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NUMERICAL ANALYSIS OF PILE RAFT WITH CUSHION AND WITHOUT CUSHION

Sreechithra P.[1], Niranjana K.[2],
[1]*PG student, Department of Civil Engineering,*
Thejus Engineering College,
Thrissur, Kerala
[2] *Assistant Professor, Department of Civil Engineering,*
Thejus Engineering College,
Thrissur, Kerala

Abstract: Due to invent of high rise building there was need to study and improve deep foundation system to reduce cost of foundation. Piled raft foundation proved to be economical in case of high rise buildings and can provide safe bearing capacity and serviceability requirements. A combination between the use of piles and raft foundation is known as piled raft foundation. The use of strategically located piles improves the load capacity of raft and reduces the differential settlement. In pile raft foundation, piles act as settlement reducers. Pile is disconnected from the raft and to treat these piles as reinforcement to subsoil rather than as structural member. Favorable conditions for unconnected pile raft are similar to that of connected pile raft. But unconnected pile raft foundation results less effective than pile raft foundation system. For to improve the efficiency provide geotextile casing around the cushion. This study reveals the performance of piled raft foundation in sandy soil through numerical analysis using Plaxis 3D.

Keywords: Pile raft system; Failure load; Settlement; Plaxis 3D.

1. Introduction

Foundation is a structural part of a building on which a building stands. Foundation transmits and distributes its own load and imposed loads to the soil in such a way that the load bearing capacity of the foundation bed is not exceeded. Mainly, Three well known foundation option to transfer heavy structural loads (1) raft foundations, where loads are transferred to the ground via a foundation raft, (2) pile foundations, where loads are transferred to deeper bearing layers, and (3) piled raft foundations, at which the loads are partially transferred by piles and partially by raft. In traditional foundation design, consider first the use of shallow foundation such as a raft. If it is not adequate, deep foundation such as a fully piled foundation is used instead. In the former, it is assumed that load of superstructure is transmitted to the underlying ground directly by the raft. In the latter, the entire design loads are assumed to be carried by the piles.

In recent decades, another alternative intermediate between shallow and deep foundation, what is called piled raft foundation or settlement reducing piles foundation, has been recognized by civil engineers. The concept of piled raft foundation was firstly proposed by Davis and Poulos. Soil strata consisting of relatively stiff clay or medium, dense sand is the favorable condition for pile raft foundation. Conversely, the unfavorable situations for piled raft include soil profiles containing soft clays near the surface, soft compressible layers at relatively shallow depths and some others. In the unfavorable cases, the raft might not be able to provide significant loading capacity, or long-term settlement of the compressible underlying layers might reduce the contribution of raft to the long-term stiffness of foundation. Many theories concerning the analysis of piled raft foundation have been proposed by various researchers.

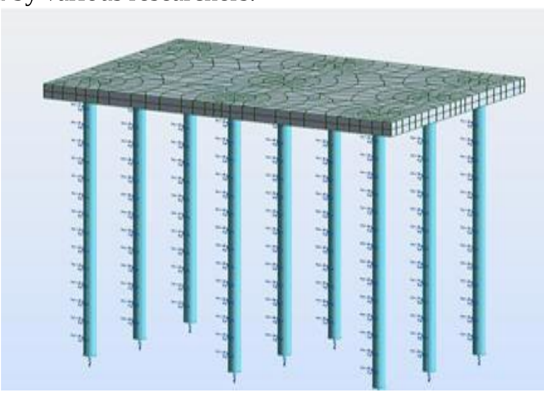

Figure 1 : Pile raft

The analysis of Piled raft is a complex problem, even more complex than that of a soil supported raft, as too many parameters influence the behavior of the system. But it is well known that the finite element method is very versatile for studying complex problems. In order to clarify behavior of the new type of foundation, especially the influences of cushion, resort to three-dimensional finite element method. Pile is disconnected from the raft and to treat these piles as reinforcement to subsoil rather than as structural member. Unconnected pile raft foundation is also a through researched method and it was found generally to be economical than connected pile raft foundation. Cushion, which is composed of sand-gravel mixture, gravel itself compacted in the layers between raft and top of piles, place an important role in mobilizing the bearing capacity of the subsoil and modify the load transfer mechanism of piles. Favorable conditions for unconnected pile raft are similar to that of connected pile raft. But unconnected pile raft foundation was found relatively less effective foundation system. Thus we provide geotextile casing around the cushion to increase the effiency. In an unconnected pile raft foundation system, the location of maximum axial load is shifted downwards to a certain length below the pile head and their important role in mobilizing the bearing capacity of the subsoil and modifying the load transfer mechanism of piles. Cushion is placed between raft and pile head. This study reveals the performance of piled raft foundation in sandy soil with and without cushion carried through experimental and numerical analysis using plaxis 3D.This study reveals the performance of piled raft foundation in sandy soil with and without cushion carried through experimental and numerical analysis using PLAXIS 3D. PLAXIS 3D is a finite element package intended for three-dimensional analysis of deformation and stability in geotechnical engineering. It is equipped with features to deal with various aspects of complex geotechnical structures and construction processes using robust and theoretically sound computational procedures

2. Previous Study

Numerous researchers were conducted study on pile raft. From the literature survey important points are follows. From the literature survey important points are follows. Piled raft foundation is a combination of the piles and the raft, which has every qualification of good integrity, stiffness and high capacity. Soil conditions, load distribution, quantity and location of piles were important factors in raft foundation design. Use of long piles underneath the heavily loaded area can help to minimize the risk of tilting as well as to reduce the overall and differential settlements. Pile diameter, length and raft thickness increases results decrease in total and differential settlement up to a optimum point. Piled raft is very beneficial to be used as settlement reducer. For an economic design, it is necessary to consider the optimum number of piles in piled raft foundation system based on the allowable settlements.Recently, the significant computing and memory resources available to the geotechnical engineer, combined with low cost, have made the Finite element Method (FEM) a powerful, viable alternative. The modeling of piles in a 2D finite element as a plate has limitation to model the pile-soil interaction, which is strongly 3D phenomenon.

3. Materials and Methodology

The Index and Engineering properties of sand used for the study was determined as per IS specifications. The sand was collected from Pavaratty, Thrissur. The Tests were conducted on a model tank of mild steel with dimension 0.75 m x 0.75 m x 0.65m. The raft was modeled by a square Perspex plate of side dimensions 0.150m and 0.006m in thickness. Circular piles of 10 mm diameter at three different lengths of 120mm, 150mm and 187.5mm were inserted in the holes. The arrangement of pile-raft system is shown in figure 2.

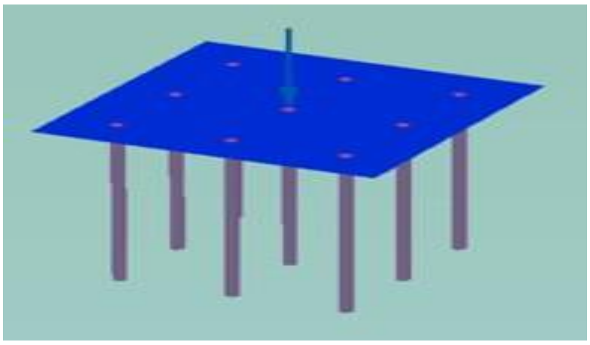

Figure 2 : Model of pile raft

Cushion, which is composed of sand-gravel mixture, gravel itself compacted in the layers between raft and top of piles. The arrangement of pile-raft system is shown in figure 3.

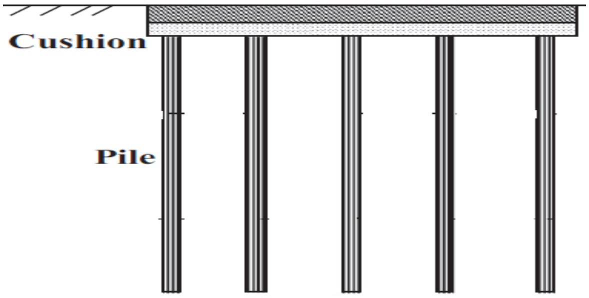

Figure 3 : Pile raft with cushion

Table 1: Properties of sand

PROPERTIES	VALUE
Specific gravity	2.66
Particle size distribution Percentage of gravel (%) Percentage of sand (%) Percentage of fines (%)	 0 96.5 3.5
Angle of internal friction(degree)	36
Relative density(%)	40
Minimum dry density(kN/m^3)	14.84
Maximum dry density(kN/m^3)	17.66

4. Finite Element Anlaysis

PLAXIS 3D was used in the study to model the pile raft system. To simulate the behavior of soil, different constitutive models are available in the software. In the present study the soil behavior is simulated by Mohr- Coulomb model. Medium meshing is adopted in all the simulations.The input parameters of soil used in the test and the input parameter for model pile raft footing are shown in TABLE 2.

Table 2: Input parameters of soil

PROPERTIES	VALUE
SAND	
Modulus of elasticity ,E(kN/m^2)	30000
Poisson's ratio(μ)	0.3
Cohesion, C (kN/m²)	1
Angle of internal friction,ϕ (degree)	36
Dilatancy angle,ψ (degree)	6
FOOTING	
Modulus of elasticity ,E (kN/m^2)	2.5x10^6

Poisson's ratio(μ)	0.38
Pile length (m)	0.120, 0.150, 0.1875
Raft Thickness	.006

Table 3: Input parameters of geotextile

PROPERTIES	VALUES
Axial stiffness, EA (kN/m)	1300

The piles are arranged in 3X3 grid pattern with spacing 5 times the diameter of the pile. The various combination are named as combination 1,2,3,4,5,6 and 7 respectively.

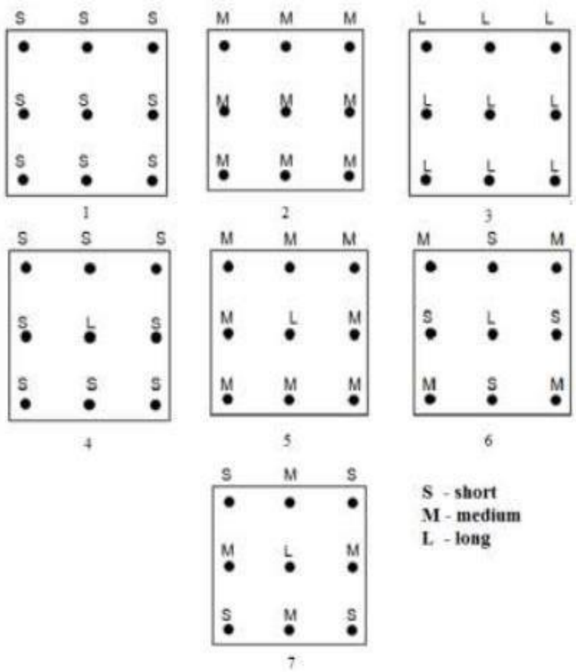

Figure 4: Different combination of pile raft

5. Results Of Numerical Analysis

To study the behavior of the pile group with varying pile length seven combinations of pile configuration have been studied.

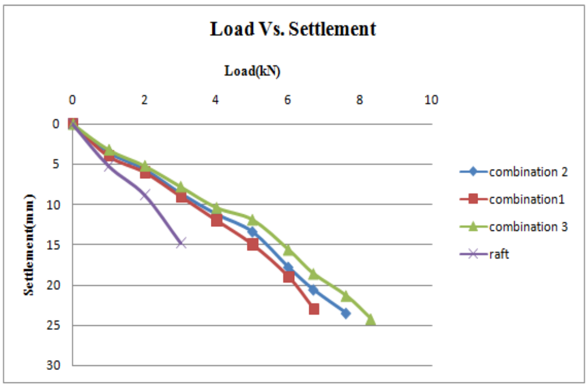

Figure 5: Load settlement graph of pile raft without cushion - combination 1,2,3

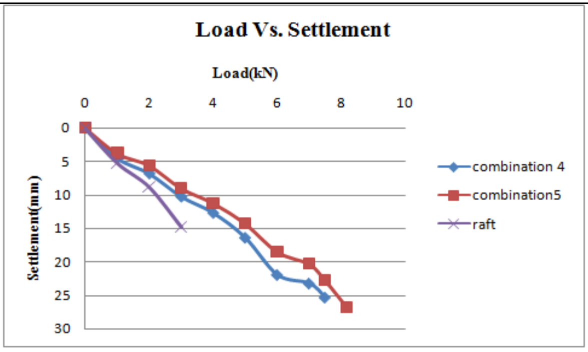

Figure 6: Load settlement graph of pile raft without cushion -combination 4,5

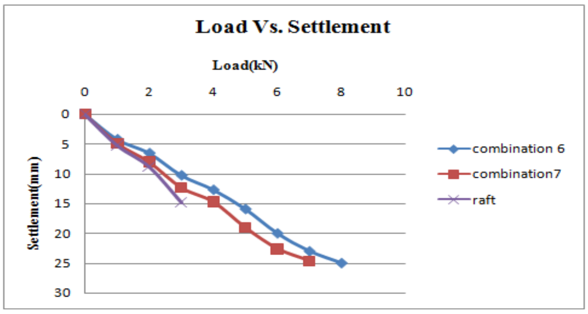

Figure 7: Load settlement graph of pile raft without cushion -combination 6,7

Comparing combination 1,2and 3, it is found that length increases the capacity of pile raft also increases. From the results, combination 6 showed better results. As a part of cost of construction combination 3 not become a suitable one. Also when compared to combination 5 and 6, number of shorter pile is more in combination 6 thus reduces the cost of construction because there is no greater difference in failure loads.

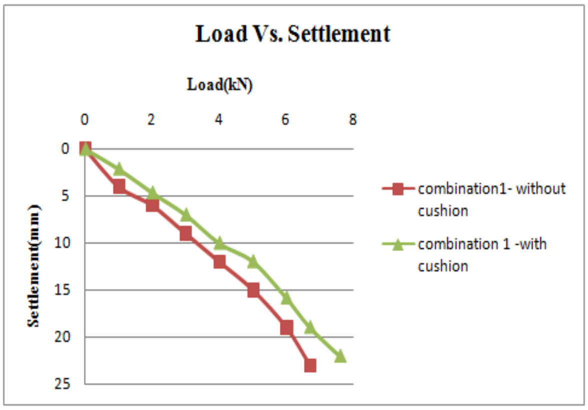

Figure 8: Load settlement graph of pile raft with cushion - combination 1

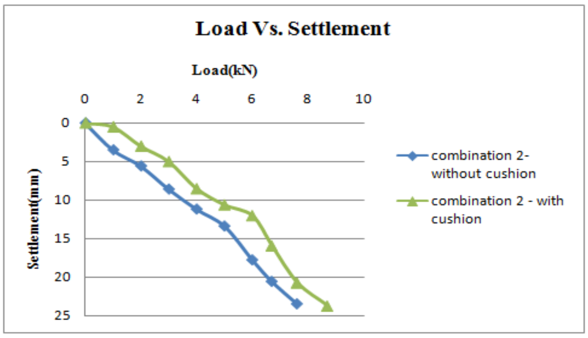

Figure 9: Load settlement graph of pile raft with cushion – combination 2

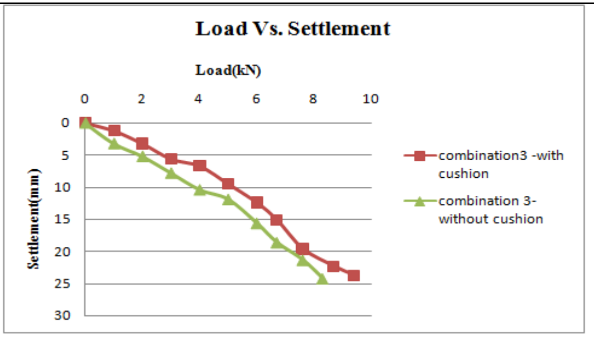

Figure 10: Load settlement graph of pile raft with cushion - combination 3

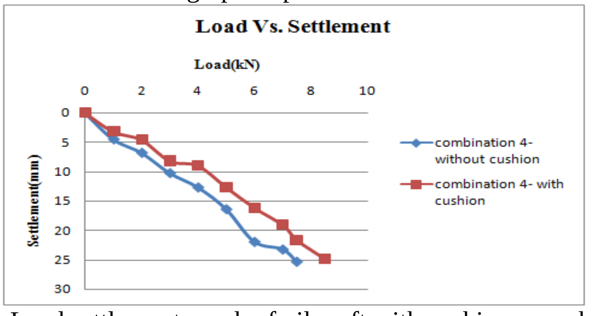

Figure 11: Load settlement graph of pile raft with cushion - combination 4

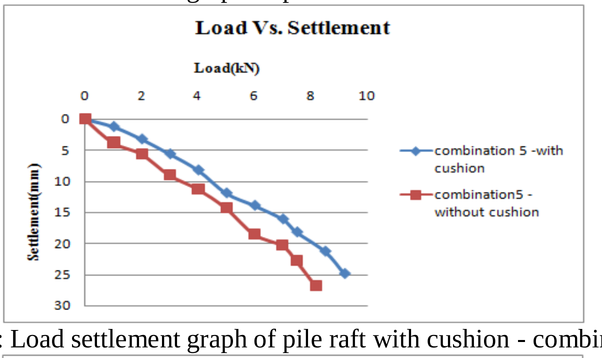

Figure 12: Load settlement graph of pile raft with cushion - combination 5

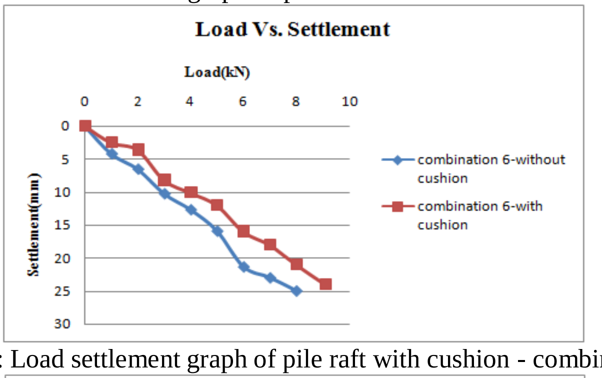

Figure 13: Load settlement graph of pile raft with cushion - combination 6

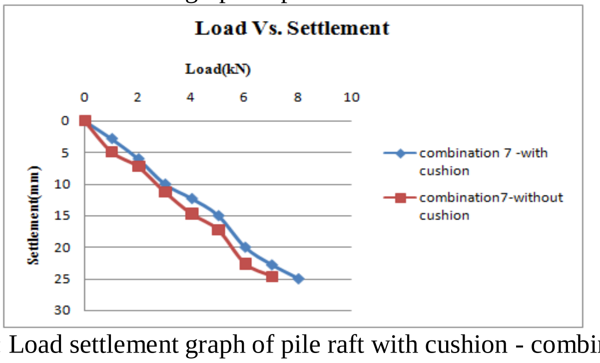

Figure 14: Load settlement graph of pile raft with cushion - combination 7

From the lab results, pile raft with cushion shows tremendous decrease in settlement. Important role in mobilizing the bearing capacity of the subsoil and mobilizing the load transfer mechanism of piles. Long piles underneath the heavily loaded area helps to minimize the risk of tilting as well as to reduce the overall and differential settlements. Combination 6 shows better result

6. Conclusion

From the study, it was observed that as the length of the pile increases failure load also increases. And load sharing behavior is better for pile raft when compared to plain raft. Connecting pile with different arrangement shows better results. Pile raft with encased geotextile cushion shows better results when compared to pile raft without cushion. Thus we can reduce the cost of construction by limiting number of long piles.

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