



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 2, February 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com



Effect of Pile Configuration on the Lateral Response of Piled Raft Foundation in Sandy Soil

Shinuja Ranjani. S¹, Karthigeyan. S²

P.G. Student, Department of Civil Engineering, College of Engineering Guindy, Anna University, Chennai, India¹

Associate Professor, Department of Civil Engineering, College of Engineering Guindy, Anna University, Chennai, India²

ABSTRACT: One of the recent developments in foundation system which is a combination of shallow and deep foundation elements are called a piled raft foundation system. It is seen as the effective and economical foundation system for tall buildings subjected to heavy structural loads. Design of piled raft foundation is such that the raft acts as the main bearing element and pile serves as the settlement reducer. But it is designed in such a way that the full capacity of the pile had been utilized. Hence, pile configuration is one of the key parameter which needs to be studied in details. Because of an optimal distribution of piles within a group that helps in reduction of settlement and bending moment. In this paper three different configuration of piles were considered for performing a series of numerical analysis to study the lateral response of a piled raft foundation in homogeneous sandy soil using ABAQUS. The difference in the lateral response of piled raft foundation for each pile configuration was compared in terms of lateral displacement. Three configurations are as follows, in first pile configuration piles are uniformly distributed over the entire raft area. In the second configuration constant numbers of piles were distributed along the length of the raft axis on either side and in the third configuration piles were distributed over the center as well as corners of the raft area. It can be inferred from the study that the pile configuration plays a significant role in reduction of the lateral displacement of the piles.

KEYWORDS: Piled raft foundation, pile configuration, FEM software, lateral displacement.

I. INTRODUCTION

The primary criteria needs to be satisfied for the foundation design are the bearing capacity and the settlement. Although the raft foundation is capable of resisting load due to high rise building especially found in loose sand and reduces the differential settlement but it shows an excessive total settlement. In such conditions if we opt for pile foundation just for the benefit of reducing settlement is proven an uneconomical solution. Hence, the more economical type of piled-raft foundation system is adopted, which is extensively used to support the high rise buildings, bridges, towers and offshore structures. The piled-raft foundation design is mainly based on the assumption that the entire load has carried by the pile but practically nearly about 30% of the total load will be carried by the raft due to its interaction with the soil as shown in Fig.1. Also, the remaining load has been transferred by means of skin friction along the pile length and the piles also contribute an effective reduction of settlement. Hence, the piled-raft foundation system has proved an economical as it increases the ultimate load carrying capacity and also reduces the settlement without increase in the cost. In this case, the pile configuration is playing the major role on overall performance of the piled raft foundation system. In view of the above, the present paper is mainly aimed on to investigate the effect of pile configurations on the response of a piled raft foundation in loose sand by performing a series of numerical analyses using ABAQUS software. Results from the numerical analysis were used for comparing and selection of the optimal pile arrangement so that the lateral deflection will be a minimum for the given load condition.

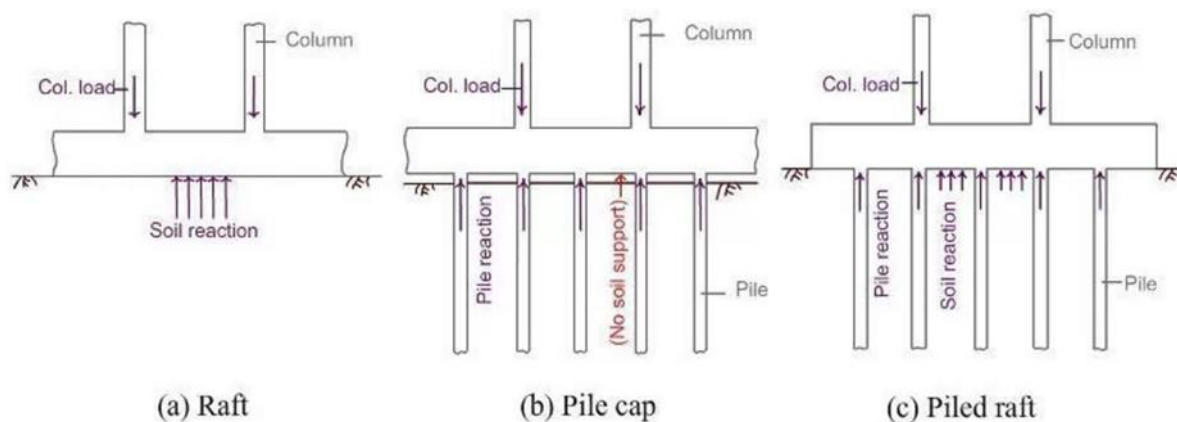


Fig.1: Concept of a Piled raft foundation

II. BACKGROUND OF THE STUDY

This section is in review of all the past research that have been conducted extensively on performance of piled raft foundation subjected to a vertical load, lateral load or combination of both. The research work has been compiled with respect to both experimental and numerical studies. From which we can identify the critical parameters governing the lateral response of piled raft foundation in sandy soil, also identify the best method of approach for beneficial results and identify the research area which has to be extensively studied further.

Elwakil and Azzam (2016) conducted an experimental investigation to study the behaviour of a piled raft embedded into sand under vertical loading condition. They had found that the percentage of load carried by the pile increases with increase in pile length and number of piles. They also found that the increase in pile spacing reduces the percentage load carried by piles. The strategically located piles improve the load capacity of raft and reduce the differential settlement considerably.

Thakare and Dhawala (2016) conducted a laboratory study on model piled raft foundation on sand subjected to static vertical load. The influence of pile configuration and number of piles in a piled raft foundation, on the ultimate bearing capacity and settlement reduction ratio were evaluated. They were tested three sets of model piled raft foundation with five different configurations of piles. They had concluded that the increase in number of piles in piled raft foundation increase the ultimate bearing capacity and decrease the settlement. The pile configuration over the raft area has a significant effect on the ultimate bearing capacity and settlement reduction ratio of a piled raft foundation. Also, concluded that the optimized configuration of piled raft foundation was the one in which the piles were distributed over the central as well as corners of the raft area.

Nguyen et al. (2014) performed a numerical analysis to investigate the behaviour of a piled raft foundation in sand using finite element software. They investigated the effect of pile position, pile length, number of piles and raft thickness on the settlement and induced bending moments of the raft. It was also found that the concentrated pile arrangement reduces the settlement and induced bending moments of the raft. They had also concluded further, that the horizontal deformation of a concentrated pile arrangement was larger than that of the uniform pile arrangement by approximately 20%.

Matsumoto et al (2010) studied the behaviour of model pile groups and model piled rafts in sand subjected to static vertical and horizontal loading conditions. They were investigated the influence of pile head connections on the behaviour of model piled raft foundation. They were concluded that the pile head connection has a little influence on the behaviour of a piled raft subjected to vertical load. They also found that the bending moments of the piles in the piled raft were reduced with the pile group. They had also observed that the horizontal loads carried by the piles in the piled raft were not influenced by the pile head connection rigidity.

Mano et al (2004) studied the behaviour of a piled raft foundation in sandy soils subjected to horizontal load by conducting a series of parametric studies. They were studied the influence of vertical load carried by the raft on the

behaviour of horizontally loaded piled raft foundation. They were concluded that the vertical load carried by the raft has a larger influence on the behaviour of horizontally loaded piled raft foundation in sand.

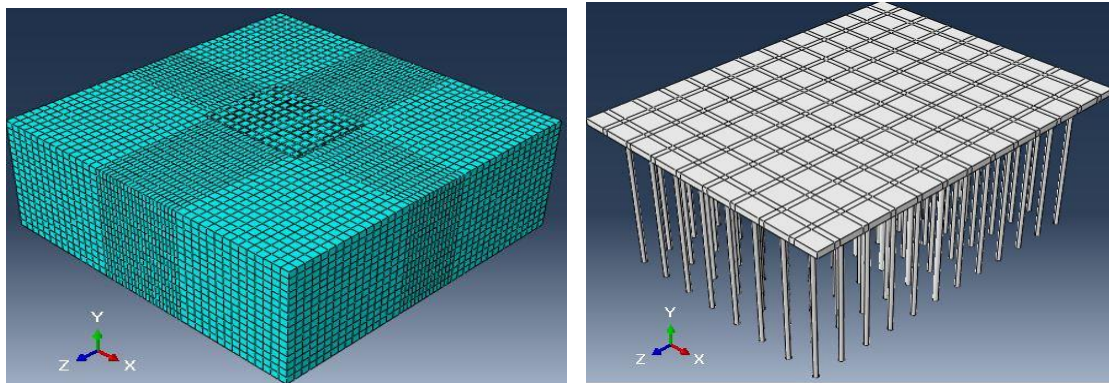
From the review of past research work, it can be identified that the pile configuration over the raft area has influence on the vertical load carrying capacity and settlement reduction ratio of both the pile and the raft. Although, the effect of pile configurations are very significant on the performance of a piled raft foundation under horizontal load very few research work available on this aspects. In view of the above, the present paper is mainly focused on to study the influence of pile configuration on the lateral displacement of a piled raft foundation.

III. METHODOLOGY

The literature reviewed from the previous section revealed that a very few studies were reported on the lateral response of a piled raft in sandy soil ground. The configuration of the pile arrangements also influences on the lateral response of a piled raft foundation. Three numbers of separate numerical analyses were performed for three different pile configurations.

1. Numerical Model Details

In order to understand the effect of pile configurations on the lateral response of a piled raft foundation a series of numerical analyses were performed on piled raft foundation subjected to a lateral load in sandy soil ground using ABAQUS software. Fig. 2(a) shows a three dimensional finite element mesh was used for the study and Fig. 2(b) show the typical piled raft foundation model. In the numerical analysis, the behaviour of the soil mass was modelled using a Mohr-Coulomb model, which was the combination of both elastic and plastic theory. The behaviour of the pile and raft were modelled by a linear elastic model. The material properties of soil, raft and pile were used in the analysis as given in Table 1.



(a)

(b)

Fig.2 Finite element model (a) 3D finite element mesh (b) Piled raft foundation model

Table 1: Material properties of the soil, raft and pile

Parameters	Symbol	Soil	Raft	Pile
Material model	Mod	Mohr - Coulomb	Linear elastic	Linear elastic
Unit weight	γ	16 kN/m ³	25 kN/m ³	25 kN/m ³
Poisson's ratio	μ	0.3	0.15	0.15
Elastic modulus	E	10 MPa	25, 000 MPa	25, 000 MPa
Friction angle	ϕ	30°	-	-

Raft and piles were modelled as linear elastic materials by using eight node linear brick element (C3D8R). Eight node hexahedral elements were used in the analysis for finite element formulation, which was more accurate and results in less computational time when compared to a four node tetrahedral elements and six node wedge elements. In a piled raft system, the interaction between the pile – soil and raft - soil surfaces needs to be assigned in order to determine the exact behaviour of the piled – raft foundation. The interaction factor depends upon the density of soil. The interaction between the raft and the soil was assumed as the surface to surface contact (standard) tangential behaviour depends on interface angle. Proper instances of pile configuration were developed to assemble the piled raft foundation in soil medium in appropriate positions. The soil boundary was chosen to avoid the vertical and lateral boundary effect on foundation components recommended by previous researchers. The fixed boundary condition was imposed on the bottom side of the mesh and the horizontally constrained condition was set on the lateral boundaries as shown in Fig.3.

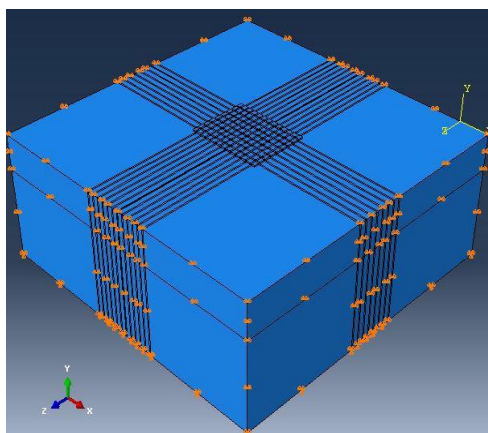


Fig. 3 Assembly of piled raft foundation with boundary conditions

The optimum mesh size was predicted by performing various trial analyses to verify the mesh. The lateral load was applied to the foundation components in terms of pressure equivalent. After completing the above stages, model was developed and submitted for analysis. In the visualization stage, the output results of the analysis and the deformed mesh was obtained.

IV. RESULTS AND DISCUSSION

The parametric studies on the lateral response of piled raft foundation were carried out by incorporating the various critical design parameters using ABAQUS software and their influence on the lateral response of a piled raft foundation was studied. One of the critical design parameter considered for detailed analysis in this paper was a pile configuration. The number of piles and its distribution over the raft area is significantly affects the lateral response of the piled raft foundation. In view of this, there were of three pile configuration with ninety six piles used in each configuration with three different patterns as follows,

- (i) piles were uniformly distributed over the entire raft area,
- (ii) piles were distributed along the length side of the raft axis
- (iii) piles were distributed over the center as well as corners of the raft area. The three different pile configurations as considered in the study are shown in Figs.4a to Fig.4c.

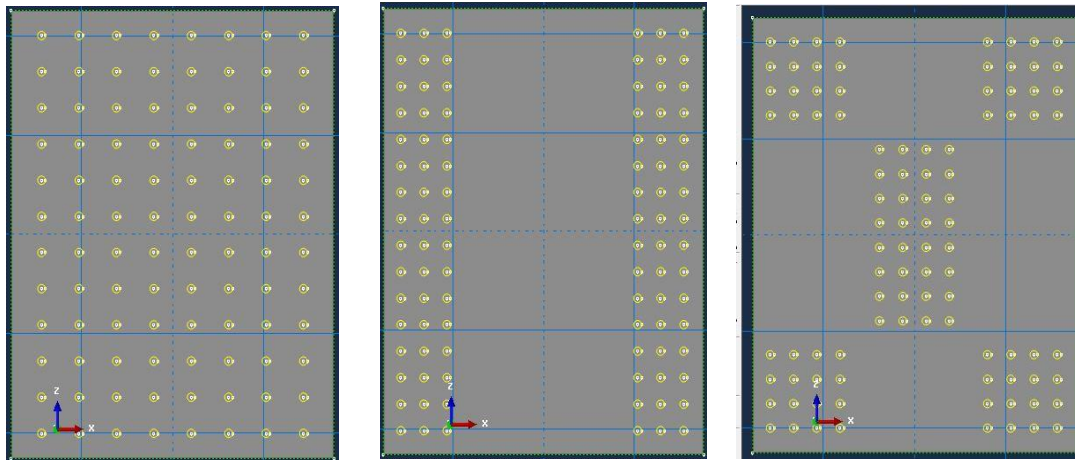


Fig. 4(a) pile configuration (i) 4(b) pile configuration (ii) 4(c) pile configuration (iii)

Fig. 5a and 5b shows the lateral deformation of a piled raft foundation for the iind and iiird types of pile distribution respectively. It is seen from these figures that the piles distributed over the center as well as corners of the raft area reduces the horizontal deformation from 23.3 mm to 19.6 mm. Fig. 6 show the horizontal displacement versus horizontal curve plots of piled raft foundation with respect to varying pile configurations. The numerical results are analysed and the percentage reduction in lateral deformation of the piled raft with pile configuration (iii) is compared with other pile configuration as shown in Table. 3. The maximum percentage reduction in horizontal deformation in case of the pile configuration (iii) with distribution of piles over the center as well as corners of the raft area is found to approximately 18 % when compared to pile configuration (i) with uniform distribution of piles over the raft area.

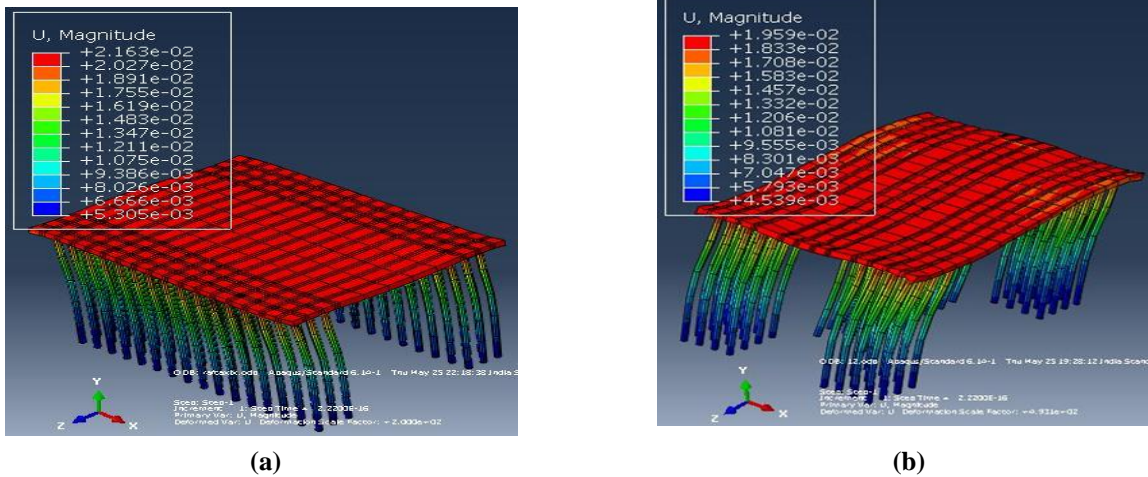


Fig.5 Lateral deformation of PRF for (a) pile configuration (ii) (b) pile configuration (iii)

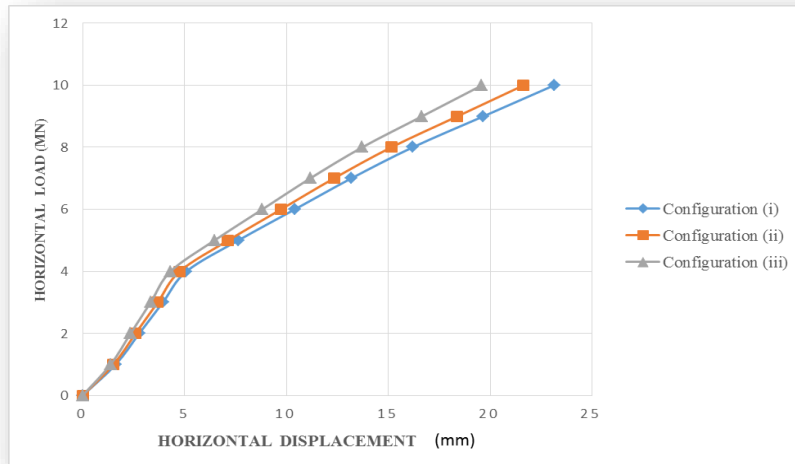


Fig.6: Effect of pile configuration on horizontal deformation

Table 3: Lateral deformation values of various pile configuration

Lateral Load (MN)	LATERAL DEFORMATION(mm)			Percentage reduction in lateral deflection for pile configuration (iii) when compared to (i)
	Pile configuration (i)	Pile configuration (ii)	Pile configuration (iii)	
1	1.64	1.64	1.48	11.1 %
2	2.79	2.79	2.38	17.2 %
3	4.02	3.85	3.44	16.7 %
4	5.16	4.84	4.26	21.1 %
5	7.70	7.21	6.48	19.0 %
6	10.49	9.59	8.85	18.5 %
7	13.28	12.46	11.23	18.2 %
8	16.39	15.25	13.85	18.3 %
9	19.83	18.44	16.72	18.63%
10	23.27	21.63	19.59	18.82%

V. CONCLUSION

The following conclusions are arrived from the detailed study on the effect of pile configuration on the lateral response of piled raft foundation in homogeneous sandy soil,

1. Pile configuration has a significant influence on the lateral deflection of a piled raft foundation under the lateral load.
2. From the comparison of numerical results we could find that the pile configuration (iii), which is distribution of piles over center as well as corner of the raft area proves economical and preferred configuration for the piled raft foundation under the given lateral loading condition, amongst the three pile configurations that were considered in the present study.
3. On an average there is a reduction in lateral deformation by nearly 18% when pile configuration (iii) is adopted when compared to the pile configuration (i).



4. Also, the lateral load corresponding to the permissible lateral deflection of 5 mm in case of the pile configuration (iii) is found nearly 1 MN greater when compared to the pile configuration (i).

REFERENCES

- [1] Balakumar.V.,Ilamparuthi.K., “Performance monitoring and numerical simulation of piled raft foundation of a twelve storied building’, *Indian Geotechnical Journal*,37(2),pp 94-115, 2007.
- [2] Elwakil.A.Z., Azzam.W.R., “Experimental and numerical study of piled raft system”, *Alexandria Engineering Journal*,vol.55,pp 547-560, 2016.
- [3] Hussien.M.,Ramadan.E.,Hussien.M.,Senoon.A.,Karray.M., “Load sharing ratio of piled raft system in loose sand: an experimental investigation”, *International Journal of Geotechnical Engineering*, ISSN: 1938-6362 (Print) 1939-7879, 2016.
- [4] Katzenbach.R., “Design and performance of piled rafts”, Proc. of *International Geotechnical Conference of Soil-Structure Interaction*, 26-28 May 2000, St. Petersburg, Russia.
- [5] Nguyen.D.D.C.,Kim.D.,Jo.S., “Parametric study for optimal design of large piled raft foundations on sand”, *Computers and Geotechnics*,55,pp 14-26, 2014.
- [6] Srilakshmi.G.,Moudgalya N S., “Analysis of piled raft foundation using finite element method”, *International Journal of Engineering Research and Science & Technology*,vol.2,No.3, pp 78-87, 2013.
- [7] Thakare.S.W., Dhawale.P, “Performance of piled raft foundation on sand bed, *International Journal of Innovative Research in Science*’, *Engineering and Technology*,vol 5(6), pp. 9209-9218, 2016.



**Impact Factor:
7.569**



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details