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A Parametric Study of Simple Footing and Piled Raft

[1]Jaydeep Bhanderi, [2]Jitendra Mehta, [3]Kinjal Rank
[1]Assistant Professor, [2]Assistant Professor & Head, [3]Assistant Professor
[1]Civil Engineering Department,
[1]VVP Engineering College, Rajkot, India

***Abstract* – A comparison is made between the effect of strip footing with and without pile. An experimental setup including mild steel strip footing with different number of piles at different spacing, loading frame with screw jack, mild steel tank is used. It is observed that settlement of footing reduces significantly by increasing the number of supporting piles and by decreasing spacing between two piles. As number of pile increases the bearing capacity ratio increases.**

***Index Terms* – Pile. Footing, Piled Raft.**

I. INTRODUCTION

Investigation of a rigid footing under a loadbearing wall may demonstrate that its conduct is unacceptable in excessive total or differential settlement. In spite of the fact that the total settlement may be decreased by expanding the footing, and the differential settlement may be diminished by stiffening the footing. The traditional way to deal with piled footing analysis, which includes the suspicion that all the load is taken by the piles, will unmistakably not prompt most extreme economy, and a more correct system for investigation appears to be attractive.

The idea of analysis for pile supported footing is taken from the analysis of piled raft foundations where the piles shows non-linear load-deflection behavior. The raft is analysed through the use of finite element methods, while piles are treated as springs having a variable stiffness, so as to model any non-linear behavior. The soil is treated as an elastic medium that may consist of soils of different stiffnesses. Interaction between the piles in the group is assumed to remain constant even though the stiffness of the piles may change with load level.

II. EXPERIMENTAL SETUP

Experimental set up is developed consisting of a mild steel tank with sides of transparent perpex sheet with dimension 120 x 120 x 150cm was prepared. A loading frame with load application using a screw jack.. Manual loading system with capacity of 10 tons was used for the experiment. The mild steel strip footing of size 60 x 10 cm and thickness of 25mm was prepared for the experiment. Diameter of Pile selected is 25 mm and length is 450 mm.

Tests are performed for different number of piles as well as varying spacing of piles. Different arrangements of Piles to be used are 2x1, 3x1, 4x1 and 5x1 and various spacing adopted are 3D, 5D, 7.5D, 10D, 12.5D, 15D and 20D, where D is diameter of Pile. In total, 14 tests are performed as shown in table - I. Laboratory tests are performed to obtain the index and strength properties of loose/dense sand used in the experiment. It was found that minimum and maximum density of sand was 15.80 kN/m^3 and 18.50 kN/ m^3. Experiments were performed for density of 16.90 kN/m3 considering relative density of 45%.

III. TEST PROCEDURE

1. The transparent fiber test tank (120cm x 120cm x 150cm) was used as test pit. Up to 1.20m depth the tank was filled with sand. That depth was divided into no. of layers. To achieve 45% relative density (γ_d = 1.69 gm/cc) the weight for each layer was counted with the help of weighing machine.
2. The weighted sand bags for every layer were kept isolated precisely and after that the sand was deliberately filled in tank such that the correct density ought to be accomplished.
3. The test plate of respective test seated over the leveled top of sand and then the proving ring and mechanical jack arrangement is provided as shown in Fig.1.
4. Two dial gauges are connected firmly with the angle bars. The angle bars are not disturbed throughout the test procedure.
5. A preliminary seating load of 70 gm/cm^2 (39.2 kg = 7 div.) is applied first which is seated before the actual loading.
6. Load increments are kept different as per the situation and time constraint.
7. A first load increment is applied after the application of seating load and settlements are recorded by mean of dial gauge. Observation of this load increment shall be kept at 1, 2, 5, 10, 15, 20 min. intervals. (As per IS 1888:1982, The load settlement shall be kept for not less than one hour or up to a time when the rate of settlement gets reduced up to 0.02 mm/min.)
8. The higher load increments are then applied and corresponding settlements are recorded. The test should continue for total settlement of 10 to 20 mm or which soil fails whichever occurs earlier.
9. The load Vs settlement graph are drawn for each experiment and from that fine out the q_{ult} by curve fitting method.

Figure 1 Experiment Setup

IV. TESTS PERFORMED

Type of Footings	Pile Arrangement	Spacing (mm)	No of Experiments
Plate load test (without Pile)	-	-	1
Strip Piled Raft	2x1	5D 10D 15D 20D	4
	3x1	5D 10D 12.5D	3
	4x1	3D 5D 7.5D	3
	5x1	3D 4D 5D	3
		Total No of Experiments	14

Table 1 Testing Program

V. RESULTS AND DISCUSSION

The results were then analysed to study the effect of each pile spacing and number of piles. This improvement in bearing capacity increases when pile spacing decreases. The comparisons of Reduction in Settlement and Bearing Capacity for experimental work was carried out at 5% settlement and 10 % settlement.

Results				
No. of Piles	**Spacing**	**Settlement**		
		Total Settlement (mm)	**Reduction in Settlement (%)**	**Reduction in Settlement (%) Comparison with 2x1 for 5D spacing**
2x1	5D	20.84	41.95	-
	10D	24.08	32.92	
	15D	26.85	25.21	
	20D	29.09	18.97	

3x1	5D	17.53	51.17	21.98
	10D	19.55	45.54	
	12.5D	21.12	41.17	
4x1	3D	13.05	63.65	43.69
	5D	14.26	60.28	
	7.5D	17.09	52.40	
5x1	3D	8.52	76.27	58.10
	4D	10.21	71.56	
	5D	12.09	66.32	

Table 2 Reduction In Settlement (%)

RESULTS					
No. of piles	**Spacing**	**BCR CALCULATION FOR 0.05 s/B**			
		q_p (kN/m^2) at s/B=5%	**BCR=q_p/q_o**	**BCR with respect to 2x1 for 5D spacing %**	**Increase BC in %**
2x1	5D	16	0.94	-	45.45
	10D	14	0.82		27.27
	15D	16	0.94		45.45
	20D	13	0.76		18.18
3x1	5D	18	1.06	12.50	63.64
	10D	20	1.18		81.82
	12.5D	18	1.06		63.64
4x1	3D	24	1.41	6.25	118.18
	5D	17	1.00		54.55
	7.5D	22	1.29		100.00
5x1	3D	30	1.76	50.00	172.73
	4D	25	1.47		127.27
	5D	24	1.41		118.18

Table 3 Increased Bearing Capacity For 5 (%) Settlement

RESULTS					
No. of piles	**Spacing**	**BCR CALCULATION FOR 0.1 s/B**			
		q_p (kN/m2) at s/B=10%	**BCR=q_p/q_o**	**BCR with respect to 2x1 for 5D spacing %**	**Increase BC in %**
2x1	5D	28	1.65	-	64.71
	10D	24	1.41		41.18
	15D	21	1.24		23.53
	20D	20	1.18		17.65
3x1	5D	30	1.76	7.14	76.47
	10D	29	1.71		70.59
	12.5D	28	1.65		64.71
4x1	3D	36	2.12	7.14	111.76
	5D	30	1.76		76.47
	7.5D	32	1.88		88.24
5x1	3D	44	2.59	32.14	158.82
	4D	42	2.47		147.06
	5D	37	2.18		117.65

Table 4 Increased Bearing Capacity For 10 (%) Settlement

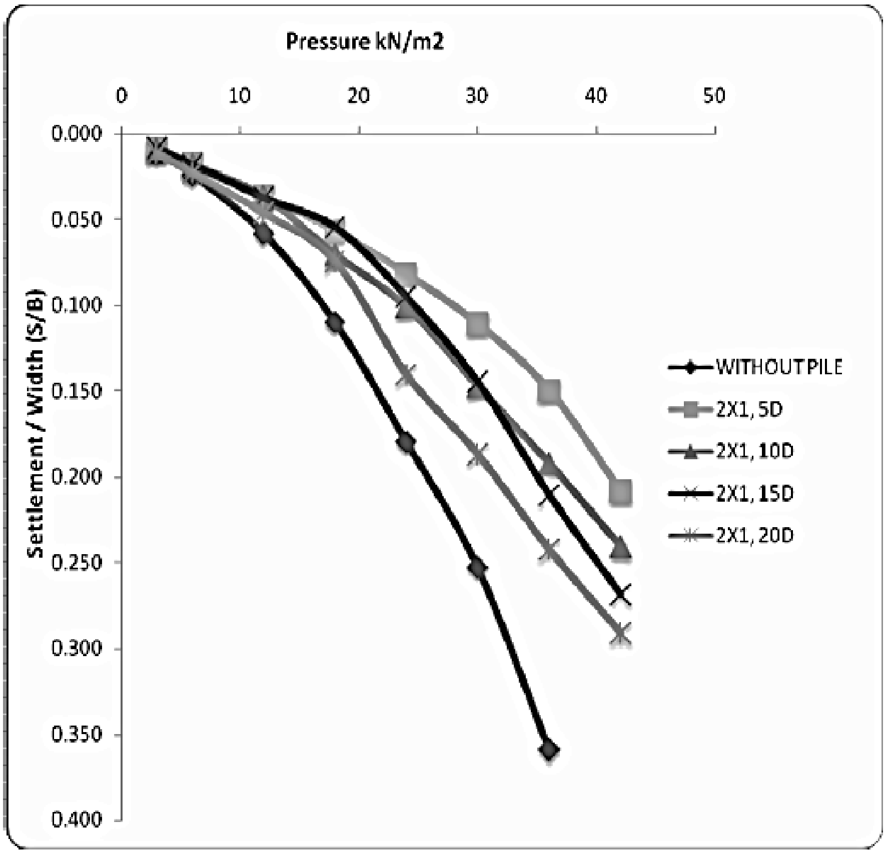

Figure 2 Load-Settlement Relationship For 2x1

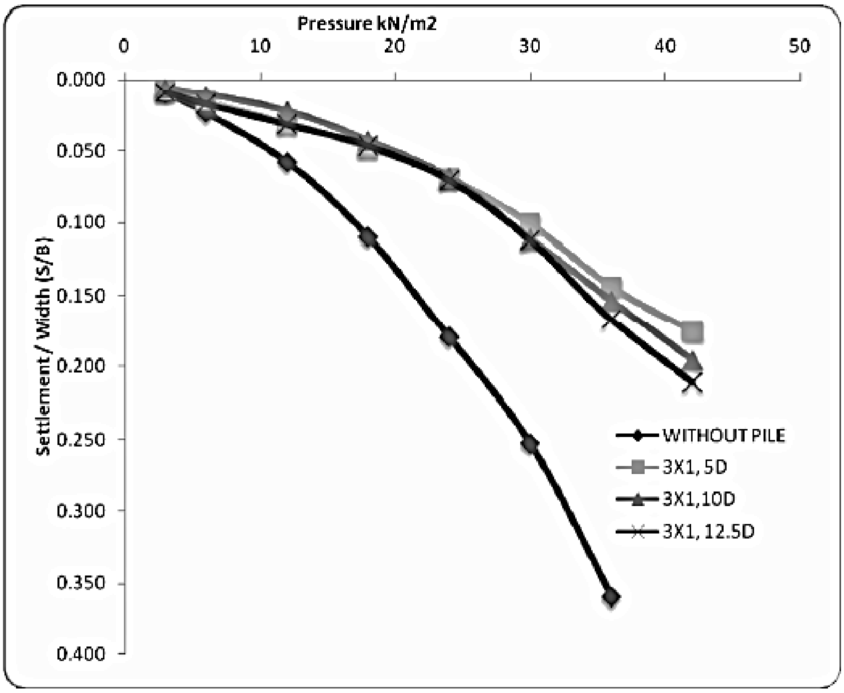

Figure 3 Load-Settlement Relationship For 3x1

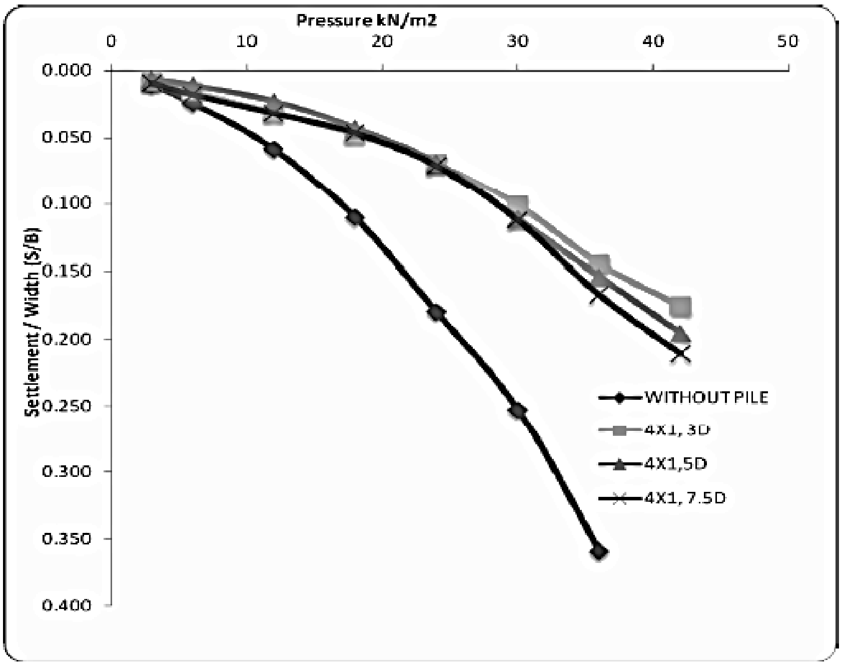

Figure 4 Load-Settlement Relationship For 4x1

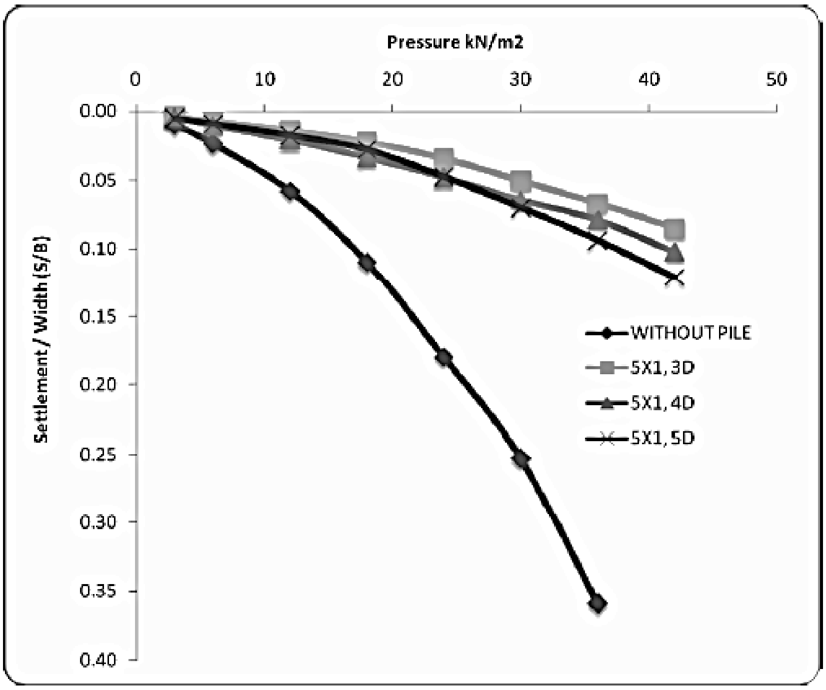

Figure 5 Load-Settlement Relationship For 5x1

Qult (kN/m2) from spacing/diameter ratio			
No. of Piles	**spacing/diameter (s/d) ratio**	**qult for s/B=0.05 (kN/m^2)**	**Q_{ult} (kN/m^2)**
2	5	16	6.4
	10.00	14	5.6
	15.00	16	6.4
	20.00	13	5.2
3	5.00	18	7.2
	10.00	20	8
	12.50	18	7.2
4	3.00	24	9.6
	5.00	27	10.8

	7.50	22	8.8
5	3.00	30	12
	4.00	25	10
	5.00	24	9.6

Table 5 Ultimate Bearing Pressure From S/D Ratio At 5 (%) Settlement

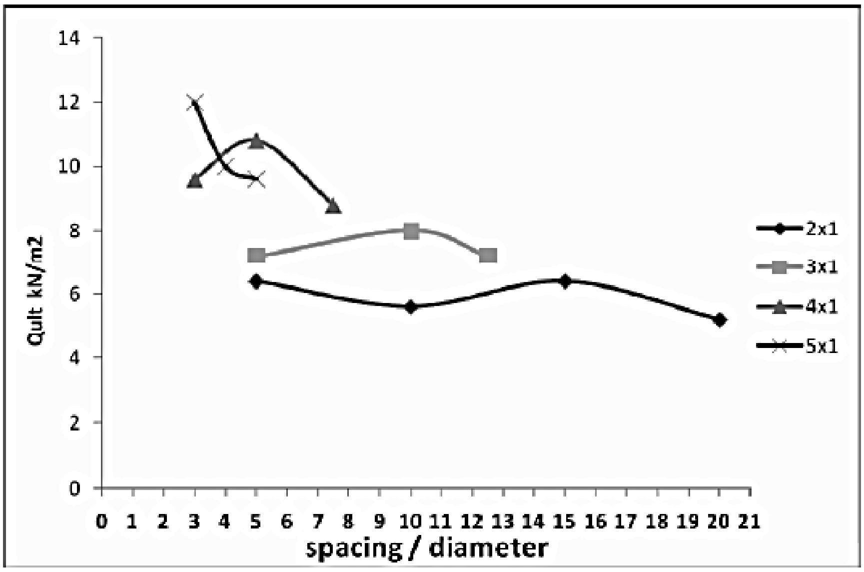

Figure 5 s/D ratio Vs Qult (kN/m2) for S/B=5%

Q_{ult} (kN/m^2) from spacing/diameter ratio			
No. of piles	**settlement/diameter (s/d) ratio**	**q_{ult} for s/B=0.1 (kN/m^2)**	**Q_{ult} (kN/m^2)**
2	5	28	11.2
	10.00	24	9.6
	15.00	24	9.6
	20.00	20	8
3	5.00	30	12
	10.00	29	11.6
	12.50	28	11.2
4	3.00	36	14.4
	5.00	30	12
	7.50	32	12.8
5	3.00	44	17.6
	4.00	42	16.8
	5.00	37	14.8

Table 7 Ultimate Bearing Pressure From S/D Ratio At 10 (%) Settlement

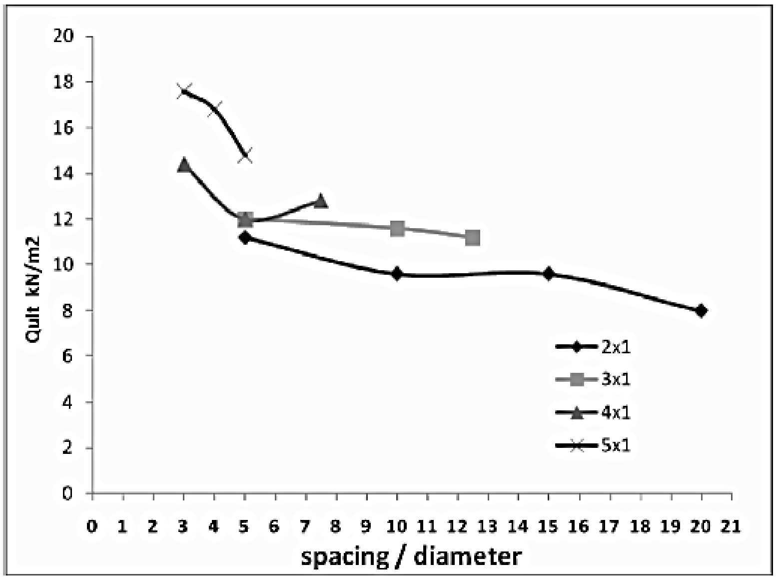

Figure 7 s/D ratio Vs Qult (kN/m2) for S/B=10%

VI. CONCLUSION

Table 2 to 7 shows the results of the experiments and Fig. 2 to 7 shows the graphical presentation of that results.
From that results, Installation of piles beneath a uniformly loaded strip footing is seen to be enable

1) The Settlement of footing reduces significantly by increasing the number of supporting piles. Settlement also reduces by decreasing spacing between two piles.
2) A considerable Increase in Ultimate Bearing Capacity by increasing the number of supporting piles and by decreasing the spacing between two piles.

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