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EFFECT OF HIGH-RISE STRUCTURE CHARACTERISTICS ON THE ROCKING OF FOUDATIONS

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Rocking of shallow foundation that is a ramification of soil structure interaction has been recently considered by many researchers and earthquake geotechnical performance-based design (PBD) codes. These researches signified the importance of this most unintentional phenomenon in amelioration seismic performance of structures. Elongation of the natural period of the soil-structure system, a decrease in both base shear and ductility demands of superstructures can be named as advantages of this rotational mode; however, unpredictable displacement of the foundation and residual settlement and/or tilting of the foundation concern engineers to allow the base separates from the contacted ground, therefore the ability of realistically modeling the rocking responses of the soil structure interaction is a necessity in this respect. In addition, the responses of soil-structure interaction like settlement, rotation, mobilized moment and dissipated energy and correlation between these results, are completely intricated, e.g. the nonlinearity of rotation-moment relationship is dependent straightly on several factors including the amount of rotation of foundation, the nonlinear behavior of underlying soil, the static factor of safety of foundation (Gaztes et al., 2013), as well, there are some parameters such as the height and the width of structure, in the same vibration, indirectly lead to some significant alterations in the rotation-moment relationship and the other responses of rocking. Therefore, this investigation attempts to study the effects of structure dimensions (height and width) on the rocking of the foundation. Rectangular blocks as superstructure subjected to dynamic loads have been simulated by finite element analysis using ABAQUS. To induce the structure to shake and the foundation to rock, horizontal displacement shown in Figure 1-a is imposed on bedrock. This displacement time-history was selected in such a way not to led the blocks to slide and the structures vibrated in a controlled way by gradually increasing vibration amplitude. The recorded horizontal acceleration of one node of soil, which is the closest to bedrock is shown in Figure 1-b. Imposed displacement caused peak horizontal acceleration 0.6 g with predominant frequency of 1.75 Hz.

For considering structure height, three structures with the same width of 20m, and 30m, 60m and 90m heights were selected. These structures, by supposing the height of each floor is 3m, respectively have 10, 20 and 30 stories. Therefore, the weight of each structure was determined by assuming 1 ton charge loads on per square meter of floors. To provide sufficient data, the supporting soil which the foundation of these structures was placed, assumed in four behavior models namely linear and nonlinear (elastic and elastoplastic). For validation of these numerical modeling, a centrifuge test namely SSG04-9b provided by Gajan et al. (2006) has been simulated. The obtained results were in good agreement with experimental results.

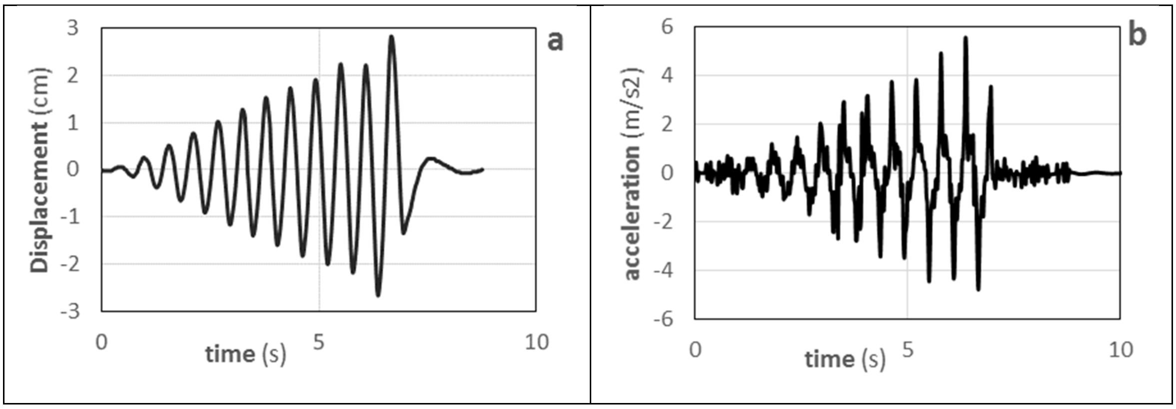

Figure 1. a) Imposed displacement time history b) recorded horizontal acceleration.

The results indicated that rotation-moment relationship was changed with the height of structures. Rotation-moment hysteresis for three structures with different height in one common cycle is shown in Figure 2. According to this figure, in the same underlying soil model, the moment-rotation relationship of low structure experienced nonlinearity and encloses a larger area in comparison two others. Besides, in the same vibration intensity, the slender structure tilted less. Because surcharge on foundation reduced by decreasing structure height, this foundation may simply uplift and displace in large geometric, eventually leads to a nonlinear relationship. Since the lower structure exerted less vertical load on foundation, the less settlement of foundation after dynamic loading was achieved. Although the highest structure is the heaviest and makes more underlying soil to plastic, the lowest structure dissipated more energy. It is because of uplift and displacement of lighter foundation, besides that, energy dissipation is the sum of radiation, plastic, viscose attenuating energy, therefore, lots of dissipated energy in low building with high natural frequency, also can be related to viscose dissipating. on the other hand, as the height of structure increases, because the radius between block center gravity to the pivot point (R) increased, the rotation of footing and structure would decrease. This study has shown, most in linear behavior soil, in the same vibration intensity the rotation of foundation is proportional to the inverse R.

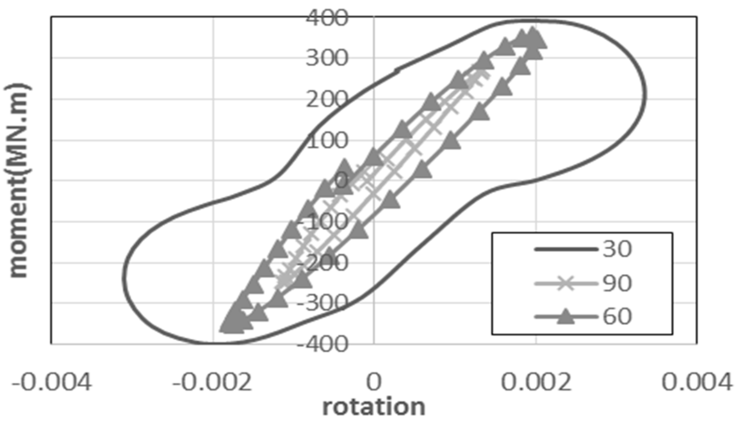

Figure 2. Comparison rotation-moment of structures with different height for one cycle (Amiri, 2019).

To study structure and foundation width, nine structures with different aspect ratio were placed on linear and nonlinear (elastoplastic) soil. Every three structures have the same height with different width. Figure 3 which is a sample of results of this study indicates that a wider structure dissipated more energy and resists more against rocking, i.e. to tilt wider structures, more rocking moment is needed. Variation of structure width affects trivially the residual settlement.

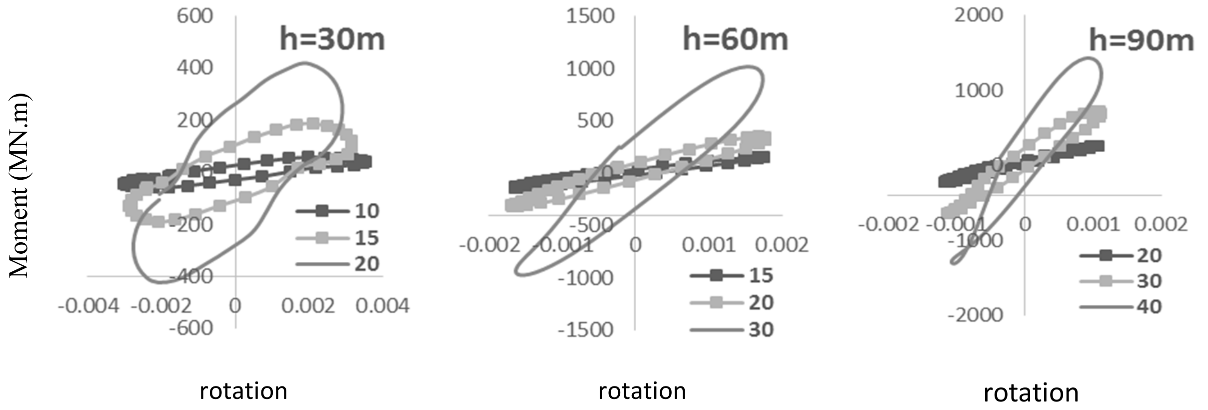

Figure 3. Moment-rotation for structure with different aspect ration for one cycle (Amiri, 2019).

REFERENCES

Amiri, A. (2019) *Study of Rocking of Shallow Foundations Subjected to Dynamic Loading by Consideration of Soil-Structure Interaction*. M.Sc. Thesis, Sharif University of Technology, Tehran.

Gajan, S., Thomas, J.M., and Kutter, B.L. (2006). *Soil-Foundation-Structure Interaction: Shallow Foundations*. Centrifuge Data Report for test series SSG04. UCD/CGMDR,Center for Geotechnical Modeling.

Gazetas G., Anastasopoulos I., Adamidis O., and Kontoroupi, Th. (2013) Nonlinear rocking stiffness of foundations. *Soil Dynamics and Earthquake Engineering*, *47*, 83–91.