Effect of soil structure interaction on the distribution of seismic vulnerability in RC structures with shear wall and moment frames

Abstract

The seismic vulnerability of buildings is usually studied regardless of soil-structure interaction (SSI). Consideration of SSI can enhance the structural analysis and result in endorsement of behavior change of structures and their responses under seismic excitations due to flexibility of soil. A number of methods are introduced in seismic codes for taking SSI into account in order to predict the real performance of structures in earthquakes. There are different methods of soil-structure interaction modeling, such as direct analysis and sub-structuring technique. The direct method considers the structure and an extensive volume of soil in a general model, while the sub-structure method simulates the effect of soil using springs and dampers. In this study, a sub-structure method, named beam on nonlinear Winkler foundation (BNWF) that is quite accurate and fast to analyze, was implemented to assess the SSI effects. The seismic vulnerability of ۳, ۵, ۶, ۸ and ۹ story buildings having moment frames both ways in one case and moment frames with concrete shear walls in another, located on the soil types III and IV that are medium and soft soils according to the ۲۸۰۰ Standard, were discussed. In the first step, buildings were designed and modeled using ETABS, conforming to the ۲۸۰۰ and ACI ۳۱۸-۰۵ codes. Buildings were analyzed using Opensees to assess their nonlinear responses. The concentrated hinge method was used in nonlinear modeling of beam and column elements. Also, the fiber method was applied for modeling of shear walls. Maximum rotation of each plastic hinge was calculated using non-linear dynamic analysis in two cases, considering and neglecting soil-structure interaction. Damage to structural elements was assessed by determination of their performance level, using FEMA ۳۵۶. Changes in vulnerability, regarding soil-structure interaction were evaluated. As a result, this study indicates that considering soil-structure interaction changes the damage extent of different elements differently. Taking SSI into account generally results in an increased damage to beams that are directly connected to the shear walls but reduces damage in moment frames in most cases. Finally, by comparing both cases, it is highlighted that consideration of soil-structure interaction transmits the maximum story drift from the middle floors to the first floor in moment frame buildings.

Key words:
Soil-structure interaction, seismic vulnerability, RC structures, nonlinear dynamic analysis.