Experimental Studies on Settlement Search of Piled Raft System

Kunal Kumar, P. P. Dahale, P. D. Hiwase

Abstract: ***Present study is an experimental work to analyse the effect of size of raft, length, number of piles on the settlement of the foundation system. In this work, study has been carried out to understand the load sharing ratio of the pile and raft with different patterns of pile and of different lengths. It was observed that, the load carrying capacity increases and settlement ratio reduces for the piled raft foundation tested on dry sandy soils deposits with relative density 70%. Total 39 tests were carriedout for the different piled raft models of different raft sizes (15 x 15 cm, 17.5 x 17.5 cm, 20 x 20 cm), number of piles (4 nos., 5 nos., 9 nos.) and of different pile lengths (10 cm, 20 cm, 30 cm, 40 cm). With the increase in raft size, load carrying capacity increased from 8.9 kN (for 15 cm raft) to 10.54 kN (for 17.5 cm raft), 17.22 kN (for 20 cm raft) for 25 mm settlement. Length of pile considerably effect on the foundation settlement, for 5 kN applied load, raft settlement (15 x 15 cm) without pile was 10 mm which reduces to 3 mm, 2.4 mm, 1.8 mm and 1.4 mm for 10 cm, 20 cm, 30 cm and 40 cm pile lengths respectively. Similar results were observed for other pile dimensions. Additionally, it is also observed that, pile number has considerable effect on the load carrying capacity and settlement of foundation system.***

Keyword: ***Piled raft system, load shearing ratio, settlement reduction ratio***

1. INTRODUCTION

The basic concept of piled raft foundation is to reduce the settlement of foundation system well below the allowable settlement and to transmit the loads from superstructures to the foundation soil. Friction piles are generally known as settlement reducers as the shaft capacity is mobilized at small settlement. The settlement reducing piles are generally used to decrease the total settlement of piles in case of rigid foundation and to reduce both total settlement and differential settlement in case of flexible rafts. In case of piled raft foundation in sandy soil, the entire load has to be taken by piles and raft acts as medium of transfer the load from the columns to the piles and raft has to withstand any hydraulic pressure that may act at the bottom of raft.

The piled raft can be designed to optimise the number of piles so as to get best results and not required to provide unnecessary piles. The piles are tactically spread in such a manner that, wherever the load is more and may cause settlement.

The present work is an extension of the work carriedout by Anjankar B. M. (2018) to study the settlement behaviour piled-raft foundation in dry sandy soil (with R. D. 70%) by carrying out experimental work (i.e. load tests) on the piled raft model. The load transfer mechanism is also studied in the terms of load sharing ratio (αPR). The combined piled raft foundation system provides a skillful concept wherein the applied load is transferred by means of a load sharing mechanism which is generated through a process of interaction between the soil, pile and raft. The piled raft foundation utilizes the pile group for the control of settlement, with the piles providing most of the stiffness at the service loads while the raft elements provide the additional capacity at the ultimate load levels. The reviewed literature shows the studies carried out in this direction in the part [Cooke (1986), Burland (1995), Poulos (2001), Bajad S.P (2008) Anjankar B.M. (2018)].

2. TEST SETUP:

Total 39 test combinations were planned for piled raft foundation system as given in the Table 2.1 for different sizes of raft and piles with different lengths and numbers. For experiments were conducted on galvanized iron rafts of 6 mm thickness and hollow piles of 12 mm diameter for testing. Sand blasting is done to roughen the surface of pile throughout the pile length. Piles were threaded at one end so that they can be easily screwed at one end to the raft model. Spacing between the piles kept between 40 – 60 mm corresponds to 2.5 d to 5 d respectively, where d is the pile diameter. Fig. 2.1 shows the piled raft foundation systems with different configurations of different patterns such as regular, square, diamond patterns with different raft size with different pile lengths 100 mm, 200mm, 300 mm and 400mm.

Circular steel tank of 600 mm internal diameter and 800 mm height is used to carryout tests. Rain fall technique is adopted to fill sand in to the tank by controlling the flow and height of fall to have desired density of 16.20 kN/m^3 throughout the tests. Proper measures are taken for insertion of piles vertically to avoid inclination in to the sand. Fig. 2.2 shows the test setup, wherein load is transferred to the piled raft assembly through plunger attached to the proving ring at the bottom. To measure the settlement of the foundation system, two dial gauges were placed on diagonally opposite ends of the raft. A calibrated proving ring of 50 kN capacity is used to measure the load applied to the foundation system. Load is applied in increments and settlements are measured using dial gauges.

Revised Manuscript Received on July 10, 2019.

Kunal Kumar, P.G Student, Department of Civil Engineering, Shri Ramdeobaba College of engineering and Management Nagpur 13, India (kunalsinghsrm2011@gmail.com)

Dr. P. P. Dahale, Assistant Professor, Department of Civil Engineering , Shri Ramdeobaba College of engineering and Management Nagpur 13, India (dahale.p.prasad@gmail.com)

Dr. P. D. Hiwase, Assistant Professor, Department of Civil Engineering, Shri Ramdeobaba College of engineering and Management Nagpur 13, India (hiwase.prashant@gmail.com)

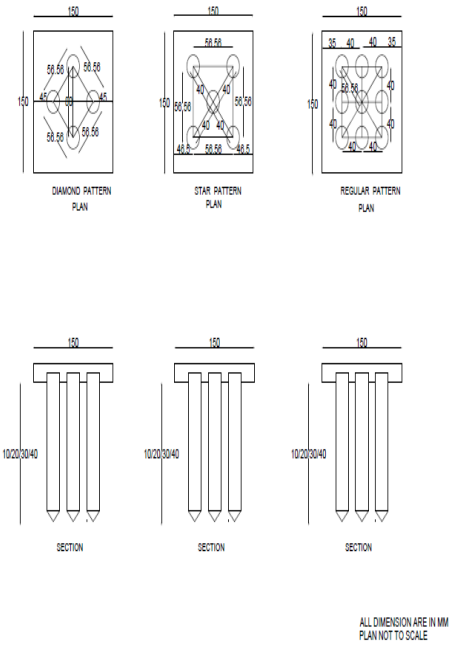

Fig 2.1: Configurations of piled raft model.

Table 2.1
Test Configuration and observation

Test No.		Nos. of Piles	Pile Length	Pattern	*Settlement (mm)*	*Ultimate load (in kN)*
Raft Size 15 x 15 cm						
1	C1			Raft	25	8.9
2	C2	4	100	D1	10	10.7
3		5	100	S1	10	10.8
4		9	100	R1	10	11.91
5	C3	4	200	D2	20	15.27
6		5	200	S2	20	15.38
7		9	200	R2	20	17.25
8	C4	4	300	D3	30	21.77
9		5	300	S3	30	22.4
10		9	300	R3	30	24.98
11	C5	4	400	D4	40	25.46
12		5	400	S4	40	26.28
13		9	400	R4	40	27.9
Raft Size 17.5x17.5 cm						
14	C6			Raft	25	10.54
15	C7	4	100	D5	10	13.58
16		5	100	S5	10	13.98
17		9	100	R5	10	17.36
18	C8	4	200	D6	20	17.94
19		5	200	S6	20	19.54
20		9	200	R6	20	20.2
21	C9	4	300	D7	30	21.43
22		5	300	S7	30	24.3
23		9	300	R7	30	24.68
24	C10	4	400	D8	40	26.86
25		5	400	S8	40	28.03
26		9	400	R8	40	29.2
Raft Size 20 x 20 cm						
27	C11			Raft	25	17.22
28	C12	4	100	D9	10	14.6
29		5	100	S9	10	15.68
30		9	100	R9	10	18.4
31	C13	4	200	D10	20	19.1
32		5	200	S10	20	20.2
33		9	200	R10	20	22.3
34	C14	4	300	D11	30	27.25
35		5	300	S11	30	28.8
36		9	300	R11	30	30.54
37	C15	4	400	D12	40	29.4
38		5	400	S12	40	30.6
39		9	400	R12	40	31.5

Note : D-Diamond, S-Star and R- Regular

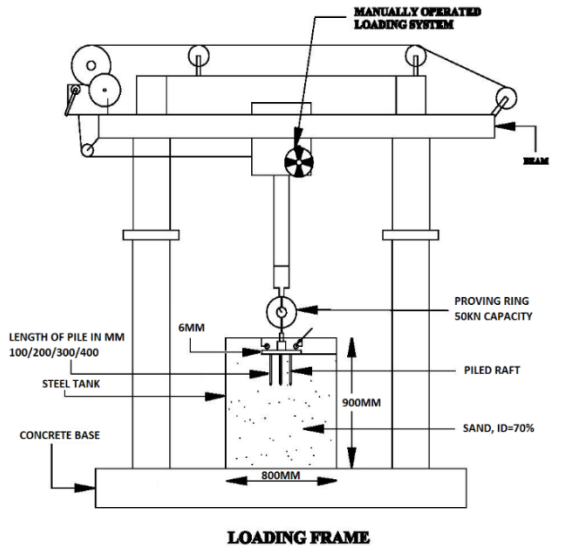

Figure 2.2 Experimental setup

3. TEST RESULTS AND DISCUSSION

3.1. Effect of pile length.

The pile length is varying as 100 mm, 200 mm, 300mm and 400 mm. It is observed that, as the pile length increases, the settlement decreases and thereby resulting into increase of load carrying capacity.

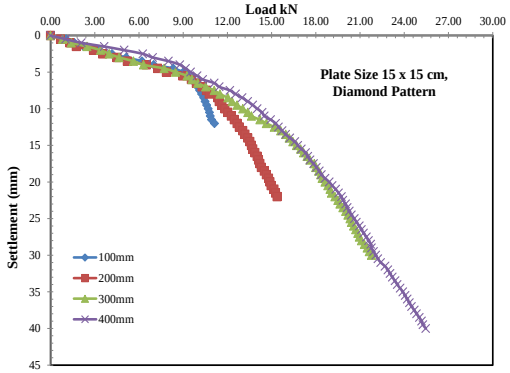

Fig. 3.1 Load-settlement curves for different pile lengths

3.2. Effect of number of piles on ultimate load capacity

The ultimate load carrying capacity of the combined foundation system increases with the number of piles. Fig. 4.2 shows the effect of number of piles on ultimate load capacity

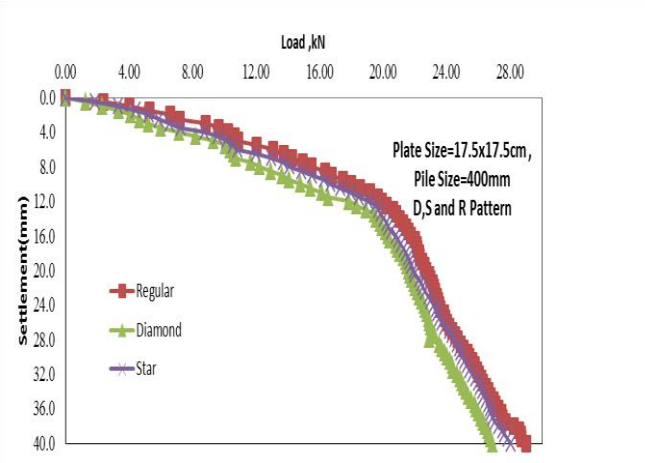

Fig. 3.2 Load-settlement curves for different patterns of same raft size and lengths

3.3 Effect of plate size

The plate size is varying as 15x15cm, 17.5cmx17.5cm and 20x20cm. It is observed that, as the plate size increases, the settlement decreases and thereby resulting into increase of load carrying capacity.

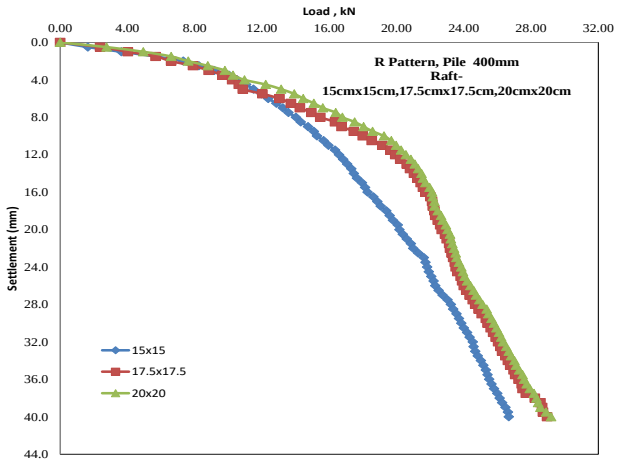

Fig 3.3 . Load Settlement Curve for different size of plate

3.4. Effect of number of piles on settlement reduction ratio

It is observed from the graph 6 that, as the length of pile increases settlement reduction ratio also increases. Also, with increase in the number of piles in piled raft foundation system, overall increase in the settlement reduction ratio is seen.

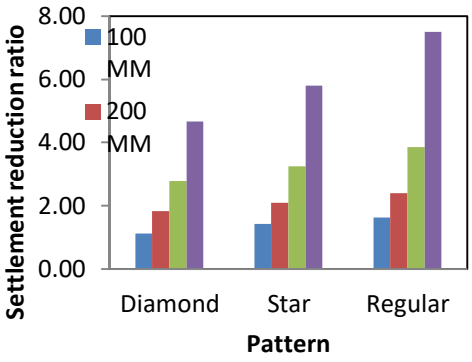

Fig 3.4 :Settlement reduction ratio for different combinations and length of pile

3.5. Effect of number of piles on load sharing

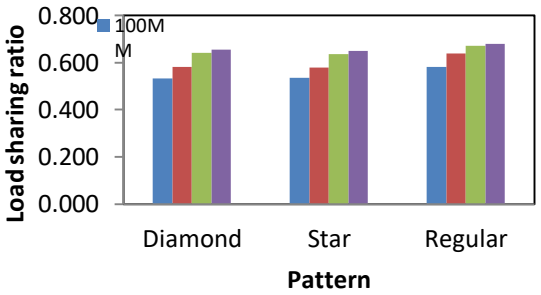

Fig 3.5: Load sharing ratio (αPR) Vs. Number of piles

The effect of Pile length on settlement and load sharing mechanism: A 3x3 pile group is analysed with pile constant spacing for three different size of raft with three different pattern. The pile length is varying as 100 mm, 200 mm, 300mm and 400 mm. It is observed that, as the pile length increases, the settlement decreases and thereby resulting into increase of load carrying capacity

3.6. Effect of L/B ratio on ultimate load capacity

As the pile length increases, the total surface area for resistance is increased which produces significant increase in shear strength of soil and respective increase in ultimate load. Therefore, as L/B ratio increases, the ultimate load capacity increases.

4. CONCLUSIONS

Present study is on experimental investigation of pile raft system of load carrying capacity. In dry sandy soil deposit

- The Load carrying capacity increased with increase in size of raft i.e 150 mm x 150 mm, 175 mm x 175mm and 200 mm x 200mm size For 25 mm settlement was observed to be 8.9 kN, 10.54 kN and 17.22 kN respectively. The bearing capacity of raft foundations on sand is always very high due to size effects where only raft is used as foundation
- Load carrying capacity of the piled raft system increases with increase in length of pile for example in case of Diamond pattern (4Nos of pile & 150 mm x 150 mm

raft size) piled raft for 10mm settlement of the foundation system , respectively 10.70 kN,11.83 kN,13.05 kN, 14.02 Kn loads applied on 100mm, 200mm ,300mm and 400mm pile length. As the length of piles increases the load carrying capacity increases.

- The load bearing capacity of piled raft increases as the number of piles beneath the raft for example in case of Raft size 150 mm x150 mm (400mm pile length)piled raft for 20 mm settlement of the foundation system , respectively 18.92 kN, 19.74 kN, and 20.18 kN. The load bearing capacity of piled raft increases as the number of piles beneath the raft for example in case of Raft size 175 mm x175 mm (400mm pile length) piled raft for 20mm settlement of the foundation system , respectively 21.58 kN, 21.92 kN, and 22.70 kN The load bearing capacity of piled raft increases as the number of piles beneath the raft for example in case of Raft size 200 mm x 200 mm (400 mm pile length) piled raft for 20 mm settlement of the foundation system , respectively 21.97 kN, 22.41 kN, and 23.04 kN load carrying capacity of piled raft increases as the number of piles beneath the raft increses.
- load sharing ratio for piled raft system(Raft size 150 mmx 150 mm, 100mm pile length) for different pattern of same length of pile forPile Raft Diamond Pattern 100mm,Pile Raft Star Pattern 100mm, Pile Raft Regular Pattern 100mm follows 0.533, 0.535 and 0.580 respectively for and it is shown that the load shared by the piles was found to be higher for pile raft with more number of piles.
- load sharing ratio for piled raft system (Raft size 150 mm x 150 mm (D), it is observed that the load sharing ratio for different length with same pattern i.e Load shared by Pile Raft of Diamond Pattern 100 mm, Pile Raft Diamond Pattern 200 mm, Pile Raft Diamond Pattern 300 mm and Pile Raft Diamond Pattern 400 mm is 0.533, 0.581, 0.640 and 0.655 respectively, due to increase in length also the load sharing ratio increases.
- The settlement reduction ratio for raft 150 mm x 150 mm (7-7.25Kn) the Settlement reduction ratio for different pattern of same length i.e Diamond, Star and regular is as follows 1.13, 1.43 and 1.62 respectively and it is shown from the graph with increase in the number of piles in pile raft system , overall increase in settlement reduction ratio is seen. The number of piles beneath the raft increases gradually, the settlement reduction ratio.
- The settlement reduction ratio for raft 150 mm x 150 mm (7-7.25 kN) for different length with same pattern i.e Pile Raft Diamond Pattern 100mm, Pile Raft Diamond Pattern 200 mm, Pile Raft Diamond Pattern 300 mm and Pile Raft Diamond Pattern 400 mm is 1.13,1.83, 2.78 and 4.67 respectively. It was observed that, the length of piles increases settlement reduction ratio increases.

REFERENCES

1. Clancy P et al, (1996)"Simple design tool for piled raft foundations",Geotechnique, 46, No.2,313-328.
2. Poulos H. G. et al(2001). "Piled raft foundations: Design and Applications", Geotechnique, 51, No.2, 95-113
3. Horikoshi Kenichi et al(2003): "Performance of piled raft foundations subjected to static horizontal loads", IJPMG, International Journal of Physical Modelling in Geotechnics pp:37-50
4. Bajad S.P.et al, (2008) "An Experimental Study on behavior of vertically loaded piled rafts on soft clay",The 12th International Conference of International Association for Computer methods and Advances in Geomechaics Pp 84-91
5. Bunce Grahame et al, (2008)"Foundation design for the Burj Dubai-The world's Tallest Building"6th International Conference, Case history in geotechnical Engineering Arlington, VA, August 11-16
6. Pasts akorn Kitiyodom, (2011). "Approximate Numerical Analysis of large Piled Raft Foundation", soils and foundations, Japanese Geotechnical Society, Volume 51, No. 1, 11,
7. Poulos H. G. et al (2011)., "Piled Raft Foundation for tall building", Geotechnical Engineering Journal of the SEAGS & AGSSEA pp 78-84
8. PatilJaymin D. et al, "An experimental investigation on behavior of piled raft foundation" International journal of geomatics and geosciences, Volume 5, No 2 pp 300-311
9. Savio Angelinet et al (2015), "Performance of piled raft with varying pile length", 50thIndian Geotechnical Conference, pp 1-10
10. ElwakilA. Z. (2016),, "Experimental and numerical analysis of piled raft system", Alexandria Engineering Journal, Vol. 10, 04-Special Issue pp 1231-1235
11. Oh. E. Y. N et al, "Parametric Study on Piled Raft Foundation in Sand Using Numerical Modelling", Griffith School of Engineering, Griffith University Gold Coast Campus, Queensland, Australia.pp 1-6
12. lamparuthiK. et al (2009)"Characterization of response of circular piled raft tested in sand" IGC,Guntur India. 989-995
13. ChandrawanshiSareesh, Kumar Rakesh and Jain P.K. et al,(2017),, Settlement Characteristics of Soft Clay Reinforced With Stone Column: An Experimental Small Scale Study. International Journal of Civil Engineering and Technology, 8(5), pp. 937–948
14. Chandrawanshi Sareesh, Kumar Rakesh and Jain.P.K. (2017) et al Effect on Settlement Reduction Due to Method of Construction of Stone Column: An Experimental Small Scale Study. International Journal of Civil Engineering and Technology, 8(6), pp. 99–108
15. Anjankar B.M (2018).et al Experimental study on settlement behaviour of pile raft foundation in dry sandy soil International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 5, pp. 1229–1236