University of Tabriz

Journal of Civil and Environmental Engineering
Volume 51 (2021), Issue 3 (Autumn), 87-101

EXTENDED ABSTRACT

Experimenta Lstudy of Behavior of Piled Raft Foundations under Vertical Loading in Sand

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Received: 31 May 2018; **Accepted:** 09 September 2019

Keywords:
Piled raft, Interaction, Physical modeling, Cast-in-place concrete piles, Sand fatigue, Stress.

1. Introduction

Several numerical studies have been carried out to analyze the behavior of piled raft foundations, but very few experimental studies are reported in literatures (Cooke RW, 1986). The conventional approach for the design of piled raft foundations ignores the raft load sharing and it has been assumed that the piles carry the whole of structural loads (Hemsley JA, 2000). This approach is unduly conservative and lead to an uneconomic design. Only when the piles cap is elevated from the ground level, this design method is valid. In a piled raft foundation, pile-soil-raft interaction is complicated. The available laboratory studies are mainly focused on steel piles. The present study aimed to evaluate the behavior of piled raft foundations in sand, using experimental physical models.

2. Methodology

Cast- in- place concrete piles and concrete raft were used for the tests. The test models in this research included: single pile, single piles in pile group, unpiled raft and piled rafts with 4 and 9 piles. Some instruments measured the load contribution between the piles and the raft. The instruments are shown in Fig. 1. The effect of the piles installation in the group was also investigated. By comparing the measured load capacities for piled rafts, the differences between the traditional and new approach in the piled raft design were studied. The effects of the number of piles and spacing on the settlement and load capacity of the foundation were also evaluated.

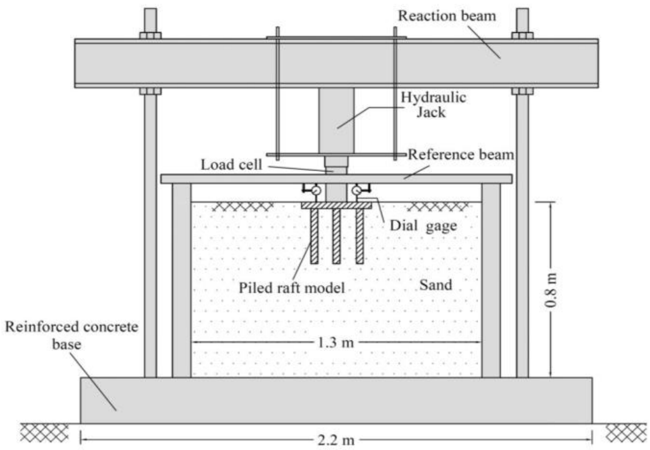

Fig. 1. Schematic of test setup

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3. Results and discussion

3.1. Single pile in group

By installation of a single pile in a group, the pile bearing capacity and stiffness increase. The bearing capacities in center, middle side and corner piles in the 3×3 group are increased by 57%, 36% and 11%, respectively. This value is about 5% for corner piles located in the 2×2 group. Corner piles have lower stiffness and bearing capacity than others. The piles located in the 2×2 group show a similar behavior as the corner piles in the 3×3 group. Increasing stiffness and bearing capacity of the center pile are due to pile confinement generated by adjacent piles and increase of soil density caused by casing penetration. In fact, the confinement increases equivalent stiffness of the soil-pile composition around the pile that decreases soil deformation and pile settlement. Furthermore, due to arching, the stress around the pile increases and as a result, the pile ultimate bearing capacity increases.

3.2. Piled raft

Comparison of load-settlement curves of piles in piled raft foundation and piles in group show the behaviors of the corner piles are approximately similar. Yielding points in corner piles coincide. The slight difference is due to the raft pressure in piled raft that increases the pile bearing capacity. In the other piles due to greater raft pressure and associated negative friction, the pile stiffness decreases and the bearing capacity increases significantly. In the corner, edge and center piles in the 3×3 piled raft, the increases in pile bearing capacity in comparison to single pile are approximately 16%, 64% and 264%, respectively.

In Fig. 2, the load-settlement curve of the piled rafts is compared with that of unpiled raft. In this figure Δ_{max} is the maximum settlement and B is the widths of the raft .By increasing the number of piles, the settlement of the foundation decreases significantly. At the beginning of the loading, due to higher stiffness of the piles than the soil, the slope of load-settlement curves for the piled raft is greater. The piled raft with 9 piles has a steeper initial slope in the loading curve. After pile failure, the loading curve reduces and becomes parallel to that of unpiled raft.

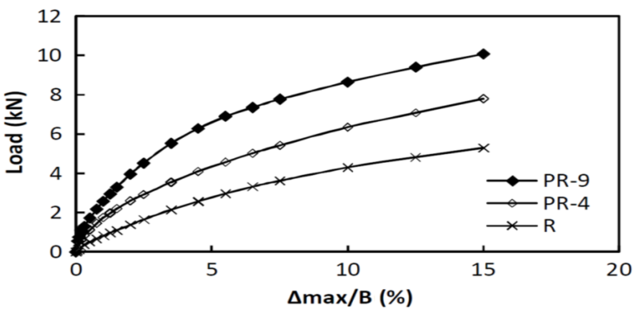

Fig. 2. Average load- settlement relations of unpiled raft, 2×2 and 3×3 piled rafts

4. Conclusions

By installing a single pile in a group, the bearing capacity and stiffness of the pile are increased due to the adjacent pile confinement and increased soil density during pile installation. By increasing the number of piles, the settlement of the piled raft decreases significantly. At the initial steps of the loading test, the pile bearing contribution is greater than that of the raft, thus the slope of the load-settlement curve is steeper. After pile failure, the curve is nearly parallel to the load-settlement curve of the unpiled raft. By designing a piled raft based on conventional approach in which the raft load-sharing is not considered, the allowable bearing capacity of the piled raft is underestimated by more than 300% and 200% for s/d of 5.2 and 2.6, respectively. On the other hand, with decreasing number of piles and increasing pile spacing, the conventional method is uneconomic. In contrast, when the raft bearing contribution is considered in the design calculations and the effect of the pile installation on the bearing capacities of the piles and raft is ignored, the difference between the calculated and measured results is insignificant.

5. References

Cooke RW, "Piled Raft Foundation on Stiff Clays-a Contribution to Design philosophy", Geotechnique, 1986, 36 (2), 169-203.

Hemsley JA, "Design applications of raft foundations", Thomas Telford Ltd, 2000.