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# NUMERICAL STUDY OF EFFECTS OF THE SUPERSTRUCTURE ON DYNAMIC RESPONSE OF A 3×3 PILE GROUP

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Pile foundations are widely used for supporting heavy superstructures in soft grounds by transmitting structural loads to deeper soil and for resisting the lateral loads from earthquakes and other external forces. Data from past earthquakes have shown that the failure of a pile foundation during a major earthquake occurs frequently. Therefore, it is necessary to understand the mechanical behavior of pile foundations during a major earthquake. Earthquake can cause lateral loads on piles. These loads can be attributed to both kinematic interactions between soil and piles and to inertial interactions between superstructure and piles. Thus, the behavior of pile foundations under seismic loading is a complex soil-pile-structure interaction which its evaluation may be a very important issue in geotechnical design of piles. The importance of soil-foundation-structure interactions has been recognized in modern seismic codes. Some investigations have been carried out to study the soil-pile-structure interaction, and it has been shown that neglecting the influence of soil-pile-structure could lead to unsafe design. Most of studies conducted on soil-pile-structure system have some defects. These studies are limited to two-dimensional behavior, are mainly focused on the superstructure response, assume linear behavior for soil, and use simplified Winkler methods for modeling soil-pile interaction. The accuracy and reliability of these simplified models have been questioned by many due to the simplifying assumptions regularly used.

The main purpose of this paper is to study the three-dimensional dynamic response of a 3×3 pile group in soil-pile-structure system using explicit scheme finite difference program, FLAC$^{3D}$ software. In this paper, a set of fully nonlinear three-dimensional numerical modeling in time domain has been conducted. A 3×3 pile group embedded in cohesive soil were subjected to 2003 Bam earthquake loading, and the pile group response, focusing on bending moment of piles induced by kinematic and inertial seismic interactions, has been investigated. It is obvious that dynamic behavior of soil-pile-structure system is influenced by soil nonlinear behavior and strain softening of soil stiffness during earthquakes. Therefore, investigation of piles response to seismic loading should take in consideration real behavior of soil. In this research, a softening model has been used for the behavior of the soil under dynamic loading. For the dynamic analysis of soil-pile-structure system, free-field boundary condition has been used. At this boundary condition, the lateral boundaries of the main grid are coupled to the free-field grid by viscous dashpots to eliminate the “box effect” i.e., reflection of outward propagating waves into the model and to simulate the free field motion which would exist in the absence of the structure and pile foundation. The pile group behavior has been investigated in the absence as well as the presence of a superstructure and the effect of stiffness of cohesive soil and the mass of the superstructure on the pile group dynamic response were discussed. Numerical grid and boundary conditions in FLAC$^{3D}$ for soil-pile-structure system are shown in Figure 1. The assumed properties for cohesive soil is summarized in Table 1.

The results of this study showed that the mass of superstructure and soil stiffness have strong effects on dynamic response of piles in soil-pile-structure system.

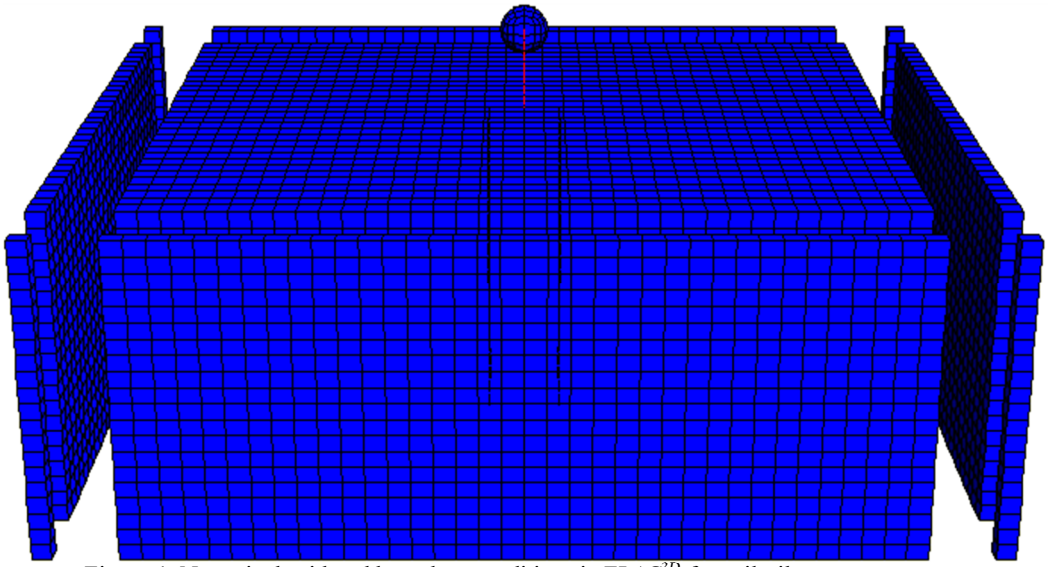

*Figure 1. Numerical grid and boundary conditions in FLAC$^{3D}$ for soil-pile-structure system.*

*Table 1. Assumed properties for soil.*

| Properties | Value |
|---|---|
| Density (kg/m$^3$) | 1600 |
| Module of elasticity (MPa) | 20, 50 |
| Undrained shear strength / effective stress | 0.3 |

## REFERENCES

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