# EVALUATION OF SEISMIC BEHAVIOR OF SITE IN PRESENCE OF TALL AND MASSIVE STRUCTURES ON SOFT SOIL UNDER HIGH FREQUENCY EARTHQUAKE

Saba FADAIE
*M.Sc. Graduate, Department of Civil Engineering, Semnan University, Semnan, Iran*
*saba.fadaie@gmail.com*

Mohammad I. KHODAKARAMI
*Assistant Professor, Faculty of Civil Engineering, Semnan University, Semnan, Iran*
*khodakarami@semnan.ac.ir*

**Keywords:** Tall structures, Massive structures, Seismic response, Soil-structure interaction, Time history analysis

The main purpose of this article is studying the seismic behaviour of site in presence of tall and massive structures by considering soil-structure interaction. To this aim, structures with different mass, geometric and stiffness specifications have been modeled two-dimensional on soft soil using direct method under earthquake stimulation with high frequency content. Results indicate that seismic response of ground is affected by presence of structure. Presence of building decreased the responses and in some cases according to dimensions of structure, have caused increase in seismic response of ground and creates critical condition. In earthquake engineering, response of lateral displacement of structure under earthquake motion in order to provide life security of structures is essential. Studying effective parameters on response of structure by scientists and controlling these parameters in order to increase life security of structures, caused paying considerable attention to soil-structure interaction in the last four decades. One of the first researches in this category had been presented by (Wong, 1975). Besides, various experimental studies have examined soil-structure interaction, results of which have shown changes in time period of structure and seismic response of ground and irrespective of the effects of soil and structure interaction on the structure response on the stiff soil and increasing the interaction effects in the presence of stiff structure on soft soil (Hosseinzadeh et al., 2004; Luco, 2014). In this paper, in order to complete the research results in this area by modeling a number of tall, massive, rigid and massive structures on soft soil in OpenSEES software, under earthquake effects with high frequency content, the effects of short structure on soil with tall structure on soil is compared. Soil and structure systems are modeled two-dimensionally using finite element and analyzed using time history analysis. In order to examine both tall and short structures, according to the seismic design guide handbook (Farzad, 2001), the width of the structures is considered from 28 m to 100 m and height of structures from 52 m to 200 m. Structures are considered as a rigid plate on soil and instead of considering floors and openings of structures, modeling has been done by finite element. In simulation of the plate as a structure, the properties of the structures such as Poisson’s coefficient, density, and elastic modulus were obtained and entered as independent parameters to the plate. In soil modeling, it is not possible to examine the soil as semi-infinite space due to modeling constraints. The main soil factors such as damping and wave propagation, soil dimensions are determined using the sensitivity analysis method. Two-dimensional soil modeling with two degrees of freedom and four-membered quadrilateral elements is carried out. Soil goes in the direction of the depth to bedrock, thus, bedrock is modeled, but due to the semi infinity of the soil environment in the modeling and the presence of stiffness and damping in the soil and in order to prevent returning of the wave, by placing the absorbing boundaries, the condition of attenuation and the stiffness of the soil in infinity is achieved by defining a number of springs and dampers in two vertical and horizontal directions on the two left and right sides of the soil. The soil under study is classified Type D according to IBC. The soil specification has been taken from the Livaoglu article (Livaoglu, 2008). The input motion is the Loma Prieta earthquake, which has a high frequency content of 6.93 and effective duration of 13.78 s. The evaluation points of the ground level response from the corners of the structure to 0.25 of the width of the structure with each other up to a maximum of five times, the width of the structure have been consecutively taken and examined. In Figure 1, the model of soil and structure systems and evaluation points of the response are shown. In order to validate the modeling, Raychowdhury’s paper (Raychowdhury and Ray-Chaudhuri, 2015) has been used and results are consistent with less than

10 to 12 percent difference, so the modeling is acceptable and validated. To investigate the effect of structural presence, the models were analyzed in two conditions of solo soil and soil-structure systems, and the results were obtained and compared.

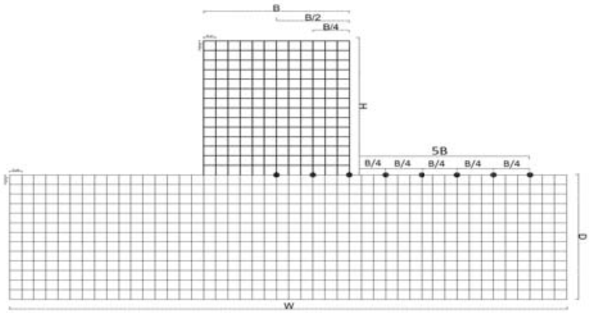


*Figure 1. Modeled soil-structure system and location of evaluation points.*

In Figure 2, the results of the analysis are shown as the ratio of the response. It should be noted that Ratio represents the ratio of ground level response in the presence of structure divided by response of ground level without the presence of structure. According to the results, as the structure located on soil is shorter, the decrese in responses is greater and the response ratio is less than 1, and the presence of structure reduces the ground response up to 31 percent. Moreover, by increasing the structural aspect ratio, decreasing the response of the ground surface is reduced (at least 3%), and in condition of presence of taller structures, the presence of the structure results in an increase of 2% of the ground surface response and creates critical condition.

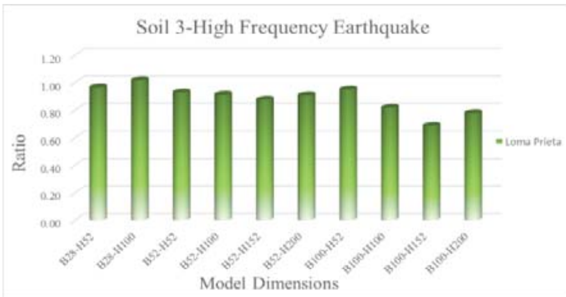


*Figure 2. Seismic response ratio of ground level in soil type 3 with high frequency earthquake.*

## REFERENCES

Farzad, N. (2001). *The Seismic Design Handbook.*

Hosseinzadeh, N., Nateghi-Alahi, F., and Behnamfar, F. (2004). Shake table study of soil-structure interaction effects on seismic response of adjacent buildings. *Journal of Advanced Materials in Engineering (Esteghlal), 22*(2), 51-71.

Livaoglu, R. (2008). Investigation of seismic behavior of fluid–rectangular tank–soil/foundation systems in frequency domain. *Soil Dynamics and Earthquake Engineering, 28*(2), 132-146.