Determination of design spectra considering soil structure interaction

Abstract

In dynamic analysis and design of structures in general, it is assumed that the soil under the foundation is rigid and the effect of soil-structure interaction is neglected. Seismic design spectra of building codes have also calculated with the same assumption. Soil-structure interaction changes the dynamic response of a structure and can have a positive or negative effect on the performance of structures. In this study the effect of soil-structure interaction on the average response spectrum is calculated using the substructure method. The equations of motion of structures resting on flexible soils are derived and decomposed into its modal components as an extension of the classical modal analysis. For non-classical analysis, the system is assumed to be a shear building having a single horizontal degree of freedom (DOF) at each floor. It is then shown that this assumption has only minimal effects on the response spectra. In addition, it is supposed that the supporting medium possesses a horizontal as well as a rotational DOF, and the input motion in the presence of structure is assumed to be identical to the free-field motion. To solve the eigenvalue problem of the soil-structure system, the state vector method is used. Also, by using the Veletsos & Ventura method the complex-valued equations are converted to their real counterparts. Three cases are considered: fixed-base buildings with classical analysis, flexible-base buildings with classical and non-classical analysis. For the purposes of this study, special steel moment frame structures being ١, ٢, ٤, ٦, ..., ١٨ and ٢٠ story buildings, two types of soils, and several suits of ground motions each containing ١٠ earthquake records especially selected for each building, are considered. The seismic responses are calculated using classical and non-classical time history and spectrum modal analysis using Matlab and SAP٢٠٠٠ softwares. Maxima of base shear, roof displacement and story drifts are provided. Cases for which the base flexibility should be considered for the higher modes too are distinguished. It is also made clear that on each soil type, when the true non-classical nature of the SSI system must be accounted for. Based on the above analysis, correction factors are presented that easily convert the rigid-base responses to their actual flexible base counterparts including nonclassical behavior of the soil-structure system.

Keywords: Soil-structure interaction, classical and non-classical modal analysis, fundamental period, correction factor.