EVALUATION OF THE SEISMIC RESPONSE OF BUILDINGS CONSIDERING THE SOIL-STRUCTURE INTERACTION WITH DIFFERENT SOIL LAYERS

Mazyar FAHIMI FARZAM
Assistant Professor, Department of Civil Engineering, Faculty of Engineering, University of Maragheh, Maragheh, Iran
m.farzam@maragheh.ac.ir

Reza ALINEJAD
Graduate student, Department of Civil Engineering, Faculty of Engineering, University of Maragheh, Maragheh, Iran
r.alinejad@maragheh.ac.ir

Keywords: Soil-structure interaction, Numerical modeling, Seismic response, Non-linear dynamic analysis, Abaqus

In order to provide a proper model of a structure, considering the soil-structure interaction with different soil layers has been emphasized in calculating the structural response. In this study, a scaled 15-story benchmark building that has been tested in previous studies on a shaking table is modelled and analysed in Abaqus software. The seismic performance of the structure is investigated under four benchmark earthquake records by considering two layers of soft soil with two different characteristics and orders. The results show different seismic responses for the structure by considering different layers of soft soils. The stiffness of the layers of soft soils and its location have also significant effect on the dynamic response of the structure which reduce the story displacement if the softer soil layer is below.

INTRODUCTION

Considering soil-structure interaction may reduce the seismic force of structures and consequently can reduce costs and increase structural safety. Therefore, recognition of the actual behaviour of structures in this regard has attracted the attention of many researchers and engineers. Although several researches (e.g., Hosseinzadeh et al., 2004, Krawinkler et al., 2003, Pitilakis et al., 2008), have studied the structural behaviour subjected to earthquake excitations considering soil-structure interaction by numerical simulations, compared to laboratory test results, the accuracy and integrity of only a few of them were examined and validated. Consequently, the numerical models should be validated to guarantee the predictions of numerical models and their agreement and conformity with measurements. In this paper, validated modelling of a shaking table test of a 15-story scaled building in Abaqus software is presented. Then, the effect of two soft soil layers with different specifications on the seismic response of the building under four benchmark earthquake records is investigated.

NUMERICAL MODELLING

Abaqus software having great abilities for performing nonlinear dynamic analysis and contact and interaction modelling between the elements is used for numerical modelling. The interface element is used to model the contact between the soil and foundation. The characteristics of the interface element include shear springs (ks) and normal springs (kn). The stiffness parameters of the interface element are obtained from Equation 1 (Tabatabaiefar et al., 2016).

$$k_n = k_s = 10\max\left[\frac{K+\frac{4}{3}G_{max}}{Äz_{min}}\right] \tag{1}$$

where, K and G_{max} are bulk and maximum shear modulus of neighbouring zone, respectively, and Δz_{min} is the smallest width of an adjoining zone in the normal direction. To investigate the effect of soil layers on the seismic response, two layers of soil is consumed in accordance with Table 1 specification. In order to define the reduced shear modulus in Abaqus, an equivalent linear method and the Mohr-Coulomb Criterion is employed. Thus, with the assumption of initial damping and shear modulus for different soil layers and recording the maximum shear strain for each layer, the damping values and the new shear modulus from the shear strain recorded of the analysis was determined by referring to the shear modulus curve (Bagheri et al., 2018).

Table 1. Adopted soil parameters in numerical simulation (Bagheri et al., 2018, Tabatabaiefar et al., 2016).

Type	Soil density ρ(kg/m3)	Shear-wave velocity Vs(m/s)	Maximum shear modulus Gmax(kPa)	Poisson's ratio υ	cohesion intercept C (kPa)	friction angle φ (degrees)	Plasticity index PI
Soil 1	1470	36	1830	0.49	1.57	0	15
Soil 2	1470	28	1100	0.4	0.67	12	15

CONCLUSIONS

The effect of different soil layers and their orders beneath a 15-story benchmark building on the seismic response of the building is investigated. The maximum roof displacement of the building under two far-field earthquake records and two near-field earthquake records is calculated and compared. The maximum roof displacement of the building with the fixed base is less than the structure with a flexible base. Furthermore, differences in the stiffness of the soil layers and their locations have also significant effects on the dynamic response of the structure, and the story displacements reduce if the surface soil layer has higher stiffness.

REFERENCES

Bagheri, M., Jamkhaneh, M.E., and Samali, B. (2018). Effect of seismic soil-pile-structure interaction on mid and high-rise steel buildings resting on a group of pile foundations. *International Journal of Geomechanics*, *18*(9).

Hosseinzadeh, N.A., Nateghi-Alahi, F., and Behnamfar, F. (2004). *Shake Table Study of Soil Structure Interaction Effects on Seismic Response of Adjacent buildings. International Institute of Erthquake Engineering and Seismology.*

Krawinkler, H., Medina, R., and Alavi, B. (2003). Seismic drift and ductility demands and their dependence on ground motions. *Engineering Structures*, *25*(5), 637-653.

Pitilakis, D., Dietz, M., Wood, D.M., Clouteau, D., and Modaressi, A. (2008). Numerical simulation of dynamic soil-structure interaction in shaking table testing. *Soil Dynamics and Earthquake Engineering*, *28(6)*, 453-467.

Tabatabaiefar, S.H.R., Fatahi, B., and Samali, B. (2016). Numerical and Experimental Investigations on Seismic Response of Building Frames under Influence of Soil-Structure Interaction. *Advances in Structural Engineering*, *17*(1), 109-130.