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Prediction of Pile-Raft Responses Induced by Adjacent Braced Excavation in Layered Soil

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Abstract : Considering excavations in urban areas, the soil deformation induced by the excavations usually causes damage to the surrounding structures. Displacement control becomes a critical indicator of foundation design in order to protect the surrounding structures. Evaluation, the damage potential of the surrounding structures induced by the excavations, usually depends on the finite element method (FEM) because of the complexity of the excavation and the variety of the surrounding structures. Besides, evaluation the influence of the excavation on surrounding structures is a three-dimensional problem. And it is now well recognized that small strain behaviour of the soil influences the responses of the excavation significantly. Three-dimensional FEM considering small strain behaviour of the soil is a very complex method, which is hard for engineers to use. Thus, it is important to obtain a simplified method for engineers to predict the influence of the excavations on the surrounding structures. Based on large-scale finite element calculation with small-strain based soil model coupling with inverse analysis, an empirical method is proposed to calculate the three-dimensional soil movement induced by braced excavation. The empirical method is able to capture the small-strain behaviour of the soil. And it is suitable to be used in layered soil. Then the free-field soil movement is applied to the pile to calculate the responses of the pile in both vertical and horizontal directions. The asymmetric solutions for problems in layered elastic half-space are employed to solve the interactions between soil points. Both vertical and horizontal pile responses are solved through finite difference method based on elastic theory. Interactions among the nodes along a single pile, pile-pile interactions, pile-soil-pile interaction action and soil-soil interactions are counted to improve the calculation accuracy of the method. For passive piles, the shadow effects are also calculated in the method. Finally, the restrictions of the raft on the piles and the soils are summarized as: (1) the summations of the internal forces between the elements of the raft and the elements of the foundation, including piles and soil surface elements, is equal to 0; (2) the deformations of pile heads or of the soil surface elements are the same as the deformations of the corresponding elements of the raft. Validations are carried out by comparing the results from the proposed method with the results from the model tests, FEM and other existing literatures. From the comparisons, it can be seen that the results from the proposed method fit with the results from other methods very well. The method proposed herein is suitable to predict the responses of the pile-raft foundation induced by braced excavation in layered soil in both vertical and horizontal directions when the deformation is small. However, more data is needed to verify the method before it can be used in practice.

Keywords : excavation, pile-raft foundation, passive piles, deformation control, soil movement
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