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EXPERIMENTAL STUDY OF SOIL-STRUCTURE INTERACTION ON IMPROVED GROUND BY MICROPILES USING SHAKING TABLE

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Micropiles are small-diameter piles with similar function to piles, which are nowadays used for ground improvement and as deep foundations. Nowadays due to increased construction, presence of problematic soils and lack of enough space for constructing piles, micropiles have become an appropriate alternative. Micropiles are high capacity drilled and grouted piles with a diameter typically less than 300 mm. They can be used either for in-situ reinforcement like ground strengthening or as structural supports for example for both existing and new foundations (FHWA, 2005).

Results of pervious numerical and experimental work on seismic behavior of micropiles shows that considering soil-micropile-structure interaction is necessary in seismic design of micropiles since the existence of super structure can enforce large inertial force and consequently a large bending moment to the upper part of micro piles. It is also indicated that during seismic loading micropiles as a group can perform better compared to single micropiles. They can also decrease the water pressure build up because of their confinement effect on soil (Shahrour & Juran, 2004).

It is shown that soil-pile-structure interaction amplifies the lateral deflections and inter-story drifts for floating pile foundations compared to fixed base foundations. By considering soil-structure interaction, natural frequency of system decreases and this modifies superstructure's seismic behavior during earthquake (Hokmabadi et al., 2014).

Although a lot of studies have investigated seismic response of micro piles, there are only a few which have investigated the effect of micropiles on soil-structure interaction system. In current research, the effect of micropiles on SSI system is determined by an experimental approach including six series of 1g shaking table tests.

The 3×2 m shaking table device in Soil Mechanics Laboratory of Tabriz University was used to induce the desired excitations to models. To minimize the boundary effects and simulate the free field soil response, a laminar box is used in the research. Physical modelling rules are used to model the superstructure and micropiles (Muir Wood, 2004). Similitude formulas and factors of all physical quantities are induced from Buckingham π theorem. The scaling factor is 25 (n=25). A four-story building with 6×6 m dimensions is considered as prototype and is simplified into a SDOF model using the physical modeling rules. The micropiles were simulated using the physical modeling rules and by using the dimensionless group which describes the pile-soil stiffness parameter (Hajialilue-Bonab et al., 2013). Micropiles were embeded once only under the superstructure model and once all over the box to observe the effect of the number of micropiles on the responses. Test apparatus, super structure model and micropiles are shown in Figure 1. Six series of shaking table tests were conducted; however, three series will be discussed in this paper which are explained in Table 1. The physical model was shaken with a sinusoidal base acceleration having a frequency of 8.0, 10.0, 15.0 Hz and maximum acceleration amplitudes of 0.35 g and 0.50 g.

Table 1. Test Arrangement.

Test Code	Soil	Micropile		Super Structure
		Under structure's foundation	All Box	
T1	✓			✓
T2	✓	✓		✓
T3	✓		✓	✓

By analyzing the natural frequency and dominant period of the models, it is concluded that consideration of soil structure interaction increases the natural frequency of the system and damping ratio. By adding the micropiles in the system, the natural period of the system and damping ratio decreases, and natural frequency of system increases. In the models in which soil was improved by micropiles, the acceleration-time response in soil surface and under the foundation was higher in comparison with the models which were not improved by micropiles. Inversely, micropiles caused a decrease in acceleration-time response of the super structure model. In addition, by estimating the drift ratio of the top of super structure with respect to foundation, it is obviously observed that drift ratio was decreased in the models improved with micropiles.

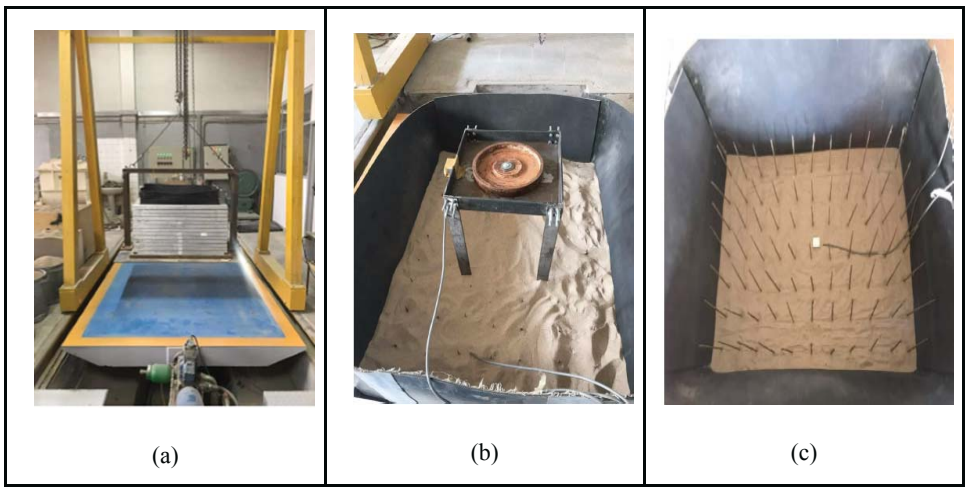

Figure 1. (a) Test apparatus (b) Super structure model (c) Micro piles embedded in soil.

REFERENCES

FHWA (2005). *Micropile Design and Construction (Reference Manual for NHI Course 132078)*. Federal Highway Administration FHWA-NHI-05-039, Washington, D.C., 436.

Hajialilue-Bonab, M.S. (2013). Study of strain wedge parameters for laterally loaded piles. *International Journal of Geomechanics*, 143-152.

Hokmabadi, A.S., Fatahi, B., and Samali, B. (2014). Assessment of soil – pile – structure interaction influencing seismic response of mid-rise buildings sitting on floating pile foundations. *Computers and Geotechnics*, 172-186.

Juran, I. (2004). *Seismic Behaviour of Micropile Systems*.

Muir Wood, D. (2004). *Geotechnical Modelling.* London: Spon Press.