



Comparison of Bearing Capacity of Piled Raft Foundations Consisting of Different Number of Piles under Static and Repetitive Loads

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Abstract:

In this study, large-scale experiments have been carried out at 5th Regional Research and Development Headquarters Engineering of Highways in order to determine the contribution of the piles in the pile-raft foundation to the bearing capacity. The bearing capacity were determined for only the raft, the raft with single pile and the raft with four pile under static and repetitive loading. In the examinations, sand samples which were taken from a river bed were used. The sand was classified as uniform clean sand (SP) according to standarts.As a result of study following results were obtained. Only raft has reached lowest bearing capacity at different alternatives under static loading. When used single pile and four piles at piled raft foundation systems, the bearing capacity has increased by 1.130 and 2.52 respectively under static loading. As the number of piles increased, it was observed that the settlements at piled raft foundations under the same repetitive loading decrease.

1. Introduction

In recent years, due to the increasing population and decreasing land use requirements, there have been improvements in civil engineering applications. In order to meet the growing population needs, it has become necessary to plan and build multi-storey high-rise buildings in soft and loose ground conditions. During the planning of such structures, they are exposed to large static and dynamic loads such as their own weight, earthquake and wind of the structures should be considered. If these effects are taken into consideration, the loads to be transferred to the soil has reached the most extreme values. In this case, shallow foundations may be insufficient in terms of settlement and the bearing capacity. Piled raft foundations is most widely used for solve these problems. The piled raft foundations are generally not economical, according to the shallow foundations. But, they transport the load from structure to the soil layers with sufficient bearing capacity. There are a lot of studies about piled raft

foundations. These studies were summarized below. One of the most important parameters of the determining bearing capacity at piled raft foundations while designing is the distance between piles. Determining the optimum value of the distance between piles make enough bearing capacity and settlement as well as economical designing of the piled raft foundation. In the literature, there are generally theoretical studies and numerical studies based on software packages like finite elements and boundary elements for determining to this parameters [1, 2, 3]. In these studies, it's stated that optimum distance between piles should be 2.5 times to 12.0 times the diameter of the pile. There are also experimental studies for determining for an optimum distance between piles in the literature. According to results of these experimental studies, optimum distance between piles should be 3 times to 4 times of the pile's diameter [4, 5, 6, 7, 8, 9, 10]. Another parameter affects the optimum distance between piles on the piled raft foundation design is the determining how to change the load proportions

between piles and raft foundation. As mentioned in the literature, experimental studies in order to be able to determine load proportions between piles and raft foundation are very limited. In general, these parameters had determined by using theoretical studies, software packages based on finite and boundary elements methods. It's determined that according to the studies conducted by finite and boundary elements methods on the piled raft foundations, bearing capacity's 15%-40% carried by raft foundation and 85%-60% carried by the piles [11, 12, 13, 14]. Parameters like diameters of piles, configurations, and properties of installed soil also have importance for piled raft foundations. Although there are a limited number of experimental studies to determine these parameters [14], in general, many theoretical studies and the studies done by software packages based on finite and boundary elements exist [1, 2, 3]. The parameters obtained from these studies is also over a wide range. When looked to literature, there are a lot of studies about piled raft foundations. But, in the literature, there is not much experimental work carried out under static and repetitive loads to investigate the different parameters of piled raft foundations embedded in sandy soils. So, this paper aim to determine the bearing capacity for only the raft, the raft with single pile and the raft with four pile under static and repetitive loading.

2. Material and Method

The model tests were conducted in the Research and Development Laboratory of 5th Regional Directorate of Highways, using by big scale cyclic plate loading system. The testing equipment consists of the test case, loading unit, data logger, and software (Figure 1 and Figure 2). The test box is designed as a rigid and length, width and height 2 m. The model raft and model piles were produced from steel which has stiffness 210000 Mpa, unit weight 77 kN/m². The model raft foundation's width, length and thickness are respectively 300 mm, 300 mm and 20 mm (Figure 3). The model pile's dimension and length are 0.05 m and 0.4 m respectively (Figure 3). The actuator produce monotonic or repeated loads to a maximum capacity of 245 kN. This actuator give different amplitudes and frequencies which produce static and cycling load with electromechanical control system. In order to determine the values of the load and settlement which were applied on the foundation plate, an electronic load cell and a Linear Variable Displacement Transformer (LVDT) were used. In the examinations, sand samples which were taken from river bed were used. Experiments were performed at soil mechanics laboratory on oven-dried sand samples. The sand was determined as

uniform clean sand (SP) according to ASTM [15], Percentage of Medium Grained Sand % 46.40, Percentage of Fine Grained Sand is % 53.60, Maximum Dry Specific Gravity is 17.06 kN/m³, Minimum Dry Specific Gravity is 15.03 kN/m³ and Specific Gravity is 26.80 kN/m³. Test procedure are given below. The side faces of the test case were scaled as 10 cm for placement of the sand to the test case for desired density by layers. The required sand for 10 cm layer was poured into the test case from a distance as close as possible, after that spreaded along the surface of



Figure 1. Test Box

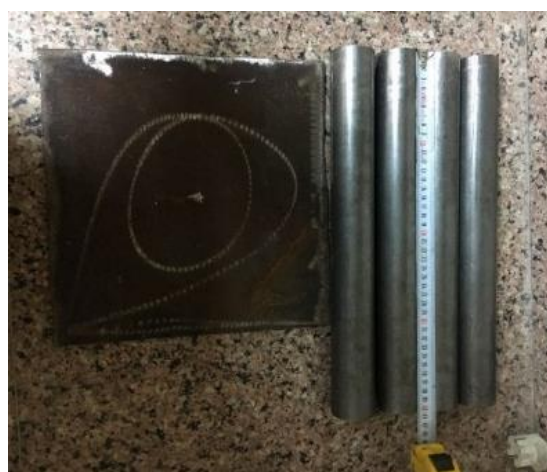


Figure2. Model Piles and Raft Foundation



Figure3. Data Acquisition System

the case with the help of a trowel. The sand has smoothed and spreaded homogeneously without applying pressure using thin wooden plates. After compaction is complete, the piled raft foundation plate was placed on the surface of the soil and embedded into the soil using loader systems with a constant penetration rate [14, 16]. As soon as the base of the raft foundation contacts the surface of the soil, the loading was stopped, controlled with a spirit level and the surface smoothness was provided. Prior to the test measuring systems was placed to the test setup. The measuring systems includes two vertical displacement gauges placed two sides on the foundation plate, and the load cell. The initial values of the measuring systems were reset, and final necessary controls were made for the load to be applied effect uniformly and for the smoothness of the system. The load was applied vertically to the foundation plate center and static and repetitive loads. The loading rate was kept constant during the test. After the tests were completed, the obtained load-displacement curves transferred to datalogger device and converted to digital values via software. After every test, bearing capacities were determined by plotting vertical load-settlement curves.

3. Results and Discussions

In this study, the behaviors of piled raft foundation consisting of four piles in two different configuration under static and repetitive loading conditions were investigated by large scale laboratory tests. The findings obtained from the experimental results were shown as Figure 4 and Figure 5 under static and repetitive loads. The bearing capacity is defined as the vertical displacement value corresponding to 10 percent of the raft foundation. All the test results were interpreted using this approach. The bearing capacity for raft foundation, piled raft foundation at single pile and for piled raft foundation at four piles are 41.150 kN, 46.400 kN and 103.715 kN respectively from Figure 4. It has been determined that the lowest bearing capacity is the only raft foundation. It has seen that the use of piles from 1 to 4 has increased the bearing capacity at a considerable rate. From figure 5, as the number of piles increased, it was observed that the settlements (displacement) at piled raft foundations under the same repetitive loading decrease from nearly 5.5 cm to 3.5 cm.

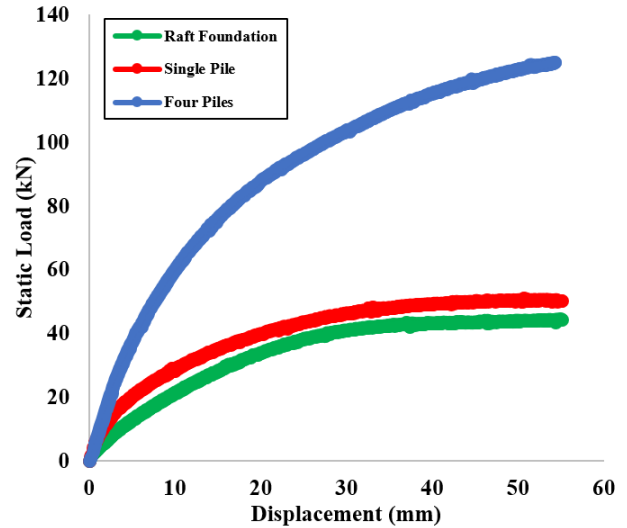


Figure 4. The load-displacement graphics for static loading.

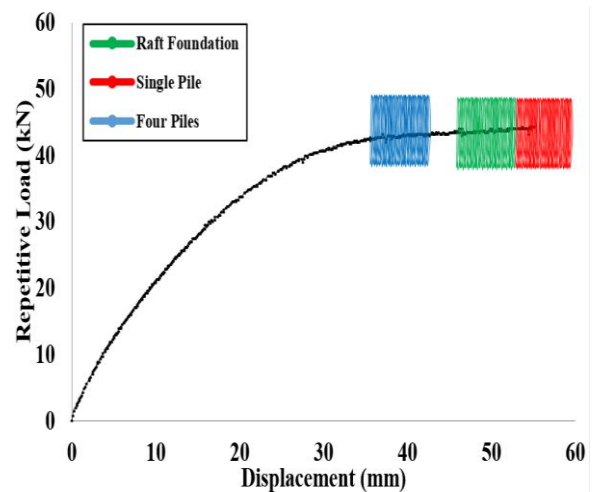


Figure 5. The load-displacement graphics for repetitive loading.

4. Conclusions

This paper aim to determine the bearing capacity for only the raft, the raft with single pile and the raft with four pile under static and repetitive loading. As a result of the study, the following results were obtained.

- The bearing capacity for raft foundation, piled raft foundation at single pile and for piled raft foundation at four piles are 41.150 kN, 46.400 kN and 103.715 kN respectively.
- It has been determined that the lowest bearing capacity is the only raft foundation.
- When used single pile and four piles at piled raft foundation systems, the bearing capacity has increased by 1.130 and 2.52 respectively under static loading.

- It has seen that the use of piles from 1 to 4 has increased the bearing capacity at a considerable rate.
- As the number of piles increased, it was observed that the settlements at piled raft foundations under the same repetitive loading decrease.

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