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Load Settlement Behaviour of Pile-Raft Foundation in Cohesionless Soil

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Abstract: Pile-raft foundation is a modern approach in place of conservative method for multi-storey buildings or in some special circumstances. In pile-raft analysis the load settlement behaviour of pile foundation, raft foundation and combination of pile-raft foundation is determined. The use of combination of pile-raft is basically a new technique for economy of foundation resting on the sand. Model Study is carried out to determine the suitability of the pile raft foundation for sand. In this modal study we have studied load deflection behavior of pile-raft foundation by making a prototype of a footing and applying a static load in each case and settlement of footing is noted in 2 dial gauges fixed at alternate edges of footing. As an observation the settlement behaviour of pile-raft foundation is being found less as compared to other two types of foundations tested. The pile-raft foundation is very important and helpful for everyone because if we have soil of low bearing capacity then stabilization of soil is need to be done using different material but the use of pile-raft in sand can eliminate this kind of expenses occurs during construction.

Keywords: Raft, Pile, Load settlement.

I. INTRODUCTION

The raft foundation or mat foundation is that type of only pile foundation. This is suitable for sandy soil in loose state because in loose sand settlement will be more.

II. OBJECTIVES OF THE PRESENT STUDY

The objective of the above research is based on different type of foundation:

1. To determine the load settlement behavior of raft foundation.
2. To determine the load settlement behavior of pile foundation.[14]
3. To determine the load settlement behavior pile-raft foundation.
4. To evaluate the type of foundation suitable for sandy strata.

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III. MATERIALS USED

In order for carrying out the study for load settlement behaviour of pile, raft, pile-raft foundation in soil media i.e. sand and to carry out the further testing[3],[10],[11], following materials are being collected and used –

1. Sand
2. Glass tank
3. Metal rods (diameter=18mm, thickness=1mm)

foundation which support the number of rows of the columns to transmit the load of superstructure to the weakest soil[4]. It reduces the differential settlement caused due to load of superstructure because concrete slab can resist the differential settlement between loading positions. This type of foundation can spread load over large areamloose or soil of low bearing capacity. Pile foundation (long slender column) can be adopted for the soil of low bearing capacity and the hard strata is so deep, use of shallow foundation is not economical[4],[9],[8]. The pile foundation is so expensive as compare to shallow foundations so it can be adopted only in some special circumstances i.e. when the shallow foundation is not feasible to use.To overcome the above problem, the pile raft foundation or a combination of pile and raft foundation is introduced. In this combination pile raft foundation the load of the structure is distributed on both the piles and raft. Load is partly taken by the raft resting on the soil and the remaining load is taken by the piles through skin friction. The pile raft is more economical aas compared to indivual pile foundation because in combination of pile and raft the piles are partly or fully penetrate but to a lesser depth then inSand- The Sand which is being used is collected from the River Markanda at Mullana, Ambala. The organic matter is removed by washing of sand and sieving. Then the sand is kept for oven drying for 24 hours and properly sieved from 4.75 mm and retained in pan after passing from 75 µ sieve and used for carry out further testing.

1. Tank used can be made of glass of 8mm thick of size50cmx30cmx30cm.
2. Hollow Metal rods used as for piles are made of galvanized iron of having modulus of elasticity of 45GPa.

IV.EXPERIMENTAL TESTING

According to the above objectives described of this study, an experimental setup is prepared for carrying out the further testing and to analysed the load settlement behavior of pile, raft, pile-raft foundation. In order to analysed this; the modal for the laboratory used has been prepared.

The footing model is assumed to be square in shape made up of concrete M25and therefore, three footings proto-type are casted for testing. The first footing prepared is the raftfooting of dimension (24cmx24cmx3cm).The second footing casted is pile foundation also of dimensions (24cmx24cmx3cm) and four piles are embedded to a depth of 2cm and the length of pile used is 24cm.The third footing casted is pile-raft foundation of the similar dimensions(24cmx24cmx3cm) and four piles are embedded to a depth of 2cm and the length of pile used is 28cmof size 30 cm × 19 cm × 2.5 cm are used. Preparation of the testing bed - An unbreakable glass tank of size 50 cm × 30 cm × 40 cm is made for the test purpose. Then the further testing is carried in the tank for different types of foundations on sand (Fig-1).In order to maintain the uniform density of sand in whole experiment, a funnel is being used to fill the sand into the tank near the surface to maintain loose condition also. The soil is filled into the box in layers. The top surface of sand bed is made flat using a straight edge made of wood.

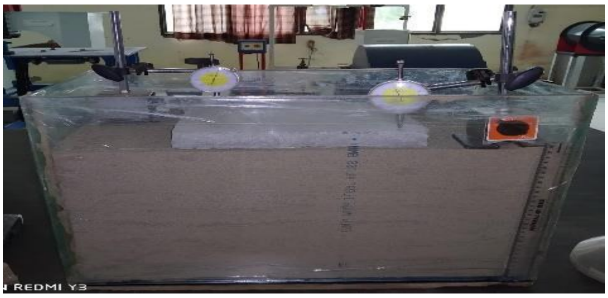


Fig 1 Experimental Setup

V. METHODOLOGY OF TEST TESTING OF RAFT FOOTING

First of all the test bed is prepared in a glass tank of suitable size. To maintained the same density of each layer, soil is filled with the help of funnel keep near the surface. Then the raft footing of rectangular in shape footing is made of square shape so the center of gravity of the footing lies at the centre, then footing is placed at centre of tank and two dial gauges are fixed at the alternate edges of the footing to note settlement of footing after the application of each successive load.In case of raft footing the load applied is transfer to soil from the surface directly contact with soil.

Fig 2 Testing of raft foundation

VI. TESTING OF PILE FOUNDATION

Secondly the pile foundation is testing in a sand bed prepared in the glass tank. In this case firstly we embed the pile to required depth then load is applied to piles with the help of pile cap. The load is directly applied to pile cap then it is transfer to group of piles equally. In pile foundation the load is transfer to soil only with the help of skin friction between pile and soil embedded in sandy strata. This can be achieved only with the help of keeping pile length greater, pile cap is not in directly contact with soil so only load is transferred through pile.

Fig 3 Pile Foundation (piles embedded in soil strata)

Fig 4 Testing of pile foundation

VII. TESTING OF PILE-RAFT FOUNDATION

In third case the pile-raft foundation over the prepared sand bed is being account for testing. The testing of pile-raft is conducted to determine the suitability of foundation for sandy soil. To achieve the combination of pile-raft the raft is casted with pile foundation and the raft is resting on the soil. The load is applied on the raft is partly distribute with pile. Firstly load is taken by raft then load left is transfer to soil with the help of pile by skin friction.

Fig 5 Testing of Pile Raft foundation

VIII. RESULTS

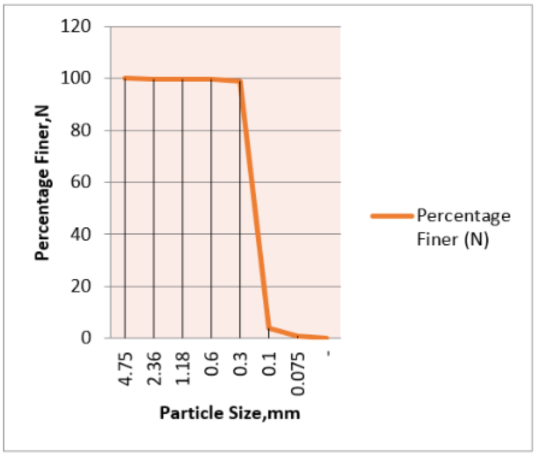
Table 1 Index Properties of sand

Properties	Sand
Water Content (%)	18.47
Permeability Test (mm/sec)	0.01035
Maximum unit weight (gd(max)) in compacted condition (kN/m³)	16.7
Minimum unit weight (gd(min)) in loose condition (kN/m³)	14.8
Maximum void ratio (e_{max})	0.77
Minimum void ratio (e_{min})	0.57
Relative density (I_d) (%)	61.92
Specific Gravity (G)	3.38

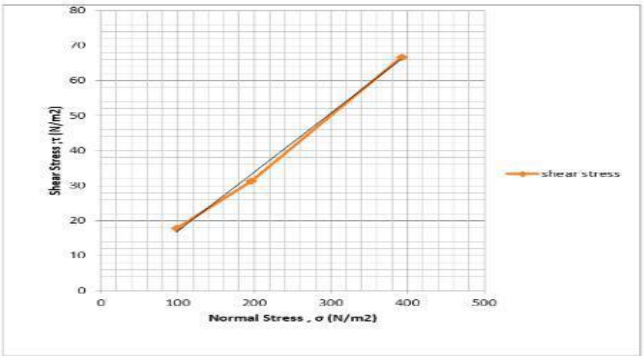
The results of the engineering properties of sand are reported in Table 2

Table 2 Engineering Properties

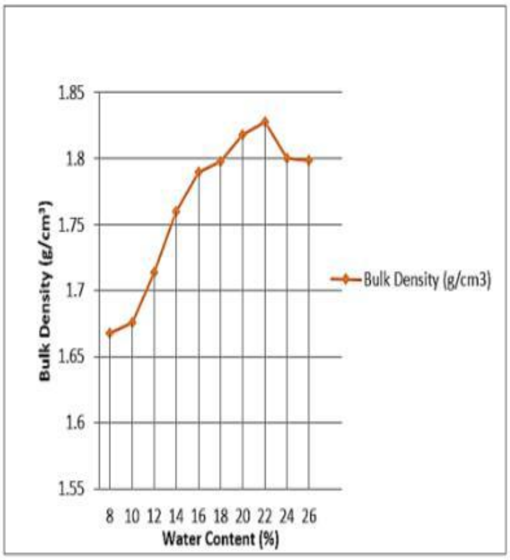
Properties	Sand
Shear Strength KN/m²	4.42
Cohesion intercept (c) (kPa)	0
Angle of internal friction ϕ (degree)	49°
Permeability (Coefficient of Hydraulic conductivity)	0.01035
Compaction characteristics Maximum Dry Unit weight)	
Optimum moisture content	22%
Maximum Dry Unit Density (g/cm³)	0.30
-Minimum unit weight (gd(min)) in loose condition (kN/m³)	14.8
-Maximum void ratio (e_{max})	0.77
-Minimum void ratio (e_{min})	0.57



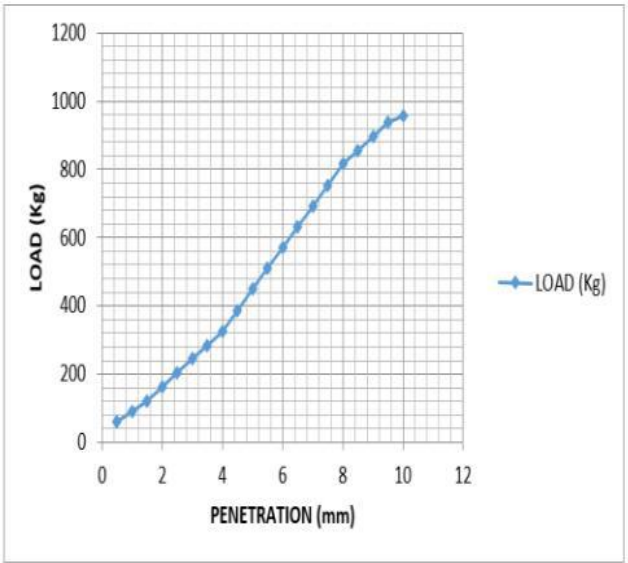
Graph1 Particle size v/s Percentage Finer



Graph 4 Shear Stress v/s Normal Stress



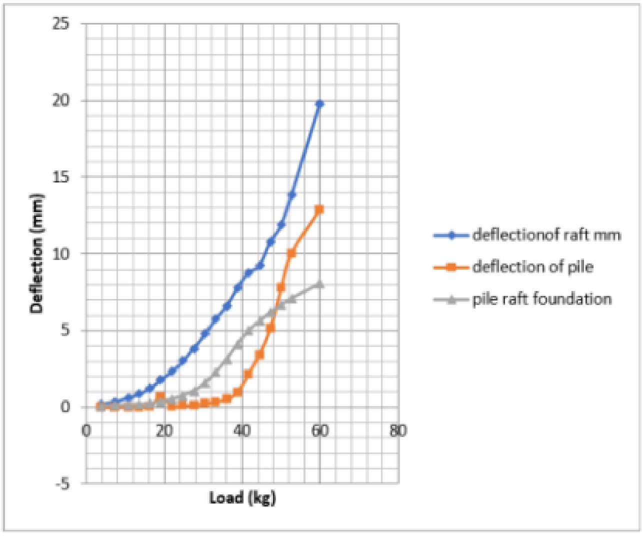
Graph 2 Water Content V/S Bulk Density



Graph 3 Load Penetration Curve for C.B.R

The load settlement behavior of pile, raft and pile – raft foundation have been analysed below in table 3 –

Load(kg)	Deflection (mm)		
	Raft	Pile	Pile-raft
3.62	0.20	0	0.08
7.22	0.36	0	0.105
10.82	0.62	0.015	0.105
13.62	0.86	0.030	0.150
16.42	1.23	0.040	0.215
19.22	1.79	0.070	0.365
22.02	2.32	0.07	0.515
24.82	3.00	0.095	0.765
27.62	3.85	0.135	1.05
30.42	4.75	0.225	1.55
33.22	5.75	0.375	2.25
36.02	6.60	0.525	3.125
38.82	7.80	1	4.125
41.62	8.80	2.165	4.975
44.42	9.20	3.45	5.61
47.22	10.80	5.125	6.20
50.02	11.90	7.775	6.66
52.7	13.90	10.075	7.115
59.9	19.8	12.90	8.075



Graph5 Load v/s Deflection

IX. CONCLUSION

This study is carried out as involving to obtain an approximate raft, pile & pile-raft settlement, in a sandy strata. Piled raft foundations have the potential to provide economical foundation systems, under the appropriate geotechnical conditions.

Further analysis may be carried out to investigate whether a raft, pile and combination of pile-raft foundation proves to be economical. By providing connected pile system the differential settlement can be reduced. [15]

In above model study the load settlement behavior of raft, pile and pile- raft combination has been observed. We have observed the following behavior of foundation under loading condition.

1. Raft foundation is the type of shallow foundation and it is suitable for approximate or 3 storey building on a sandy strata, becausese if the multi storey building is build on a raft foundation it will collapse before completion because the load transferred through the raft only to a small area in contact.
2. In pile foundation the load is transferred through a skin friction and it is rested on a hard strata, but in our study the piles is not rested on hard strata so after a successive increment of load the pile will immediately settle but not fail. So pile foundation is best option for multi storey building if hard strata is easily available at shallow depth and cost will be reduce. Otherwise the cost will be increases to more then estimated cost.
3. Combination of pile and raft foundation is such a best and economical option for multi storey building resting on a sandy strata. Because in this type of foundation the length of pile required will be less then pile foundation and load settlement behavior of such a footing is more satisfactory then other.
4. I am observing that the settlement of raft will be depends upon the boundaries, because when I am testing the raft of some dimensions as I made pile cap and pile-raft combination. Then the settlement will be less when I am testing the raft of smaller size 10cm*10cm. Then the immediate settlement will be occur.
5. This means the settlement will be more if the raft farming will have foundations more than 1.5B to 2B.

X. FUTURE SCOPE

This model study has been carried out in order to investigate whether a combination of raft, pile and pile-raft foundation proves to be economical as compare to other types of foundation.

1. This will be applicable for soil strata of low bearing capacity.
2. Combination of pile raft footing reduces the cost of the foundation as a whole.
3. This combined system of pile – raft footing footing help in saving the cost required for stabilization of the soil of low bearing capacity.
4. This will reduce the differential settlement of foundation and some extent overall settlement will be reduce by loacating piles strategically below the raft.

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