EFFECT OF PILE DIAMETER AND LAYOUT ON THE PERFORMANCE OF PILED RAFT FOUNDATION

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ABSTRACT -Piled raft foundations are preferred, when raft or pile foundation alone cannot satisfy the settlement requirement in case of soil profile containing soft clays and loose sand. In the present study, laboratory model test were carried out to study the load settlement behaviour of piled raft on medium dense sand on a test tank size of 600mm x 600mm x 750mm. The model test was conducted on vertical steel piles of 3x3 configuration with 12mm diameter as base diameter. The raft sizes of 150mm x 150mm and 180mm x 180mm with each of 12mm thickness was used. Tests were also conducted by varying the diameter of corner piles and centre-edge piles using both 10mm and 16mm diameter piles while the other piles has 12mm diameter. The load settlement behaviour of all these model piled raft were observed and reported. Results showed that piled raft with different diameter piles can carry higher loads than the piled raft with equal diameter piles for the same amount of settlement. The change in layout of piles showed that when piles are spaced sufficiently apart, the load carrying capacity gets increased compared to that of closely spaced piles.

Key Words: Pile group, Vertical load, Settlement, Different configuration, Different diameter.

1. INTRODUCTION

1.1 General

A foundation system is the element of a structure which associates the ground to the superstructure. Foundation systems transfer the load safely into the soil ensuring overall stability and serviceability of the superstructures. There are different types of foundations designed to serve the varying needs of the structure intended to be constructed. They are mainly classified as shallow foundations and deep foundations. Shallow foundations are generally used for residential and comparatively less load carrying structures whereas deep foundations are employed where the load to be supported by the structure is large. The choice of the type of foundation system also depends on the soil strata in which it is to be founded.

The Deep foundation system employs vertical elements called piles to transfer the load from superstructure to the ground. It is well known that there are three principal foundation options to transfer heavy structural loads. They are Raft foundations, which is a type of shallow foundation, where loads are transferred to the ground via a foundation raft, the Pile foundation, where the loads are transferred to deeper bearing layers, and Piled raft foundations, in which the loads are partially transferred by piles and partially by raft. The main purpose of the piles in Piled Raft Foundation is to act as settlement reducers and the load carried by piles is considered as a secondary issue in the design. When compared with the conventional pile foundations, piled raft system provides more magnitude of allowable settlement, the factor of safety of the structure being the same.

1.2 The Concept Of Piled Raft Foundation

In situations where the performance of raft or pile alone is not sufficient to satisfy the design requirements, in order to control excessive differential settlements and to improve the ultimate load bearing capacity of the strata, a combination of Pile foundations and raft foundations, called the Piled raft foundation are used.The Load transfer mechanism in piled raft system is carried out by both raft and the pile. It is generally approximated that 60% of the total load is carried by the raft and 40% by the piles.The piles in combination with raft plays an important role in settlement reduction and can lead to economical design without compromising the factor of safety of the structure.

1.3 Small Scale Model Studies

Even though the use of piles and raft either independently or in combination is extensive, experimental studies on piled raft appear to be limited. The limited studies reported in the literature based on the small scale model studies relating to the behaviour of piled raft are grouped under following method of studies:

(1)1g model studies
(2)Centrifuge model studies

2. MATERIALS AND METHODS

2.1 Soil Sample

River sand was used as a foundation bed medium and the properties are listed below.

Table 1. Properties of sand

Properties	Values
Specific gravity	2.66
Coarse sand	2.2%
Medium sand	32.7%
Fine sand	63.7%
Silt and Clay	1.4%
D_{10}	0.22mm
D_{30}	0.35mm
D_{60}	0.55mm
Uniformity coefficient of the sand, C_u	2.50 (<6)
Coefficient of curvature, C_c	0.99 (<1-3)
Soil classification	Poorly graded sand (SP)

2.2 Steel plate and rods

Mild steel (Fe250) plates and rods having modulus of elasticity 2x 10^5 N/mm^2 are used.

Raft size: 150x 150mm,180x180mm

Pile diameter: 10mm, 12mm, 16mm

Pile length: 150mm

2.3 Methods

In our experimental study, model tests were conducted as a 1g model studies. In 1g model studies, all the tests were conducted on a one gravity value surrounding (normal condition in earth) but in the case of centrifuge model studies, small scale models were subjected to acceleration fields of many times earth's gravity.

2.4 Pile configurations

There are five different pile configurations were used in our experimental programme. The different pile group configurations are listed in the table-2.

Table 2. Pile group configuration details

Description	Diameter of Corner Piles (mm)	Diameter of Center Edge Piles (mm)	Diameter of Center Piles (mm)
Case-1	12	12	12
Case-2	10	12	12
Case-3	12	10	12
Case-4	16	12	12
Case-5	12	16	12

3. Experimental study

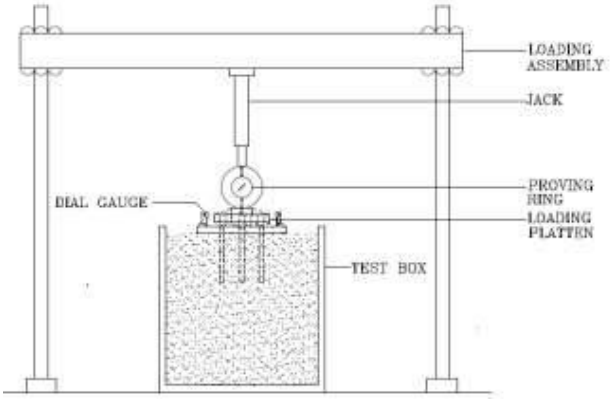

Fig. 1. Test setup

The above figure shows that the load setup arrangement to conduct the load vs settlement test on the piled rafts of two different sizes and having varying diameter of piles.

3.1 Graphs

3.1.1 COMPARISON OF ALL THE FIVE CASES INCASE OF 150mm X 150mm x 12mm SIZE PILED RAFT

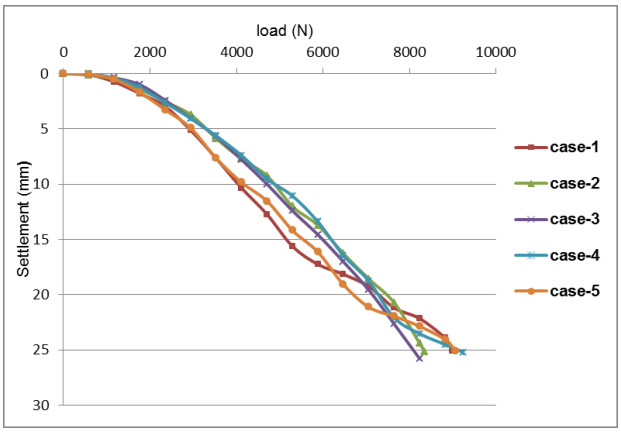

Fig .2. Load Vs Settlement for all the cases with raft size of 150 x 150 x 12 mm

All the five curves corresponding to the five different configurations are almost following the same type of path with smaller variations.

On comparing all the five cases incase of 150mm x 150mm raft size it was found that all the piled raft cases behaves in a similar pattern for a few mm of settlement and then showed variation. Among all the cases ,piled raft of case-4 carries a higher load.

3.1.2 COMPARISON OF ALL THE FIVE CASES INCASE OF 180mm X 180mm x 12mm SIZE PILED RAFT

Load vs settlement results of the all the five different configurations are compared and the configuration which is capable of carrying higher load was found.

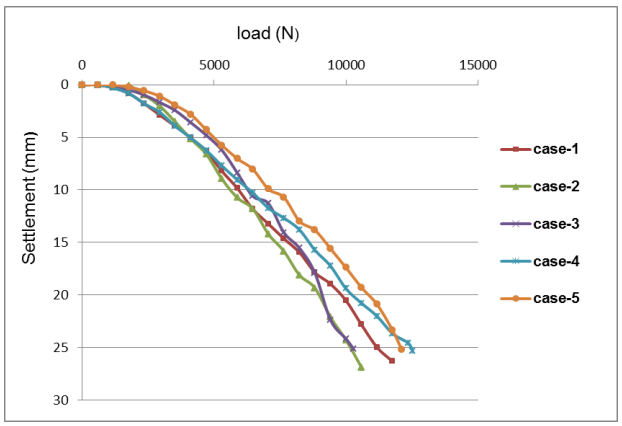

Fig .3. Load Vs Settlement for all the cases with raft size of 180 x 180 x 12 mm

When comparing all the cases of piled raft foundations we concluded that from the initial of the test to the ending of the test differently configured piled rafts showed a clear difference in their load settlement relationship. The piled raft having case-4 configuration showed a good result among the all the cases.

4. RESULTS AND DISCUSSION

From the experimental study of piled raft diameter and layout, Piled raft with raft size of 150mm x 150mm x 12mm and in the pile configuration of 3 x 3 having 12mm diameter piles with corner piles alone of 16mm diameter can carry 9235N for the permissible settlement of 25mm.

From the experimental study of piled raft diameter and layout, Piled raft with raft size of 180mm x 180mm x 12mm and in the pile configuration of 3 x 3 having 12mm diameter piles with corner piles alone of 16mm diameter can carry 12593N for the permissible settlement of 25mm.

DESCRIPTION	ULTIMATE LOAD (N)		%INCREASE IN LOAD
	150x150x12 mm	180x180x12 mm	
Case-1	9000	11765	30.72%
Case-2	8353	10588	26.76%
Case-3	8235	10294	25.00%
Case-4	9235	12593	36.36%
Case-5	9059	12118	33.78%

5. CONCLUSION

From the laboratory model test, the following conclusions are drawn:

- On comparing all the five configurations with two different raft sizes observed that the piled raft of size 180mm x 180mm x 12mm of corner piles of 16mm diameter with remaining piles 12mm diameter is capable of carrying higher loads.
- Piled raft carries higher load , when the larger diameter piles were placed in corner position. In the case with larger diameter piles placed in a center edge position the load carrying capacity reduces because in a piled raft frictional resistance is more in the outer ring piles irrespective of the intensity of the load. It is also observed that piles in the outer ring resist higher load than inner ring and centre piles. This is attributed to tributary area of the raft for the outer row piles being higher than inner row and centre piles.
- The change in layout of piles showed that when piles are spaced sufficiently apart, the load carrying capacity gets increased compared to that of closely spaced piles. At smaller pile spacing piled raft does not show any significant improvement of load sharing. However, at larger pile spacing there is increased in load sharing of the pile. This is because of no significant relative movement between the piles and soil in the case of less pile spacing, and the pressure bulb developed for each piles are interference and form a block foundation. However, in the case of larger piles spacing, individual performance of the piles can be fully utilised and activated.

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