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RESEARCH ARTICLE

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Load-sharing ratio of prebored and precast pile in top-down method construction process

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Summary

The load-sharing ratio of the prebored and precast pile in top-down method foundation was investigated by using a numerical analysis and field case study. The emphasis was on quantifying the apparent load-sharing ratio of the prebored and precast pile during the top-down method construction process. A series of three-dimensional finite element analysis were conducted, with special attention given to the pile load-sharing ratio under various conditions, such as soil condition, pile geometry, pile length, and structure load. In addition, the load-sharing ratio of a single pile was also investigated based on the location of the pile in the raft (footing). The analysis model was validated by comparing the analysis model with the field data of an actual construction site using the prebored and precast pile and the top-down method. On the basis of the series of analysis results and the field measurements, when the soil condition is better than weathered rock and for moderate pile length, at least 15% of the total structure load was supported by the pile throughout the construction process. Furthermore, it was shown that the pile near the center of the raft carried more structure load compared with the piles in the side and the corner of the raft.

KEYWORDS

load-sharing ratio, mat foundation, percussion rotary drill (PRD) pile, prebored and precast pile, 3D FE analysis, top-down method

1 | INTRODUCTION

An increasing need for optimized foundation designs, which ensure stability and financial feasibility, is the main focus in the field of foundation engineering. In addition, the consideration of the environmental effect of construction is also a big issue, especially in population-concentrated urban areas, due to existing buildings, roads, and residents. To prevent public nuisance, such as noise, vibration, and dust, during construction, a top-down construction method is widely used in major Asian cities in Korea, China, Japan, Singapore, and Taiwan.[1–4] Top-down construction methods have the advantage of being able to protect nearby buildings as well as underground structures[5–7] and can thus be applied as an alternative construction method to the conventional bottom-up construction method. Using the top-down method also enables the simultaneous construction of both the superstructure and substructure, which reduces the construction period significantly.

The main structural elements of the top-down method include retaining walls, preinstalled columns, slabs (floors), and a mat foundation (footing). Among the structural elements, the preinstalled columns play a critical role in stability during construction. The preinstalled columns serve as a temporary foundation that supports the structural load during construction. Due to the preinstalled columns, the top-down method is capable of constructing the superstructure and substructure simultaneously, which leads to a shorter construction period.[8]

Prebored and precast piles are widely used as preinstalled columns in the top-down method, because they do not induce high noise, vibration, and dust during the installation process.[9] Usually, H-shaped steel piles are commonly used as preinstalled columns to support structural load during the top-down construction process. Even though the preinstalled columns still contain the capacity to support the structural load during the service period of the structure, the bearing capacity of the preinstalled column is usually ignored in the design of the mat foundation (footing).[4,10] Due to this, the design of the mat foundation (footing) tends to be conservative, which leads to thicker footing and higher construction costs.

