CONTRIBUTION OF SOIL MATERIAL DAMPING TO THE DEMANDS OF SOIL- MDOF STRUCTURE SYSTEMS

Ehsan AHMADI
PhD Student, Monash University, Melbourne, Australia
ehsan.ahmadi@monash.edu

Mahsa HOSSEINI
Amirkabir University of Technology, Tehran, Iran
Mahsa_hosseini@aut.ac.ir

Faramarz KHOSHNOUDIAN
Associate Professor, Amirkabir University of Technology, Tehran, Iran
Khoshnud@aut.ac.ir

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In this paper, the role of soil material damping in the seismic response of soil-structure systems is investigated subjected to 59 ground motions. For this purpose, the superstructure is modeled as a nonlinear multi-degree-of-freedom shear building. The beneath soil is simulated based on the cone model concept (Meek and Wolf, 1993; Wolf and Deeks, 2004). The 3-, 10-, 15- and 25-story models are considered as low- and high-rise buildings, respectively. Two values of 0 and 0.25 are assigned to soil material damping in order to show how soil material damping affects the responses. A comprehensive parametric study is carried out and effects of various parameters such as non-dimensional frequency, structural nonlinearity, and number of stories on the contribution of soil material damping to the structural responses are detected.

The superstructure model is based on the structural modeling explained by FEMA 440. On the basis of FEMA 440 (chapter 2), in some cases (e.g. shear beam or strong beam-to-weak column frames), engineers can simplify complex structural models into equivalent MDOF models which are called stick models. Herein, the stick model of shear beam is used. Consider an n-story shear building as shown in Figure 1, supported by swaying and rocking springs and corresponding dashpots. m_i and I_i stand for the mass and the mass moment of inertia around its geometric center in the i^{th} story, respectively. The story height and the effective load (dead as well as live load) are taken 3.3 m and 1_0 kN/m^2 as for the conventional buildings. Also, lateral stiffness and yielding strength over the structure height are distributed nonuniformly to account for higher-mode effects. To this end, the vertical distribution factor is computed as suggested by ASCE/SEI 7-10 standard.

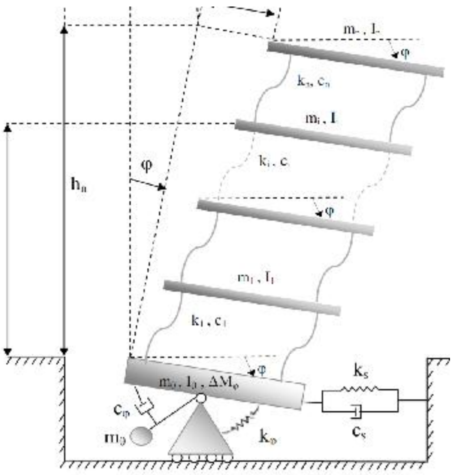

Figure 1. Soil-MDOF structure model

In order to investigate the effects of soil material damping on various seismic demands of the soil-MDOF structure systems, an extensive assembly of records is required. A suit of 59 far-fault records with their corresponding characteristics provided by peer strong database motion is presented in Seylabi et al. (2012). This ground motion ensemble includes earthquakes with moment magnitude (M_s) ranged from 5.8 to 7.5. It is intended to elucidate the contribution of soil material damping to seismic analysis of soil-structure systems. To this end, variations of some engineering demand parameters (EDPs) are examined in order to reflect the role of material damping in these seismic responses. In this study, the assessed EDPs are divided into two groups of displacement and force demands and are completely explained in the following. To quantify the material damping effects on a desired EDP, corresponding relative reduction percentages (E) are computed, i.e., difference between responses of the systems with radiation damping only and radiation as well as material damping divided by the response of systems with radiation damping only.

For example, Figure 2 illustrates $E_{\theta r}$ (roof drift angle (θ_r)) versus story numbers for soil-structure systems with various values of a_0. As it was noted previously, a_0 is the single most important parameter which controls the significance of inertial SSI effects. It can be seen that as a_0 parameter increases, the effects of material damping increase.

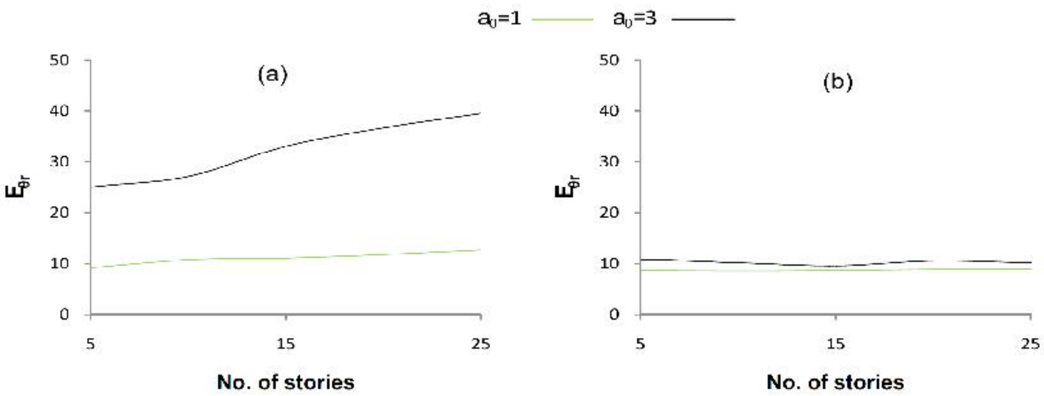

Figure 2. $E_{\theta r}$ values versus number of stories for soil-structure systems with μ=8 for (a) h_n/r=4 (b) h_n/r=1

The results confirm that soil material damping should be taken into seismic analysis of soil-structure systems when the superstructure becomes slender. Moreover, as the nonlinearity in the superstructure increases, importance of soil material damping effect on the responses increases. Case of increasing story number or fixed-base period of the building also requires more attention to the incorporation of the soil material damping to the analysis. Generally, effects of soil material damping on displacement demands are more pronounced than force demands. Furthermore, roof displacement is impressed by soil material damping more than maximum story drift angle.

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