas earthquake and longitudinal component, a) X-Direction, b) Y-Direction.

As indicated in Figure 1, the stiffness of three-dimensional frame in X-Direction is greater than Y-Direction. It is found that the Cone Model utilized for considering SFSI predicts results which have good agreement with corresponding ones with fixed base when the structure lies on type I soil. In general, taking into account SFSI can cause smaller response of a structure, and, the greater the frame's stiffness, the more decrease in structure's response.

REFERENCES

BHRC (2014). *Iranian Code of Practice for Seismic Resistant Design of Buildings* (Building Housing Research Center).

Matinmanesh, H. and Asheghabadi, M.S. (2011). Seismic analysis on soil-structure interaction of buildings over sandy soil. *Procedia Engineering*, *14*, 1737-43.

Moghaddasi, M., Cubrinovski, M., Chase, J.G., Pampanin, S., and Carr, A. (2011a). Effects of soil–foundation–structure interaction on seismic structural response via robust Monte Carlo simulation. *Engineering Structures*, *33*, 1338-47.

Moghaddasi, M., Cubrinovski, M., Chase, J.G., Pampanin, S., and Carr, A. (2011b). Probabilistic evaluation of soil–foundation–structure interaction effects on seismic structural response. *Earthquake Engineering & Structural Dynamics*, *40*, 135-54.

Riahi Nouri, A., Anastasopoulos, I., Vetr, M.G., and Kalantari, A. (2016). Efficiency of low-rise steel rocking frames founded on conventional and rocking foundations. *Soil Dynamics and Earthquake Engineering*, *84*, 190-203.

Riahi Nouri, A., Vetr, M.G., and Rohani Hajiagha, A. (2017). Effect of weak layer on seismic stability of anchor-reinforced slopes. *Journal of Seismology & Earthquake Engineering*, 19.

Torabi, H. and Rayhani, M.T. (2014). Three dimensional finite element modeling of seismic soil–structure interaction in soft soil. *Computers and Geotechnics*, 60, 9-19.

Vetr, M.G., Riahi Nouri, A., and Kalantari, A. (2012). Efficient application of rocking motion in design of steel structures. *15 WCEE*, Lisbon.

Vetr, M.G., Riahi Nouri, A., and Kalantari, A. (2016). Seismic evaluation of rocking structures through performance assessment and fragility analysis. *Earthquake Engineering and Engineering Vibration*, 15, 115-27.

Wolf, J.P. (1998). Simple physical models for foundation dynamics. *Developments in Geotechnical Engineering* (Elsevier).