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RESEARCH ARTICLE OPEN ACCESS

Settlement Analysis of Raft Foundation Embedded With Winged Piles

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Abstract:

Technological advancements and recent developments are increasing in the construction field. This creates more development in foundations as well. Nowadays, more land is required for the construction of buildings due to high population. Therefore, sometimes weak ground and coastal regions are chosen for construction purposes. A strong foundation is essential for all buildings. Therefore, in weak soil and heavy load structure conditions, a piled raft foundation is more suitable. A piled raft foundation gives the combined effect of both a pile and raft foundation. This study mainly focuses on settlement analysis of a modified piled raft foundation, specifically a winged piled raft foundation, with various thicknesses of raft. From this study, it was found that settlement decreases as the thickness of the raft foundation embedded with winged piles increases.

Keywords **— raft, piled raft, winged piled raft, settlement**

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I. INTRODUCTION

In the design and construction of any structure, the role of soil is crucial. As the soil is in direct contact with the structure, it serves as a medium for load transfer. Therefore, when analyzing the forces acting on a structure, consider the distribution of stress through the soil as the stability of the structure depends on soil properties. Constructing a building in poorly graded soil, especially sandy soil is very complex. The arrangement of voids, particle distributions and other properties creates additional problems such as settlement. In today's world, a strong foundation is essential for effectively distributing loads and minimizing settlement. In this regard, raft foundations are particularly advantageous for large structures as they can withstand horizontal loads. In the case of pile foundations which are better suited for tall buildings, they provide support in sandy soils.

The piled raft foundation is a combined system of piles and a raft. Both components share the load of the structures. This type of foundation is mainly used in weak and compressible strata, areas with a high water table, and for high-rise buildings. The advantages of the piled raft foundation include reducing settlement, providing a combined effect of pile and raft foundation, resisting various loads, especially lateral loads, and reducing environmental impact.

In this scenario, modified pile and raft combinations are required in the construction field. Winged pile is a modified form of pile and it is a type of precast pile. In a winged piled raft foundation, wings are fixed in a vertical manner on the pile. It is a directly driven pile. The area of interaction of a winged pile with soil is high, so it is effective in weak soils.

II METHODOLOGY

The purpose of the study is to analyze the settlement of raft, piled raft, and winged piled raft foundations with varying thicknesses. In this study, raft foundations with thicknesses of 8, 10, and 12 mm are used.

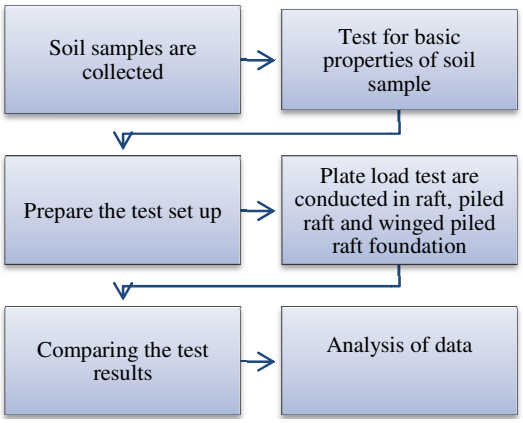

Fig-1: Flow chart of methodology

III MATERIALS USED

The soil sample is collected from Trivandrum, and its basic geotechnical properties are determined through various experimental tests.

Table 1 :Properties of sandy soil

Sl no	Properties	Soil
1	Specific gravity	2.616
2	Percentage of sand	98.98%
3	Percentage of gravel	0.7%
4	Percentage of silt and clay	0.32%
5	Cu	3.35
6	Cc	1.1
7	Water content	3.59
8	Percentage of bulking	12.36%
9	Optimum moisture content	8%
10	Dry density, (ρ_d)	1.36 g/cc
11	Percentage of voids	25.19%
12	bulk density(loose state)	1.96 g/cc
13	bulk density(dense state)	2.137 g/cc
14	Cohesion, C	0.03 Kg/cm^2
15	Angle of internal friction,Ø	27^0
16	Relative Density	2.55 %

The mild steel plate is used as a raft foundation. The density of the raft foundation is 7.85 g/cc. The dimensions of the raft foundation are 120 x 120 mm. A square shape is used to determine the settlement. The thickness of the raft foundation is respectively 8mm, 10mm, and 12mm.

A piled raft foundation is a combination of a pile and a raft foundation. The diameter of the pile is 10 mm. The length of the pile is five times its diameter, which is 50 mm. The center-to-center spacing of the pile is seven times its diameter, which is 70 mm. The distance between the edge and the center of the pile is 2.5 times its diameter, which is 25 mm. Four piles are fixed on a raft. All piles are of the same dimension. Here, three types of piled raft foundation are provided with varying raft thickness. Three different thicknesses are provided, which are 8mm, 10mm, and 12mm respectively.

Galvanized iron sheet is used as a wing. The width of the wing is two times diameter of pile, which is 20 mm. The wing thickness is 2 mm. The length of the wing is three times the diameter of pile i.e., 30 mm. wings are placed at bottom. Raft thicknesses of 8mm, 10mm, and 12mm are used. 8mm, 10mm, and 12mm raft thicknesses are used to analyze the settlement behavior of a winged piled raft foundation with varying thickness.

Fig-1: Winged - piled raft foundation (8, 10 and12 mm raft thickness)

IV EXPERIMENTAL SETUP

The procedure for the plate load test is as follows: Sand is prepared for testing with an optimum moisture content, which means that 8% is used as the optimum moisture content. Optimal moisture content is achieved through sand bulking. Then, a raft with varying thickness and a pile raft foundation with varying thickness are placed over the sand. After that, the load is applied to the raft foundation. Here, a spacer is used to adjust the space between the raft and the plate load apparatus.

4.1 Raft foundation

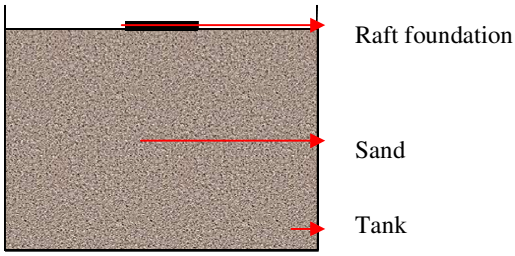

Fig 2: Installation of raft foundation

Sand is mixed with water having optimum moisture content, then it is filled in a tank and compaction is provided layer by layer. A raft is placed over the sand. Then load is applied using a hydraulic jack.

4.2 Piled raft foundation

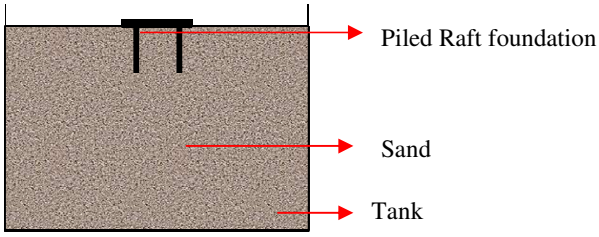

Fig 3: Installation of piled raft foundation

Piled raft foundation is a directly driven foundation; additional boring is not required. After filling sand in the same manner during raft installation, the piled raft is directly driven into the sand and load is applied. Spacer is provided for effective load distribution.

4.3 Winged piled raft foundation

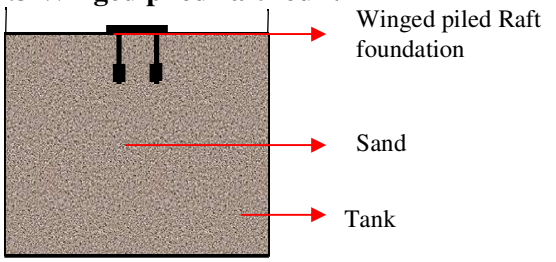

Fig 4: Installation of winged piled raft foundation

After filling the tank with sand, the winged piled raft foundation is directly driven and then the load is applied.

IV RESULTS AND DISCUSSION

A settlement analysis of a winged piled raft foundation is conducted because it is a direct-driven pile and torque is not required, making it economical and easier to install than a helical piled raft foundation. The test includes a raft foundation embedded with winged piles with various raft thicknesses of 8mm, 10mm, and 12mm, respectively. The other dimensions of the raft are kept constant.

Parameters of wing	*Test1*	*Test 2*	*Test 3*
Raft Thickness	8 mm	10 mm	12 mm
Length	30 mm	30 mm	30 mm
Width	20 mm	20 mm	20 mm
Thickness	2 mm	2 mm	2 mm
Position	Bottom	Bottom	Bottom
number	4	4	4
shape	Square (90^0)	Square (90^0)	Square (90^0)

Settlement analysis of winged piled - raft foundation

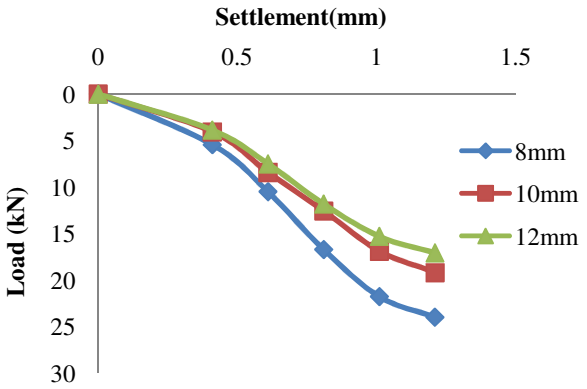

Fig 5: Graphical representation of winged piled raft foundation

Settlement analysis of 8 mm thickness raft, piled raft and winged piled raft foundation

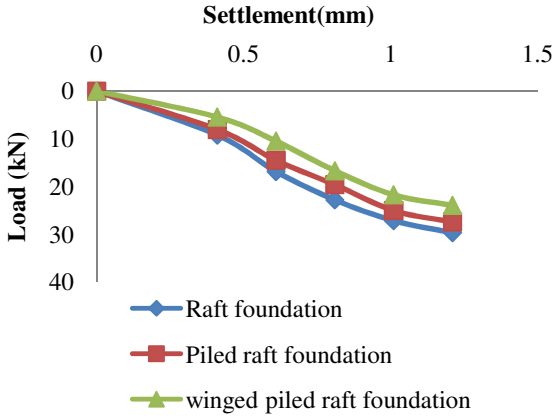

Fig 6: Graphical representation of settlement analysis of 8 mm thickness raft, piled raft and winged piled raft foundation

Settlement analysis of 10 mm thickness raft, piled raft and winged piled raft foundation

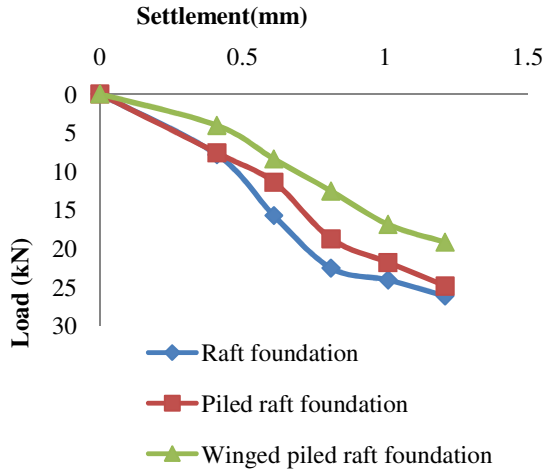

Fig 7: Graphical representation of settlement analysis of 10 mm thickness raft, piled raft and winged piled raft foundation

Settlement analysis of 12 mm thickness raft, piled raft and winged piled raft foundation

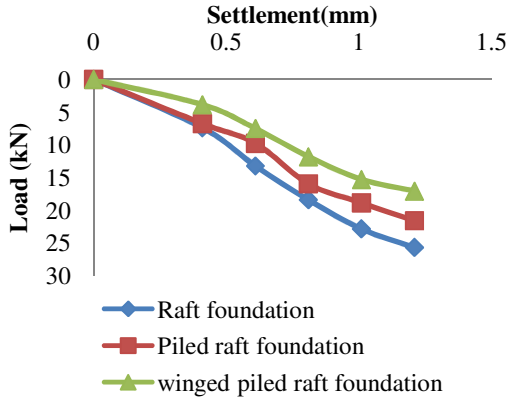

Fig 8: Graphical representation of settlement analysis of 12 mm thickness raft, piled raft and winged piled raft foundation.

The winged piled raft foundation effectively influences settlement. Settlement is reduced when the thickness of the raft foundation embedded with winged piles increases. 28.9% of settlement is reduced from an 8 mm thickness winged piled raft foundation to a 12 mm winged piled raft foundation. Due to the wing, the soil holding capacity of the foundation is higher. Raft is provided on winged piles so that the load of superstructures is partially shared by the raft and piles. Therefore, the depth of the winged pile is minimized to compensate for settlement by adopting a raft. Here, all parameters of the wing, as well as the raft thickness, almost equally influence the settlement. Raft foundation plays a crucial role in load distribution. Both raft and pile foundations share the loads of the superstructure. The maximum settlement occurs in a raft foundation, while the minimum settlement occurs in a raft foundation embedded with winged piles. Similarly, as the thickness of the raft foundation increases, settlement is reduced. Therefore, an 8 mm raft foundation has maximum settlement, while a 12 mm raft foundation has minimum settlement.

V CONCLUSIONS

In this study, it is evident that the collected sand is a poorly graded sand. An increase in the thickness of the raft, piled raft, and winged piled

raft foundation leads to a reduction in settlement. The settlement of a piled raft foundation is lower than that of a raft foundation. The winged piled raft foundation also influences the reduction of settlement with varying raft thickness. Percentage settlement reduction of winged piled raft foundation from raft foundation (12 mm thicken raft) is 33.55 %.The percentage reduction in settlement for a winged piled raft foundation compared to an 8 mm raft foundation is 42.62% .

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