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Effect of Change in Thickness of Raft & Grade of Concreteon Bearing Capacity of Piled Raft Foundation

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Abstract: Piled raft foundation is an economical foundation system where the bearing capacity of the raft is taken into consideration in supporting the loads from superstructure. The piles in a piled raft system are used to enhance the bearing capacity of the raft and also to control settlement, especially differential settlement and hence, these piles are commonly known as ''settlement reducing piles''. In this paper nonlinear finite difference analysis was carried out to model the piled raft problems using the commercial software "CSI SAFE." A comprehensive parametric study was performed on a piled raft. The variation was made in thickness of raft & grade of concrete of raft. The effect of these variables upon the average settlement and differential settlement was studied.
Keywords: Piled raft foundation, Pile Raft Interaction, silty clay soil, 3D modelling, finite element analysis.

I. INTRODUCTION

Piled raft foundation is a foundation that implements the piles as elements used for enhancing the behaviour of the raft to satisfy the design requirements, and they are not considered as carriers for the total structural load. The design requirements may be related to the settlement control or increasing the ultimate bearing capacity of the foundation. Since the main purpose of the piles in the majority of piled foundations is to limit settlement, then the piles in the piled raft will serve mainly as settlement reducers. The piled raft foundation has a complex behaviour involving different interactions between its various components. Therefore, a proper analytical model is needed to evaluate these interactions. Numerical methods, which are approximate, have been developed widely in the last two decades because numerical methods are less costly and may be used to consider many kinds of different soil and foundation geometries compared to field and model tests. The overall objective of this study focuses on investigating the behaviour of the piled raft foundation system by changing of parameters such as thickness of raft & grade of concrete of raft. The concluded observations from the parametric study aims at helping the engineers in taking a logical path in an iterative design process for a piled raft foundation.

II. PILE RAFT INTERACTION

Very often, the deep foundation elements are only placed beneath portions of a foundation & are intended to carry only a portion of the superstructure load. Thus this is fundamentally different from foundation application where the piles or shafts are placed beneath the entire foundation & are assumed to carry all loads. An additional unique aspect of the piled raft concept is that the deep foundation elements are sometimes designed to reach their ultimate geotechnical axial compressive capacity under service loads.
A piled raft is a foundation which acts as a composite construction consisting of three load
bearing elements viz. piles, raft and subsoil. According to its stiffness, the raft distributes the total load of the structure as contact pressure and over the piles in the ground. The piled raft concept needs evaluation of a number of factors in order to come up with analysis & design models that simulate the actual site conditions. A piled raft foundation is assumed to have four kinds of interactions. These interactions are Pile- Pile, Pile-Raft, Pile-Soil and Raft-Soil (Fig 1). A model for full analysis and design of piled raft foundations has to predict these interactions accurately.
With increasing raft settlement, the vertical and the horizontal stress states change (Interaction 3). Due to a higher stress state of the soil, the ultimate shear strength of the soil and thus the bearing capacity of the pile increase (Pile-Raft Interaction). When the pile spacing is small, the Pile-Pile interaction additionally has to be taken into account. The requirements of the interactions 1 – 4 can only be satisfied by a three dimensional model of the total structure.

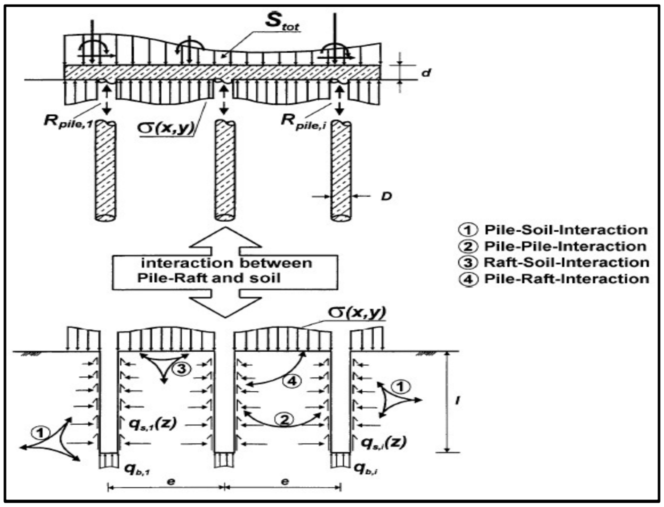

Figure I: Pile raft & soil interaction

III. PROJECT RESOURCES

The work of soil investigation was comprised of five trial boreholes developed using rotary wash boring technique. It is noteworthy that the strength and geotechnical parameters of experiments on which results are based on are presented in the table below. The values of dry density (DD), uniaxial compressive strength (UCS), specific gravity (SG), water absorption (WA), porosity (PST) of each sample are mentioned below.

Table i:
Rock Classes With Respect To Dry Density & Porosity

Class	DD (gm/cm^3)	Descriptio n	PST (%)	Descripti on
1.	> 1.80	Very Low	> 30	Very high
2.	1.80 - 2.20	Low	30-15	High
3.	2.20 - 2.55	Moderate	15-5	Medium
4.	2.55 - 2.75	High	5-1	Low
5.	Over 2.75	Very high	< 1	Very Low

Table ii:
Rock Test Data

Sr. No.	Core No.	UCS (Kg/cm^2)	SG	WA %	PST %	L/D Ratio
1.	30	597.00	2.73	0.04	0.12	1.94
2.	46	636.00	2.75	0.23	0.61	1.87
3.	34	1444.00	2.86	0.03	0.08	1.98
4.	17	1253.00	2.75	0.11	0.30	1.89
5.	21	1356.00	2.75	0.07	0.20	1.85

IV. PARAMETRIC STUDY

A comprehensive parametric study was performed to study the behaviour of piled raft foundation founded on suitable subsoil conditions and using variable thickness& grade of concrete for raft. The pile configurations involved uniform concentration below raft & total of 323 piles were used with uniform socketing length of pile of 4D.

The raft used in the parametric study is square in plan with dimensions of 25 X 25 meters and varying thickness equals 1.2& 1.5 meter. Pile configurations were kept constant throughout the study involving 323number circular piles. The pile diameter used was 0.6 m for all cases in the study. Also uniform socketing length 2D was used throughout the study. Both the raft and the piles are

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made from reinforced concrete which is modelled as a linear elastic material. In order to get the maximum values of settlement and straining actions, all the analyses throughout the present study were effective drained analyses.

V. DETAILS OF MODEL

The present study determined the ultimate bearing capacity, a raft of thickness 1.2m & 1.5m cylindrical concrete piles with a diameter of 0.6m and uniform socketing length of 2D under different conditions as a primary base model are considered. Note that the details of piles is considered according to software guidance for concrete type to provide a Poison's ratio equal to 0.15. Young's module is equal to 2.1 X 10^5 MPa and pile density is equal to 25kN/m^3. So according to the above, piled raft foundation modelled in soil has been studied to investigate the effect of length to diameter ratio on the bearing capacity of the piled raft foundation.

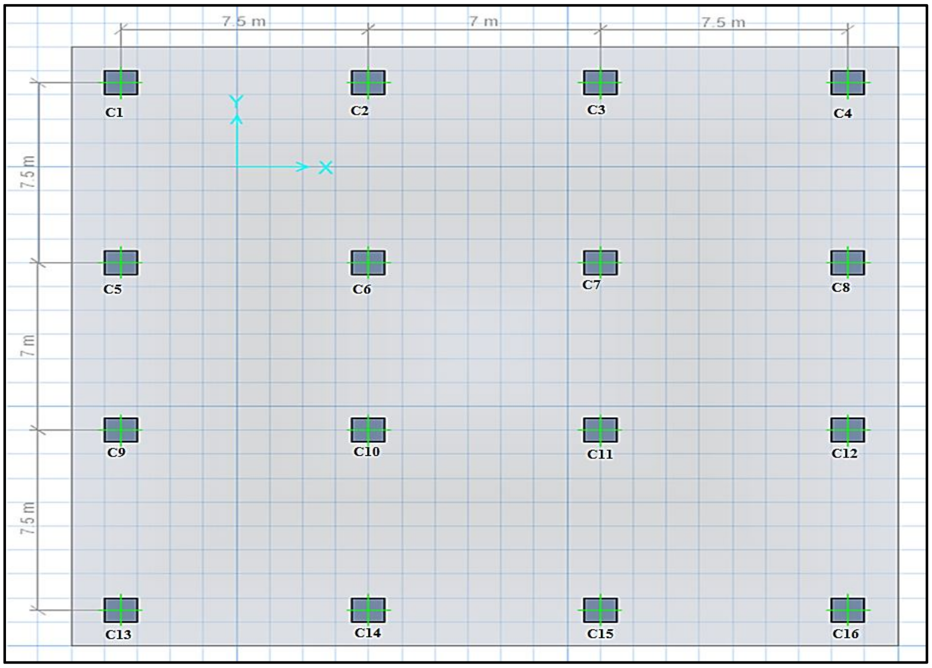

Figure ii: Plan of raft foundation & column location

VI. RESULTS & SOFTWARE OUTPUTS

The results of this study shows the increment in the thickness of raft tends to increment in ultimate bearing capacity of pile draft foundation by considerable value, but the change or increment in grade of concrete does not contribute any changes in ultimate bearing capacity.

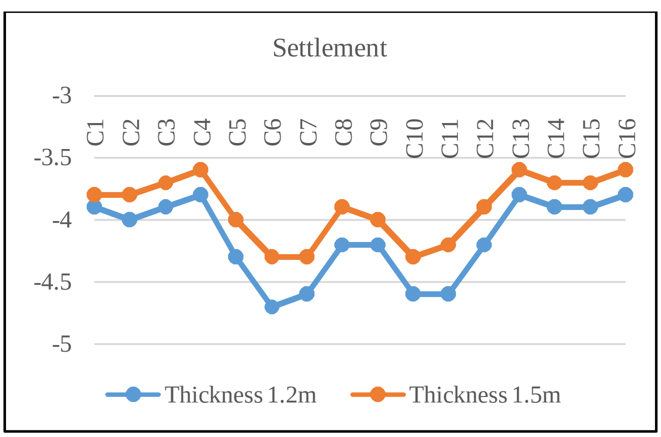

Figure iii: Settlement curve for raft thickness of 1.2m & 1.5m for m45 grade of concrete.

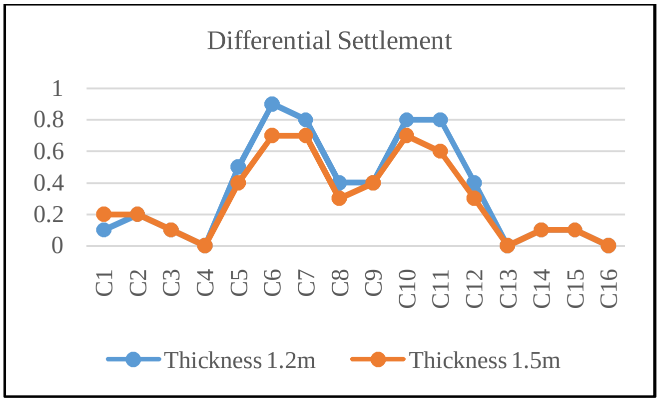

Figure iv: Differential settlement curve for raft thickness of 1.2m & 1.5m for m45 grade of concrete.

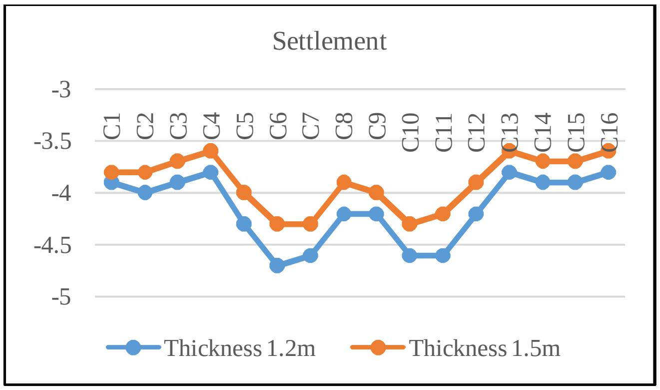

Figure v: Settlement curve for raft thickness of 1.2m & 1.5m for m60 grade of concrete.

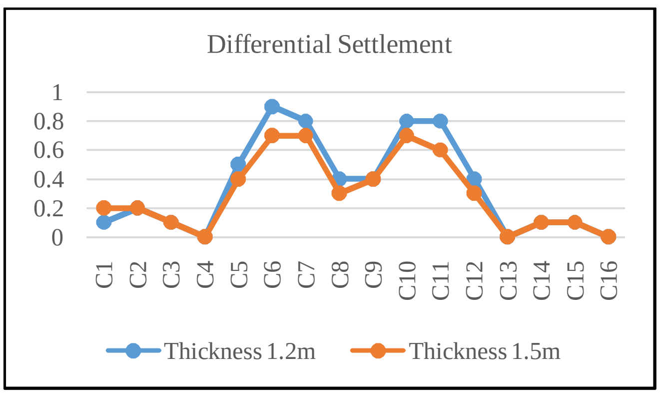

Figure vi: Differential settlement curve for raft thickness of 1.2m & 1.5m for m60 grade of concrete.

VII. CONCLUSIONS

A. The three dimensional finite difference modelling of piled raft foundation proved to be an efficient tool for analysing real piled raft systems.

B. Increasing thickness of raft has a significant effect on the piled raft average settlement and differential settlement between raft and piles.

C. There is no effect of increment or change in grade of concrete on ultimate bearing capacity of foundation.

D. The average and differential settlements of the piled raft are dependent on the combination of pile & raft geometries; thus the design of pile raft geometries should be carefully considered to satisfy the both settlement criterion.

E. In the case where pile length is restricted, the optimum performance is likely to be achieved by increasing the thickness of raft in piled raft foundation.

VIII. ACKNOWLEDGEMENT

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