Indian Journal of Science and Technology, *Vol 10(31), DOI: 10.17485/ijst/2017/v10i31/113867, August 2017*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Behavior of Pile Raft Foundation in Organic Clay

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Abstract

The soils cover in the valley areas of Manipur are fluvial-alluvial soils with clay interspersed with organic clay forming the major portion of the substrata. Construction for rapid urbanization taking place in the valley area has historically been a problem due to the typically low strength and high compressibility. This paper gives the details of tests carried out on piled raft system of foundation embedded in clay soil. The effect of number of piles and the rigidity of raft on the response of load-settlement was studied. It is observed that higher number of piles and rigidity of raft act as settlement reducers.

Keywords: Flexible and Rigid Raft, Organic Clay, Pile, Pile Raft, Raft

1. Introduction

The most popular types of foundations used for high rise buildings or special structures are raft foundations or pile foundations. When used alone these can cause some problems under certain conditions. These systems can be combined under certain conditions and one can have a more efficient, safe and economical design.

The behavior of piled raft system has been studied extensively[1,4-8,11,12]. In soft clay which shows large settlement, use of minimum number of piles below the raft improves the ultimate capacity, settlement and differential settlement of the foundation system[9]. The settlement reducing piles at center of raft can be loaded to full capacity without affecting the foundation stability[3]. For a piled raft foundation the load is taken partly by the contact pressure between the raft and the soil and partly by the piles. Lesser load is taken by raft at initial load stage and increase in skin friction is caused due to contact pressure between cap and soil[10]. The contribution of raft towards load sharing was found to start after piles reached the ultimate capacity. The stiffness of the foundation system increased as number of piles underneath the raft increased. Piled raft stiffness increases by 30% than that of free standing pile group[2].

In this paper, results of laboratory tests to study the effect of rigidity of raft and number of piles on the load settlement behavior of piled rafts embedded in organic clay are presented.

2. Experimental Studies

2.1 Soil Properties

The organic clay found in Langol area of Manipur consists mostly of highly decomposed organic matter with traces of semi decomposed organic matter. The organic matter is amorphous in nature. The organic content of the soil was determined by loss of ignition as per ASTM D 2974-87 guidelines and was found to be 16.66%. Table 1 gives the specific gravity and the consistency limits of the soil.

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2.2 Test Raft Pile

Experiments were conducted on model raft pile made of mild steel. Piles were of uniform circular cross section of 10 mm diameter with length of 100 mm and the bottom was made into conical tips. The rafts used were of sizes 200x200x10mm considered rigid rafts and 200x200x2 mm considered as flexible rafts (Figure 1 and 2). Each pile was welded to the bottom surface on rafts made of mild steel square plates.

2.3 Experimental Set-Up

The tests were conducted on artificially consolidated organic clay bed for determining load-settlement behavior of piled raft system in organic clay. Organic clay was mixed with water and placed in a tank in layers. A layer of sand was put at bottom of the tank for drainage over which a thin cloth was laid to separate the layer of organic clay from the sand before putting the organic clay. At the top of the organic clay, another layer of sand was spread over a cloth. Weights were placed over the sand layer to consolidate the organic clay and kept for two days for consolidation. At the end of two days the sand and cloth over was removed and tests are performed on the organic clay prepared. Loading was applied vertically using a frame. The schematic diagram of the frame is shown in Figure 3.

Table 1. Soil properties

Soil	Organic content (%)	Specific gravity	Liquid limit (%)	Plastic limit (%)	Plasticity Index (%)
Organic clay	16.6	1.67	129	62.16	66.8

Figure 1. Model flexible pile raft system of 9 piles.

Figure 2. Model rigid pile raft system of 4 piles.

Model pile raft system was pushed in the consolidated clay bed until the raft touched the organic clay top. There was full contact between the soil layer and the raft. The settlement was measured using two dial gauges having a 50 mm range with 0.01 mm sensitivity. Loads were applied in gradual increment and settlements were recorded till there was not appreciable change in settlement for a particular load increment. The tests were continued until the settlement was more than 10% of width of corresponding raft.

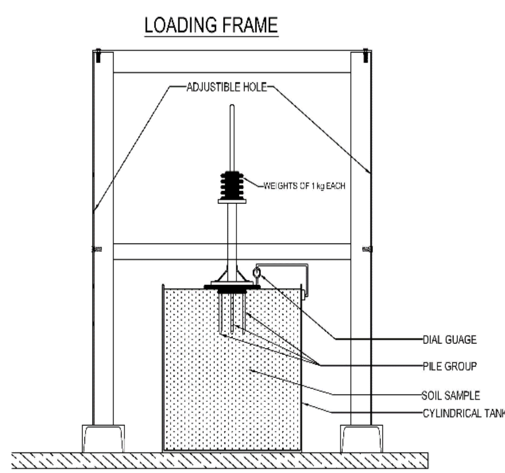

Figure 3. Pile raft model with loading arrangement.

3. Results and Discussions

Figure 4 and 5 shows the load-settlement behavior of the piled raft system for flexible rafts and rigid rafts respectively. It is observed from these figures that for any load, the settlement decreases as the number of piles increases. For comparison, the load carried by the piled raft system with different numbers of piles at settlements of 1 mm and 10 mm for both rigid and flexible rafts is shown in Figure 6. It is observed that the load carrying capacity is higher for rigid pile raft system than for flexible one. Figure 7 shows the percentage increase in load carrying capacity at 1 mm settlement for rigid and flexible piled rafts. The increase in load carrying capacity at 1 mm settlement for rigid piled rafts is more than 100 percent even with only one pile at the centre of the raft. This percentage in load carrying capacity increases as the number of piles increases. In the case of flexible piled raft, the increase in load carrying capacity with one pile is only 25% at 1 m settlement.

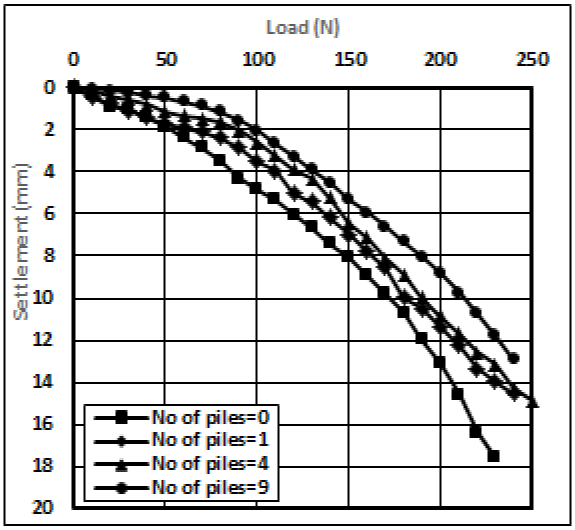

Figure 4. Load vs. settlement curve with raft size 200x200x[2] mm (flexible).

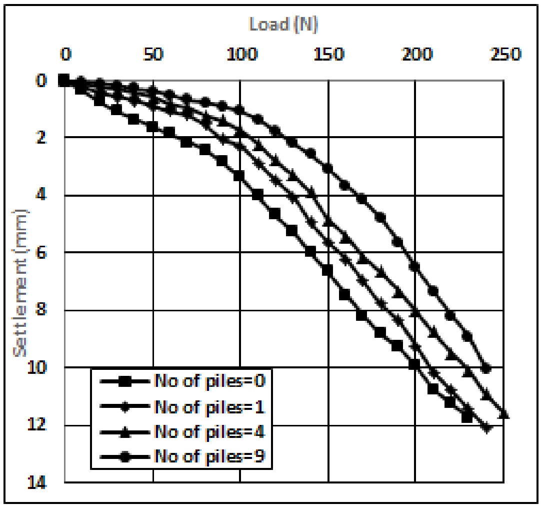

Figure 5. Load vs. settlement curve with raft size 200x200x10 mm (rigid).

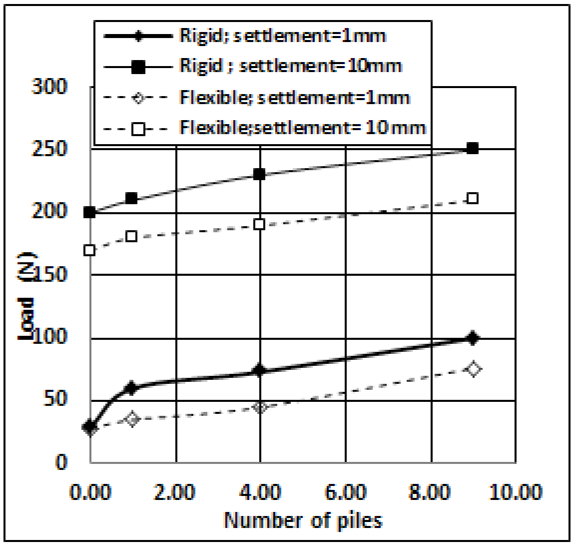

Figure 6. Load carrying capacity of piled raft system with different numbers of piles at settlements of 1mm and 10mm for both rigid and flexible rafts.

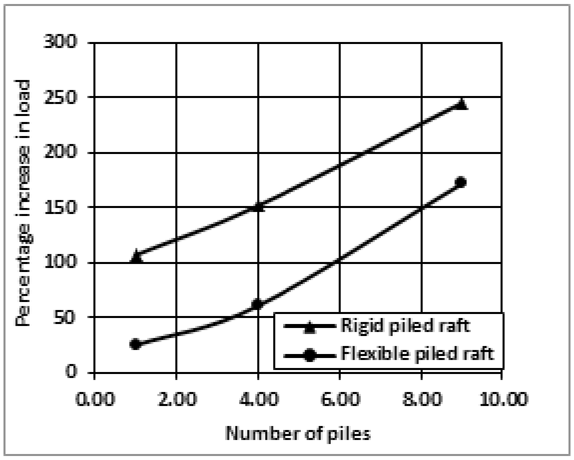

Figure 7. Percentage increase in load carrying capacity of piled raft system with different numbers of piles at settlements of 1 mm for both rigid and flexible rafts.

4. Conclusions

In this study of piled raft system in organic clay with different numbers of piles, it is observed that settlement decreases as the number of piles increase. Hence piles contribute as settlement reducers in the system. Also it is observed that the rigidity of the raft influences the load carrying capacity of the pile. Higher rigidity gives higher load and lesser settlement of piled raft system in organic clay.

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