EFFECTS OF SOIL-STRUCTURE INTRACTION ON THE SEISMIC RESPONSE OF EXISTING BRACED STEEL FRAMES

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Recent researches in analyses of the characterizations of local sites effects on strong shaking have led to significant advances in both code-based and more advanced procedures for evaluating seismic demand for structural design. A missing part is soil-structure interaction (SSI) effects on both the strong motions transmitted to structures and the structural response to these excitations.

The term Soil-Structure Interaction is used to describing the effect of Soil-structure interaction on the collective response of a structure under strong ground motions (Arefi, 2008; NIST, 2012).

Responses of a structure under strong ground motions is affected by interaction of some linked and continued systems such as the structure, the foundation, the soil underlying and surrounding the foundation. Mexico City, (1985) and many recent earthquakes illustrate the importance of soil properties on the seismic response of structures. These excitations demonstrated that the rock motions could be amplified at the base of a structure. If a lightweight flexible structure is built on a very stiff rock foundation, a probable assumption is that the input motions at the base of the structure are the same as the free-field earthquake motion. This assumption is logical for a large number of building systems since most building type structures are approximately 90 percent voids, and it is not unusual that the weight of the structure is excavated before the structure is built. However, if the structure is very massive, such as a concrete gravity dam or a foundation is relatively soft, the motion at the base of the structure may be significantly different than the free-field surface motion (Lussou, 2000).

Performance evaluation and design of civil facilities against earthquakes is a challenge to engineers because of the large uncertainty in the seismic forces and the system capacity to withstand these forces against damage and collapse (FEMA 2009; ASCE 41-06).

Methods that can be used to evaluate the effects of SSI can be categorized as direct and substructure approaches. In a direct analysis, the soil and structure are included within the same model and analyzed as a complete system. In a substructure approach, the SSI problem is partitioned into distinct parts that are combined to formulate the complete solution.

This paper presents results of a study aimed at evaluating the effects of SSI on braced steel frames. For this purpose, the direct analysis method was considered for evaluating the effects of SSI on steel braced frames. In this procedure the soil, the structure and the foundation were modeled with suitable elements in OpenSees software, an open-source finite element platform, developed at the University of California-Berkeley for earthquake performance assessment.

As schematically, the procedure of modeling is depicted in Figure 1, the soil is often represented as a continuum (e.g., finite elements) along with foundation and structural elements, transmitting boundaries at the limits of the soil mesh, and interface elements at the edges of the foundation.

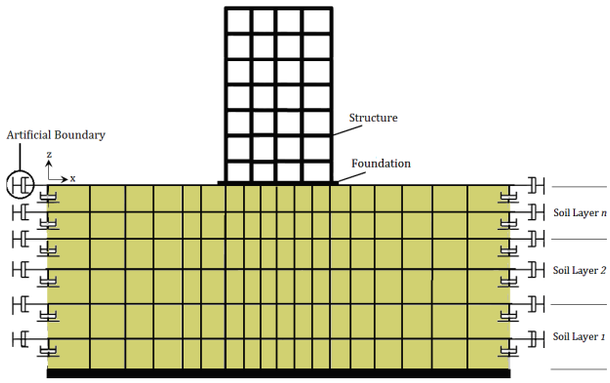

Figure1. The schematic illustration of the direct analysis of soil-structure interaction

In order to evaluate the elastic and inelastic structural response of regular mid-rise building frames under the influence of soil-structure interaction, two types of mid-rise braced 2D frames, including 3 and 15 story braced buildings are considered in conjunction with three soil types with the shear wave velocities less than 750 m/s, representing soil classes: I I (Vs=450m/s), and III (Vs=250m/s) according to Iranian Standards (Iranian standard, 2800).

The structural sections are designed after conducting nonlinear time history analysis, based on both elastic and inelastic procedures. Fully nonlinear dynamic analyses under the influence of four different earthquake records are conducted and the results in terms of lateral displacements, inter-story drifts, and base shears for both mentioned boundary conditions are obtained, compared, and discussed.

According to the numerical investigations, conducted in this study, soil-structure interaction has effects on the elastic and inelastic seismic response and performance level of mid-rise resisting building frames.

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