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Experimental Study on Seismic Behaviour of Liquefiable Soil using Piled Raft Foundation with Varying Length of Pile

Mansi Katta[1], Karan Mistry [2], and Nidhi Pancholi[3]

[1]HJD institute of technical research and education, Kutch, Gujarat
Mansikatta5@gmail.com
[2]Applied mechanics department GEC-BHUJ,Gujarat
karanbmistry@gmail.com
[3]HJD institute of technical research and education, Kutch, Gujarat
Nidhi2613pancholi@gmail.com

Abstract. Due to heavy load, complicated stress condition and the limited capacity of the soil, the settlement of high rise building occurs. As a solution to this problem piles are introduced in the raft foundation. The design of Piled-raft foundation depends upon various parameters like pile length, pile diameter and pile spacing. Although the combined Piled-raft system was developed with overconsolidated clay in mind, it is also applicable in the sand because permissible settlement for the foundation is less than that of foundation resting on clay. However several published literature are available on the effect of various parameters, they all have piles of equal lengths. It makes the requirement to know the effect of variation in pile length on the settlement reduction and load sharing behaviour of piled raft in earthquake loading. In this experimental work, the tests were carried out using a tank with liquefiable soil having pile raft foundation over it. A raft of 150mm x 120mm with 3×3 configuration of the pile having lengths 0.80,1.00 and 1.25 times the raft width was used for the study. The earthquake load of defined frequency was applied using a uniaxial shake table. Liquefiable soil was collected from the Mundra region in the Kutch district of Gujarat which is laying under the Zone-5 of the earthquake zone. It was found that the footing having a varying length has the almost same effect as that of equal pile length raft in some cases. So we can use varying pile length as an economic and effective solution to reduce the settlement in Piled- raft foundation

Keywords: pile raft foundation, earthquake loading, pile settlement, varying length of the pile

1 Introduction

In weak soil having low bearing capacity raft foundation is the suitable choice for most of the engineers. But due to heavy load, complicated stress condition and limitation of bearing capacity of soil, settlement of building occurs. As a solution of settlement problem numbers of piles are introduced in raft and new type of foundation called piled raft foundation is coming up in big way. The present state of knowledge

on the behaviour of piled raft is mostly centred on the piled raft seated on deep deposits of over consolidated clay, However it is quite possible that this system can be adopted to support structures sensitive for settlement and are to be supported on loose to medium dense sand. Liquefaction is main problem in seismically active area. Where soil is mainly consist of silt and sand which is non plastic, the problem of liquefaction is increased. In Gujarat district Kutch is came in earthquake zone V. in kutch region there was large damage occurred during 2001 earthquake because of liquefaction. In various area like Rann of Kutch, Kandla , Khavda and Mundra there is large amount of silty and sandy soil which are susceptible to the liquefaction. Raft foundation is generally used in construction. But the settlement problem leads to damage of the structure. So piled are introduced in raft and new type of foundation called piled raft foundation are coming up in a big way. This is advantageous over pile also because the pile length is reduced and load is carried by not only the pile but also the raft slab. So, the design of piled raft should be well established considering various parameters. Although a number of published literatures are available on the effect of various parameters, they all have piles of equal lengths. In case of plaza like structures wherein the raft thickness as well as the pile length can be varied depending upon the capacity requirements, it becomes requirement to understand the effect of variation in pile length on settlement reduction and load distribution of piled raft.

2 Shake Table and Soil Tank Design

To check the liquefaction phenomenon laboratory set up is prepared which includes shake table, acrylic material tank. The tank will be set over the shake table with proper arrangement and then will be filled with soil having field density. Shake table has started at frequency of 15Hz and displacement of 3mm for about 120 seconds because Kutch earthquake lasts for about 120seconds.

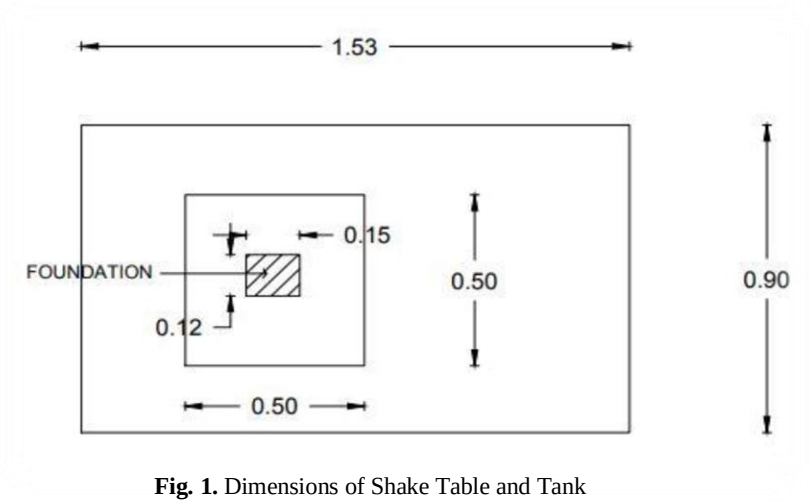

Fig. 1. Dimensions of Shake Table and Tank

- **Shake table**: 1.53m X 0.90m
- **Acrylic tank**: 0.50m X 0.50m X 0.50m
- **Footing**: 0.15m X 0.12m X 0.08m

3 Soil Collection and Testing

With the reference of Gujarat map found that the area of Kutch have sandy soil. Mundra, Kandla and Khavda are the regions which is having sandy soil. By literature survey, conclusion is made that the SPT value indicates the liquefaction chances and liquefaction resistance. Higher SPT number indicates the high resistance of liquefaction and vice versa. From findings above soil of Mundra region is appropriate in this work. Site locating 12kms far from the Mundra.

Fig. 2. soil collection site at Mundra

4 Test results

Test for soil characteristic	Results
Soil classification	SM
Liquid limit	28.7 %
Plastic limit	Non plastic
Relative density	61%

5 Determination of Initial Water Content of Soil

According to Bhuj earthquake 2001, earthquake lasted for 120 seconds. Concerning the worst case set the time limit of 2 minutes in shake table. First of all started the test at liquid limit of soil that is 28%. But the liquefaction resistance time is above 120

seconds. Then the work follows for the 30 %, 35%, 40%, 45%, and 50%. At 50% of water content liquefaction occurs at only 31 seconds which is too early liquefaction. At 35 % of water content liquefaction occurred at 86 seconds. So for further study of mitigation took 35% of water content as a initial water content.

Fig. 3. Experiment with 33% and 35% water content

Table 1. Result of determination of water content

Water content in %	28	30	33	35	40	45	50
Time at which soil liquefied In sec	136	123	102	86	60	42	31

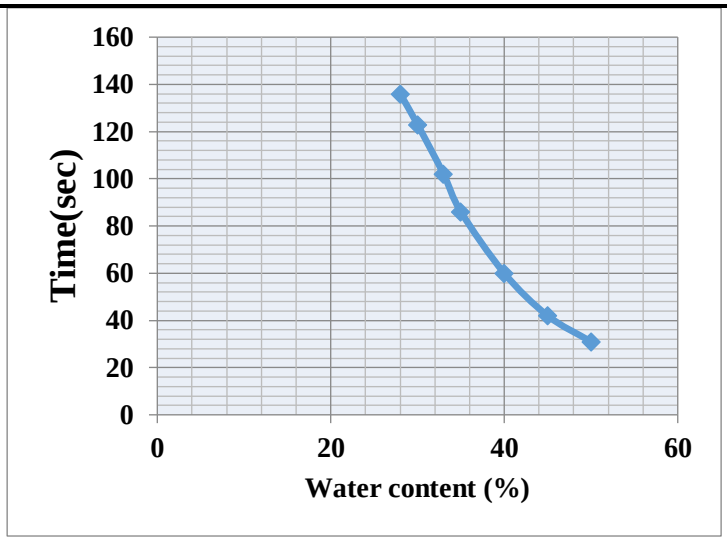

Fig.4. Graph of water content (%) v/s Time (sec)

6 Raft and Pile Models

MODEL RAFT

- The raft of size 150mm X 120mm and thickness 8mm is to be used as a model raft
- Steel is used as a raft material.

MODEL PILE

- Steel circular shape pile is used as pile models.
- The lengths of pile will 1.25B, 1B and 0.8B. We can call it as short(S), medium (M) and long (L) piles.
- These are various pile arrangement which are tested. Seismic load is applied using shake table at uniform frequency of 15 Hz. Settlement is calculated using dial gauge. And time vs. settlement graph is plotted.

Fig. 5. Piled raft model

	L	L	L			M	M	M			S	S	S
1	L	L	L		2	M	M	M		3	S	S	S
	L	L	L			M	M	M			S	S	S
	L	M	L			L	S	L			M	S	M
4	M	L	M		5	S	L	S		6	S	M	S
	L	M	L			L	S	L			M	S	M
	L	S	L			L	M	L			M	S	L
7	S	M	S		8	M	S	M		9	S	M	S
	L	S	L			L	M	L			L	S	M
						L	S	L					
					10	S	M	S					
						L	S	L					

Fig. 6. various pile arrangement

7 Experiments and Results

Set of piled raft foundation is tested on shake table one by one. Shake table frequency is set to the 15 Hz. Load is applied up to 120sec because Bhuj earthquake of 2001 lasts till 120 seconds. Settlement was calculated using dial gauge and Time vs. Settlement curve is plotted.

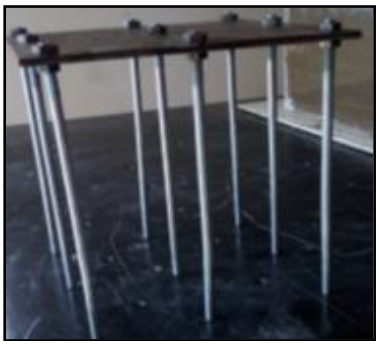

Fig. 7. various arrangement of pile

Time(sec)	Settlement(mm)		
	A-1	A-2	A-3
20	3	4	4
40	4	5	8
60	6	7	13
80	10	11	16
100	13	14	19
120	15	18	23

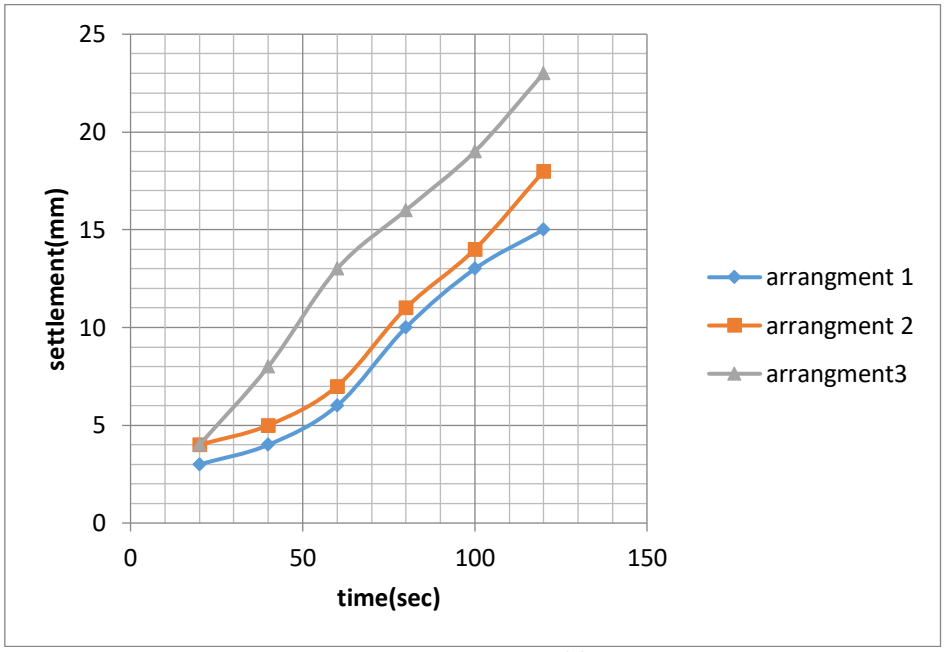

Fig.8. Graph: time v/s settlement graph of first 3 arrangements

Time(sec)	Settlement(mm)		
	A-4	A-5	A-6
20	3	4	7
40	4	7	11
60	7	11	15
80	12	15	19
100	13	18	21
120	16	19	23

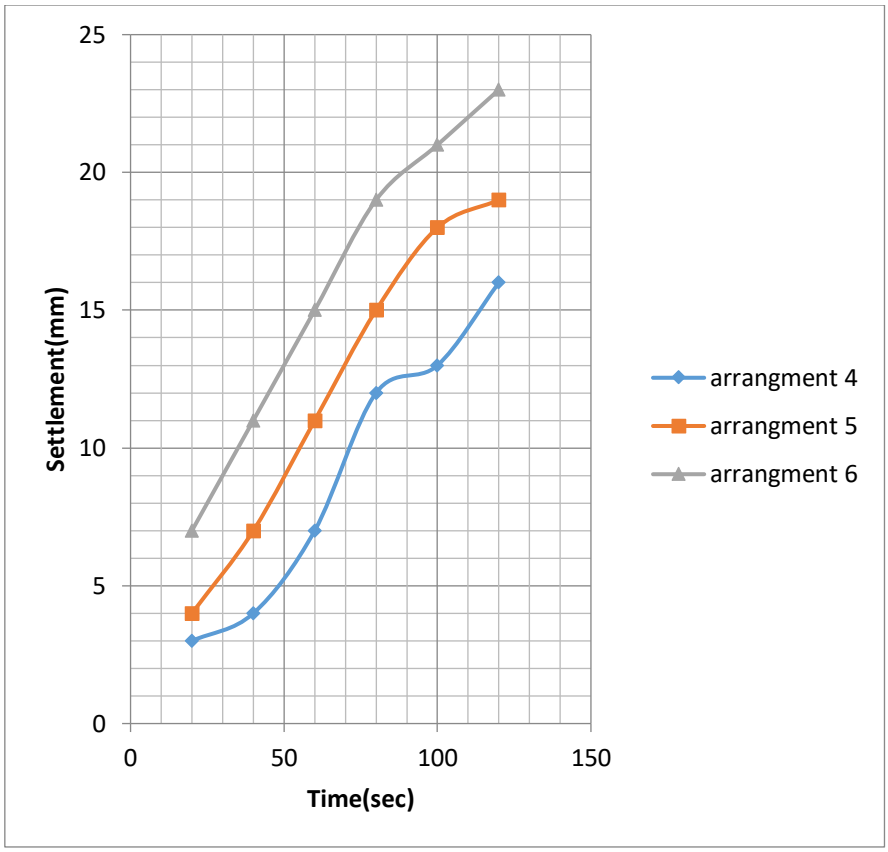

Fig.9. Graph: Time v/s settlement graph of second 3 arrangement

Time(sec)	Settlement(mm)			
	A-7	A-8	A-9	A-10
20	4	3	3	3
40	7	6	7	7
60	10	9	9	12
80	12	13	14	15
100	15	15	17	18
120	17	18	20	20

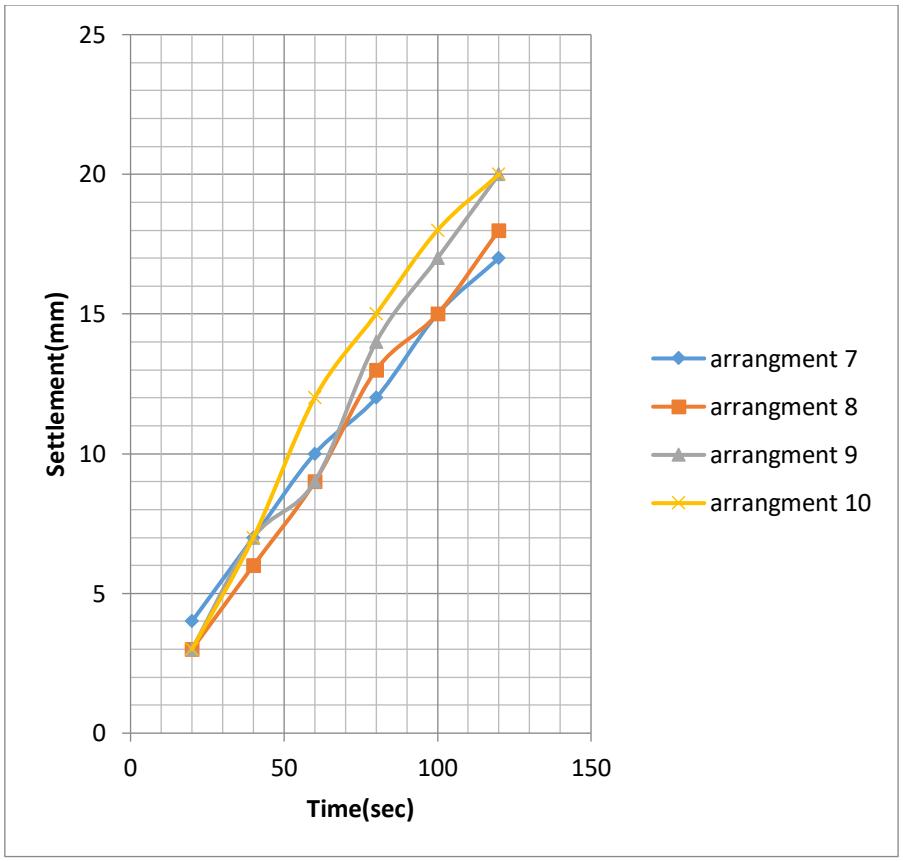

Fig.10. Graph: Time v/s settlement of last 4 arrangement

8 Conclusions

1. From the results obtained it was observed that, Mundra region is highly prone to liquefaction.
2. The result of 4th and 8th arrangement is almost similar. So we can say that middle pile length have not much effect on the piled raft foundation. The result of 5th and 10th arrangement is also similar which also validate the above fact.
3. We can conclude that the suitable arrangement of varying length pile is proved to the economic solution of conventional piled raft foundation.

References

1. Mostafa EI Sawaff, “Experimental study of eccentrically loaded raft with connected and unconnected short piles.” American society of civil engineers, 10.1061/_ASCE_GT.1943-5606.0000341, 23 August 2013

2. Suresh R. Das, L Govindraju and Shubhamoy Bhattacharya, "A case study of Kandla port and custom office tower on mat pile foundation in liquefied soils under 2001 Bhuj" Elseveir, Soil Dynamics and Earthquake Engineering 29 (2009) 333– 346, 13 march- 2008
3. Chunyang Liu and Jiting Xu, "Experimental Study on Effects of Initial Conditions on Liquefaction of Saturated and Unsaturated Sand" American society of civil engineers, (ASCE)GM.1943-5622.0000350,15 August 2013
4. Angelin Savio, Sreekumar.N.R, and V.Balakumar, "Performance of piled raft with varying pile length" Indian geotechnical conference –17 December 2015
5. D. S. Liyanpathirana and H. G. Polous, "Seismic lateral response of piles in liquefying soil" American society of civil engineers 10.1061/_ASCE_1090-0241_2005_131:12_1466 December 2015
6. Dang dinh chung nguyen, Dong so kim and Seong bae jo, "Settlement of Piled Rafts with Different Pile Arrangement Schemes via Centrifuge Tests." Journal of Geotechnical and Geo environmental Engineering – February 2013
7. Shailendra N. Endley, Wayne Dunlap, David Knuckey, Jeffrey Allen, and Karun Sreerama, "Settlement of Pile Supported Mat Foundations." American society of civil engineers 2015