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Model study of load-settlement characteristics of pile, raft and piled-raft system resting on uniform fine sand and layered soil

[1]Ad Kiran Limjibhai, [2]P. J. Mehta

[1]PG Student, [2]Associate Professor,

[1]Applied Mechanics Department, L. D. College of Engineering, Ahmedabad, India

***Abstract*—Now a days pile-raft foundations are being widely used for high rise buildings and other major structures in India. It carries both the advantages of rigid pile groups and flexible unpiled raft. Very little research work related to layered soil is available using pile-raft system. Present research work aims to study load-settlement characteristics response of pile-raft system embedded in uniform fine sand and layered soil using physical model approach. In this study, piled raft foundations which are subjected to static vertical compression load in uniform fine sand and also in the layered soil has been taken into account. The load settlement curve for each tests have been plotted to calculate ultimate bearing capacity. The behaviour of piled raft system was compared with responses of flexible unpiled raft, single pile, rigid pile groups. The results show that the effectiveness of the L/D ratio and number of piles used with and without raft in the uniform sand and layered soil. Significant increase in load bearing capacity is achieved when we increase the length of pile and also when we provide piled raft in place of only pile foundation.**

***Index Terms*—layered soil, rigid pile group, unpiled raft, piled raft.**

I. INTRODUCTION

In the design of foundations, shallow foundation is the first option where the top soil has sufficient bearing strength to carry the superstructure load without any significant total and differential settlements to prevent damage of infrastructure and superstructure.

Rafts are generally considered only as a “cap” which structurally connects the heads of the piles. However, the positive contribution of rafts to the load/settlement behavior is disregarded. As structural elements, rafts are mostly in contact with the soil, therefore has/have a capacity to transfer the load comes from the superstructure to the soil beneath. Considering this contribution (or load sharing), the total length of the piles may be significantly decreased. So, piled raft foundations become an alternative to the piled foundations or foundations with “settlement reducing piles” for an economic/feasible design.

Piled raft foundations consist of three elements; piles, raft and the subsoil. Therefore, it is essential to mention the behavior of piled raft foundations starting from the single piles, pile groups and the raft only. In this study, piled raft foundations with friction piles, which are subjected to static vertical compression load in uniform fine sand soil and also in the layered soil of kaoline clay and silt has been taken into account.

II. EXPERIMENTAL SETUP

Laboratory tests were performed on models of unpiled raft, single pile and piled raft to examine the settlement behavior of axially loaded pile raft system. The pile-raft model system is fabricated using aluminium material for the slenderness ratio L/D of 10 and 13 with suitable scale factor. The dimensions of raft are 160 mm * 160 mm with thickness as 8mm. Aluminium plates with fixed thickness of 8 mm served as model rafts. The outer diameter of pile is 19mm and inner diameter is 16mm with varying length of 190 mm and 250 mm. The modulus of elasticity and poisson’s ratio of the aluminium pipe were 70 GPa and 0.33 respectively. Top head of each pile was threaded to connect the pile to the cap to ensure a fixation between the pile and the cap. The centre to centre distance between the pile in pile group were twice the diameter of the pile. The tests were done using tank having 500 mm inside diameter and 500 mm height. The average relative density of sand kept up throughout all the tests is 70%.

To carry out the compression test on pile-raft system, the compressive load was applied by the use of mechanical jack. This mechanical jack was fixed at the inner side of the top section angle at equal distence from both extreme ends of loading frame. In compression test, proving ring of 1 tone capacity was used to measure compressive load.

The test was performed on uniform fine sand and layered soil. Height of soil sample in the tank was 420mm in both the cases. In the layered soil there were 3 layers, each having height of 140mm. The top and bottom soil in the layered soil case was uniform fine sandy soil and in the middle layer there was mixture of kaoline and silt in equal proportion.

The optimum moisture content and maximum dry density of kaoline clay and silt mixture used in layered soil was 18 % and 14.6 kN/m^3.

Figure 1: Experimental Setup

III. MATERIAL PROPERTIES

Properties of the material used for the research work is given below.

Table 1 Sand Properties

Specific Gravity	2.68
Cohesion	0
Angle of Internal Friction	39
Classification of Sand	SP (as per ISSCS)

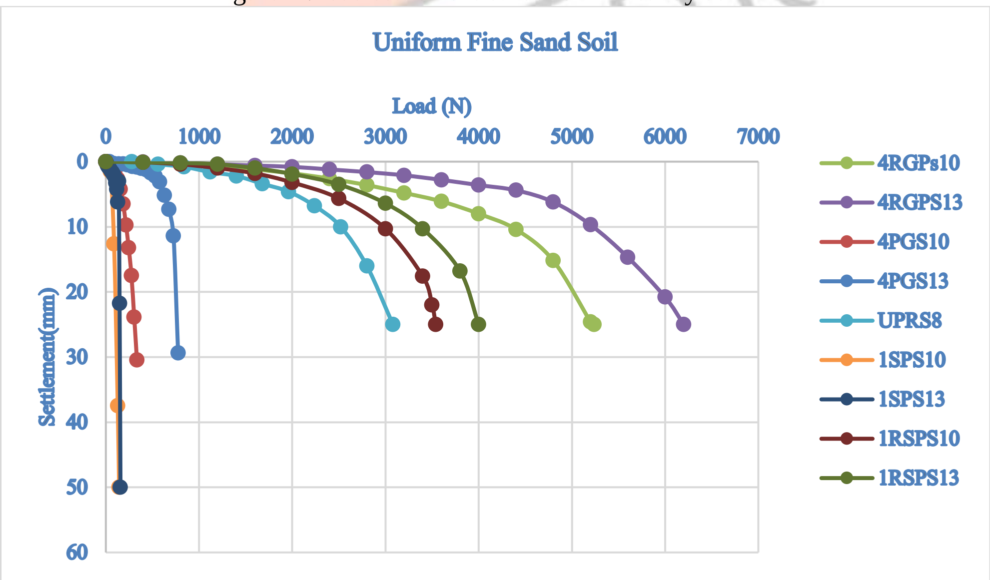
Table 2 Kaoline Properties

Liquid Limit	73.5 %
Plastic Limit	40.9 %
Plasticity Index	32.6 %
Specific Gravity	2.75
Classification	CH type, Clay of High Plasticity

IV. RESULTS

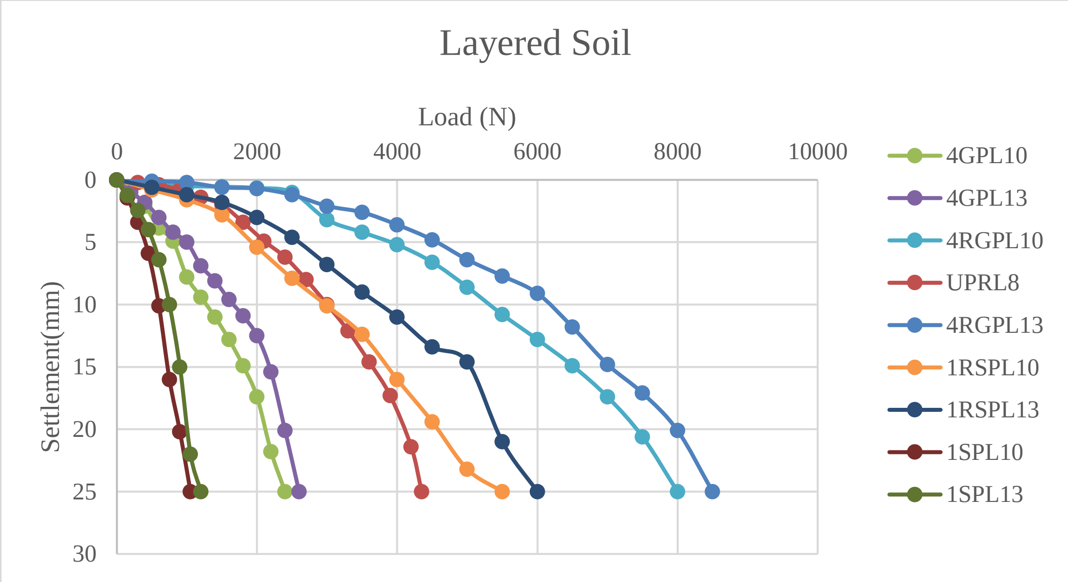
Load Settlement Curve in fine sandy soil

Figure 2 : load settlement curve for fine sandy soil



Load Settlement Curve in layered soil

Figure 3 : Load settlement curve for layered soil



V. Conclusions

- It has also been noticed, as the length of pile increases, the magnitude of compressive load increases for corresponding settlement. From the results it is evident that pile with higher slenderness ratio is more effective than pile with smaller slenderness ratio when embedded in medium dense uniform fine sand.
- The ultimate load carrying capacity of a pile group increases 110 % in uniform fine sand and 111% in layered soil as going from L/d ratio of 10 to 13
- The ultimate load carrying capacity of a single pile increases about 10% in uniform fine sand and 21.5 % in layered soil as going from l/d ratio of 10 to 13.
- Pile slenderness ratio has a considerable effect on the vertical load carrying capacity of pile and pile group.
- The ultimate load carrying capacity increases 5.8 times in uniform sand and 2.32 times in layered soil when we go for group of pile 4 instead of single pile at the slenderness ratio of 13.
- The ultimate load carrying capacity increases 2.51 times in uniform sand and 2.53 times in layered soil when we go for group of pile 4 instead of single pile at the slenderness ratio of 10.
- The ultimate bearing capacity of Unpiled raft in layered soil is 1.41 times the ultimate bearing capacity of the Unpiled raft in uniform fine sandy soil.
- The ultimate load carrying capacity increases 1.56 times in uniform sand and 2.27 times in layered soil when we go for (Raft + group of pile 4) instead of (Raft + single pile) at the slenderness ratio of 13.
- The ultimate load carrying capacity increases 1.47 times in uniform sand and 1.5 times in layered soil when we go for (Raft + group of pile 4) instead of (Raft + single pile) at the slenderness ratio of 10.

VI. Acknowledgment

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