Nonlinear 3-D Analysis Method for Piled Raft Foundation under High-rise Building Loads

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Summary

A three-dimensional approximate computer-based method was developed to analyze the behavior of piled raft foundations in this study. A raft was treated as a 4 node flat shell element including torsional degrees of freedom, and a pile was modeled as a beam-column element in this proposed method. The behavior of pile head and soil were controlled by using 6×6 stiffness matrix, and the soil-structure interaction between soil and pile was modeled by using nonlinear load-transfer curves (t-z, q-z and p-y curves). The overall objective of this study focused on the application of analysis method for predicting behavior of mega foundations. Through the comparative studies, it was found that the computer programs developed in this study, YSPR gave similar results of settlement behavior and pile axial force compared with those from other numerical studies and field measurement. Therefore, YSPR can be effectively used to perform the design of large piled raft foundations.

Keywords: piled raft; approximate computer-based method; interactive analysis; high-rise buildings.

1. Introduction

A growing number of urban population clustering incidents due to industrial development and the resulting increase in land prices have given rise to the planning and construction of skyscrapers in recent years, which offer relatively higher cost-effectiveness and utility per square meter. With increase in height, the super tall buildings have enormous load of superstructure which is transmitted to the foundation. Thus, the foundation structures of super tall buildings have also been built more massively to ensure that the buildings are supported with maximum stability. With multi-purpose super tall building, the substructure undergoes settlement due to the enormous loads being applied. The displacement of the substructure affects the deformation in the superstructure. Thus, an accurate behavior analysis system is required based on the unified structure-foundation-soil analysis, which considers interaction between the superstructure and the foundation. This is judged to be one of the most efficient ways to realize the optimum design. In general, for the accurate analysis, a complete three-dimensional analysis of a foundation system can be carried out by a finite element analysis (Smith & Wang, 1998; Lee, 2007). However, a finite element analysis is more suitable for obtaining benchmark solutions against which to compare simpler analysis methods, or for obtaining solutions of a detailed analysis for the final design of a foundation, rather than as a preliminary routine design tool.

In this study, a numerical method is used to combine the pile stiffness with the stiffness of the raft, in which the flexible raft is modeled as flat shell element and the piles as beam-column element, and the soil is treated as linear and nonlinear springs. Based on the proposed analysis method, approximate analysis computer program of YSPR for raft and piled raft foundations are developed respectively. In order to examine the validity of the developed computer programs, the results from YSPR are compared with the available solutions from previous researches. In the field case study, comparative analyses between YSPR and a three-dimensional finite element analysis are carried out for the pile load and settlement behavior.

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