A Study Model of Micropile Group Efficiency Under Axial Loading Conditions

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***Abstract*—[The Black cotton soil is the unusual soil which isn't skilled for supporting the constructions on shallow foundations. As one of the most incredible ground improvement procedure Micro pile (likewise called as minipiles) is talked about, where micro pile heap are utilized for establishment supporting, reducing foundation settlement. In this review, single Micro pile (different L/d proportion) and Group Micro pile of changing L/d ratio with various spacing is tried under the square footing. Then, at that point, the Experiments results shown that the load carrying pressure for the group piles increments with in length which implies the load carrying capacity of the micro piles is directly proportional to their length and load carrying pressure of the piles also increases with their spacing's.. it is observed that the pile group efficiency increases with increase in spacing. Also, the group efficiency decreases as the length of the pile increases.**

***Index Terms*—[Black cotton soil; Micro pile; L/d ratio; Group efficiency.]**

I. INTRODUCTION

The Black cotton soil is the Problomatic soil which isn't skilled for supporting the structures on shallow foundations. The deep foundations is utilized when the surface soil is unsatisfactory for the shallow foundations which transfers the load to the more profound layers and if, the consistent layer is deep it can't be reached economically by the shallow foundations. There are not many choices for deep foundations; one of the better choices is a Micro pile (likewise called as minipiles) which are utilized for foundation underpinning, reducing foundation settlement.

A micro pile is a small diametre, ordinarily under 300 mm, penetrated and grouted non-displacement pile which is vigorously built up and conveys the majority of its loading on the high-capacity central steel reinforcement (covered by mortar). The concreting was completed by pressure grouting in the scope of 0.8Mpa to 1Mpa. The pile is introduced in dry land by unearthing a barrel shaped opening which is bigger in distance across, the base should be cleaned, then, at that point, the reinforcement is given and as to as conceivable concreting should be done in dry condition. The piles can be utilized in group moreover. The codes do not to allow the utilization of under three piles to help a major column and under two piles to support an foundation wall. The bearing capacity and settlement of group pile are required for the design of the foundation. To concentrate on the load settlement conduct of the micro piles, model investigations were done on single and group micro piles of various length placed at different spacing.

II. LITERATURE REVIEW

NiharGogoi, SanandamBordoloi and Binu Sharma (2014): They have studied in the model study of group piles for different L/D ratio as well for different spacing between the piles in the group. These piles were installed in sand bed of relative density and subjected to vertical loading where the ultimate bearing capacity of the pile group, Group efficiencies of micro piles groups were determined for L/D ratio and spacing between the piles. This experimental study concludes that Ultimate load capacity increased with the increase in L/D ratio but the increase was not linear. The settlement before reaching the ultimate load capacity decreased with the increase in L/D ratio. The maximum efficiency is dependent on L/D ratio and increases with the increase in L/D ratio Sonu Mathew.11, November-2014: The model experimental study of single and group micro pile with different spacing between the piles was studied in which the piles were installed in clay and subjected to vertical loading, where the Group efficiency of micro pile having 12.5 mm diameter was determined. The group efficiency increases with increasing in spacing

from 2D to 3D and after that group efficiency found to be decreasing for 4D spacing. The improvement of load bearing capacity was found to be increased for both single and group micro piles in clay.

HoyoungSeo, M. ASCE 2013: The experimental investigation results of a static load test determined on a micro pile socked in limestone layers. These tests micro pile having a diameter of 197 mm and length 8.2m with 2.7 m embedded in weathered limestone and 1.5 m in hard limestone. They subjected to the load test to determine the load-transfer characteristics of rock-socked micro piles and to confirm the design limit. The shaft resistance value used for the hard limestone layer, to provide the high-quality data needed for the development of specific design methods for the amylase.

III. MATERIALS & METHODOLOGY

Black Cotton Soil: Black cotton soil used in this academic work was collected from Kodaganuru domain, Davangere District. In site, both disturbed and undisturbed clay soil sample is collected from the open trench of depth 1.5 meter below the natural ground surface. For the testing purpose as per IS code 2720 standard, the sample should be air dried and pulverized systemically and it must be passing through 4.75mm IS sieve. The properties of expansive clay soil sample are tabled below.

Sl. No.	Properties	Values
1.	Specific Gravity	2.72
2.	Water Content	28%
3.	Liquid Limit	62%
4.	Plastic Limit	21.52%
5.	MDD	15.2 KN/m^3
6.	OMC	27.2 %
7.	UC Test	11 KN/m^2
8.	% of Clay Particles	50 %
9.	% of Silt Particles	39.8 %
10.	% of Sand Particles	2.0 %
11.	Free Swell Index	45.47 %

Cement and Sand: The micro piles used for tests were casted using 43 grade cement and the sand passing through 4.75mm IS sieve. Sand and cement were mixed in the ratio of 1:1, with the water cement ratio 0.45.

Technical Instruction reinforcement and UPVC Pipes: In this, Pile test was provided with a central reinforcement having a diameter of 2 mm. The UPVC pipes (un-plasticized polyvinylchloride) are excellent resistance to aggressive environments and it is a non-conductor, galvanic and the elector chemical effects do not occur in these pipes.

Sl. NO.	Central Reinforcement		UPVC Pipes	
	Test	Value	Test	Value
1	Maximum Grit Size	2mm	Specific gravity	1.42-1.43
2	Compression Strength	56 N/mm^2	Tensile strength	500 Kg/cm^2
3	Tensile Strength (flexure)	9.7 N/mm^2	Bending strength	950
4	Property of hardened mortor	2060 Kg/m^3	Modulus of elasticity	3.2 10 kg/cm^2
5	Density of green mortor	2200 Kg/m^3	Hoop stress	8.6 mpa
6	-	-	Shore hardness	70-90 Deg.
7	-	-	Impact strength	4.7 -5.4 Joules.

Methodology:

Test was conducted in square test tank (size of test tank was decided by the footing size),of size 300×300×300 mm with thickness 3mm and the size of footing was 120×120×6 mm thick. Both test tank and footing is made up of mild steel plate. The tank is sufficiently large to take the footing size of 120×120×6 mm thick, where the size of test tank taken for the investigation was equal to 2.5 times the size of the 120mm square footing. Then, the black cotton soil which is air dried and mixed with optimum water content of 27.2% was filled in the test tank in three layers followed by tamping was made to achieve the required density. The micro pile was casted by mixing the cement & sand at equal proportion of 1:1 by keeping the central reinforcement in UPVC pipes (the inner diameter and external diameter of UPVC pipes was 2 cm and 2.2 cm respectively) and then it was cured for 3 days. The universal testing machine is set up in compressive movement at a strain control rate to ensure the load settlement interaction in 1D, 2D and 3D spacing's of micro piles placed in black cotton soil. The 45%, 65% & 85% length of the micro piles were used. Later, the model test was carried out on these micro piles which are placed in soil filled test tank at different spacing with L/d ratios. Then, the footing was placed over the inserted micro piles where the load was applied over the footing plate through the loading frame consist of movable platform which can move up and down by means of motorized mechanism. In order to measure the settlement, the dial gauge was fixed on bottom test tank and concentric load was applied. Then, the load applied on the micro pile was recorded for the corresponding settlement till the maximum settlement

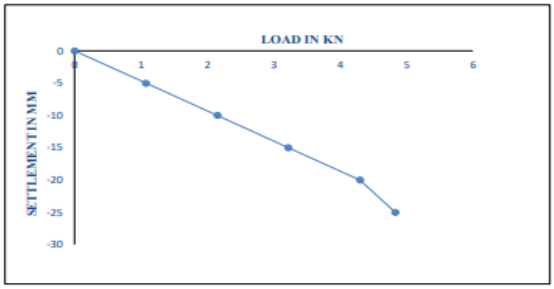
reaches to 25 mm. The above procedure repeats for every testing.

5. RESULTS AND DISCUSSION

5.1 SINGLE MICRO PILE

5.1.1 Load Settlement Behavior for 45% Length Micro Pile

The test was conducted for the single micro pile which was inserted into the black cotton soil (density 15.2 KN/cm^3) exactly at the center having 45% of L/d ratio. The model footing size of 120×120×6mm was placed over the micro pile and the load was applied till the total settlement reaches 25 mm.

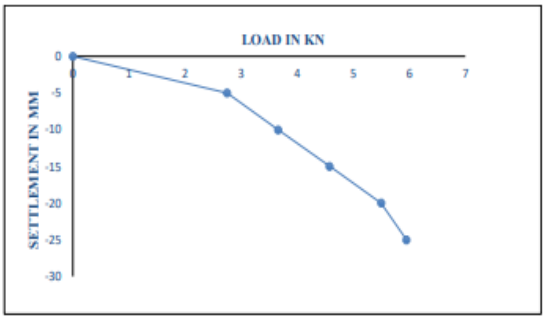


. Fig 5.1 Load -settlement plotting on L/d ratio 45% on single Micro pile

The load-settlement graph was drawn from the recorded data. The ultimate load for the single micro pile of 45% L/d ratio was 4.83 KN at 25 mm settlement.

5.1.2 Load Settlement Behavior for 65% Length Micro Pile

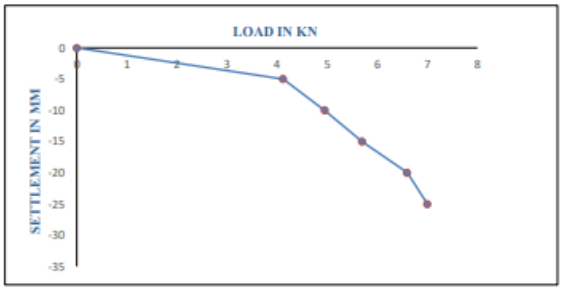
The test was conducted for the single micro pile which was inserted into the black cotton soil (density 15.2 KN/cm^3) exactly at the center having 65% of L/d ratio. The model footing size of 120×120×6mm was placed over the micro pile and the load was applied till the total settlement reaches 25 mm.



. Fig 5.2 Load -settlement plotting on L/d ratio 65% on single Micro pile

5.1.3 Load Settlement Behavior for 85% Length Micro Pile

The test was conducted for the single micro pile which was inserted into the black cotton soil (density 15.2 KN/cm^3) exactly at the center having 85% of L/d ratio. The model footing size of 120×120×6mm was placed over the micro pile and the load was applied till the total settlement reaches 25 mm.



. Fig 5.3 Load -settlement plotting on L/d ratio 85% on single Micro pile

The load-settlement graph was drawn from the recorded data. The ultimate load for the single micro pile of 85% L/d ratio was 7.0 KN at 25 mm settlement.

5.1.4 ULTIMATE LOAD CAPACITY

From the graph it is clear that, for different L/d ratios of single micro pile the load carrying capacity increases in a linear manner.

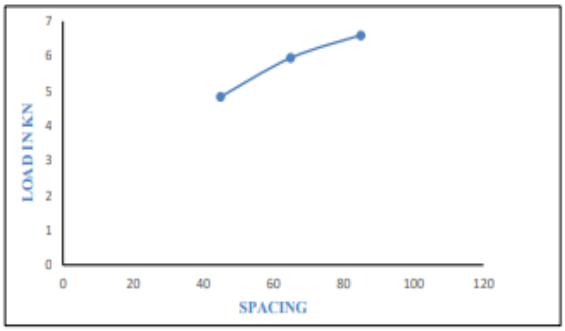


Fig 5.4 Load versus spacing plotting on single Micro pile

5.2 GROUP MICRO PILE

5.2.1 Load Settlement Behavior of Group Micro Pile for 45% Length with 1D spacing

The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 45% of length (12 cm) and at a spacing of 2 cm (1D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

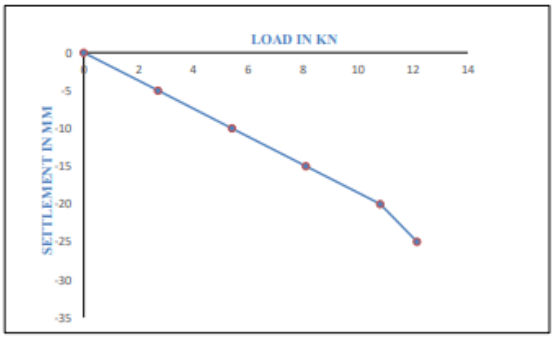


Fig 5.5 Load -settlement plotting on 45% length Micro pile with 1D spacing.

The load-settlement graph was drawn from the recorded data. The ultimate load for the 45% (12 cm) length of piles with 1D (2 cm) was 12.15 KN at 25 mm settlement.

5.2.2 Load Settlement Behavior of Group Micro Pile for 65% Length with 1D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 65% of length (18 cm) and at a spacing of 2 cm (1D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

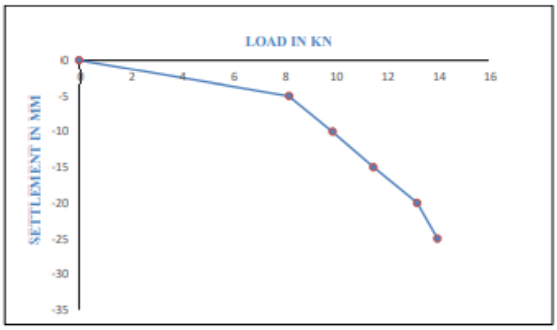


Fig 5.6 Load -settlement plotting on 65% length Micro pile with 1D spacing.

The load-settlement graph was drawn from the recorded data. The ultimate load for the 65% (18 cm) length of piles with 1D (2 cm) was 13.3 KN at 25 mm settlement.

5.2.3 Load Settlement Behavior of Group Micro Pile for 85% Length with 1D spacing the test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 85% of length (24 cm) and at a spacing of 2 cm (1D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

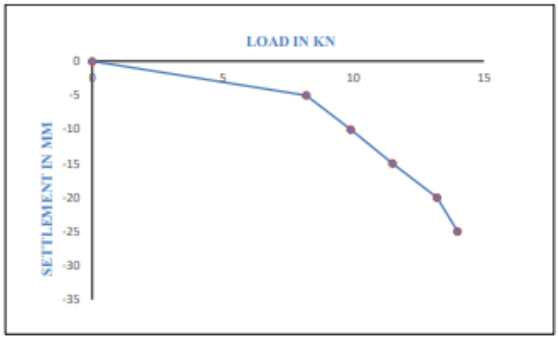


Fig 5.7 Load -settlement plotting on 85% length Micro pile with 1D spacing.

The load-settlement graph was drawn from the recorded data. The ultimate load for the 65% (18 cm) length of piles with 1D (2 cm) was 14 KN at 25 mm settlement.

5.2.4 Load Settlement Behavior of Group Micro Pile for 45% Length with 2D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 45% of length (12 cm) and at a spacing of 4 cm (2D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

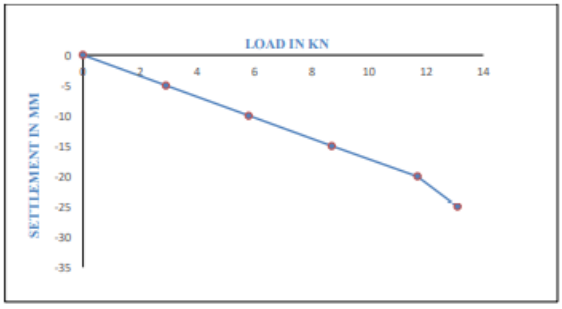


Fig 5.8 Load -settlement plotting on 45% length Micro pile with 2D spacing

The load-settlement graph was drawn from the recorded data. The ultimate load for the 45% (12 cm) length of piles with 2D (4 cm) was 13.1 KN at 25 mm settlement.

5.2.5 Load Settlement Behavior of Group Micro Pile for 65% Length with 2D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 65% of length (18 cm) and at a spacing of 4 cm (2D). The model footing of 120×120×6 mm was placed over the micro piles and

load was applied till the total settlement reaches 25 mm.

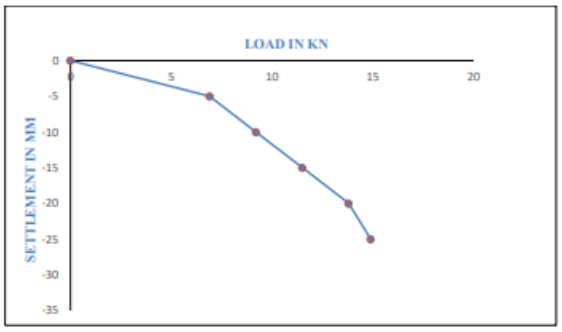


Fig 5.9 Load -settlement plotting on 65% length Micro pile with 2D spacing

5.2.6 Load Settlement Behavior of Group Micro Pile for 85% Length with 2D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 85% of length (24 cm) and at a spacing of 4 cm (2D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

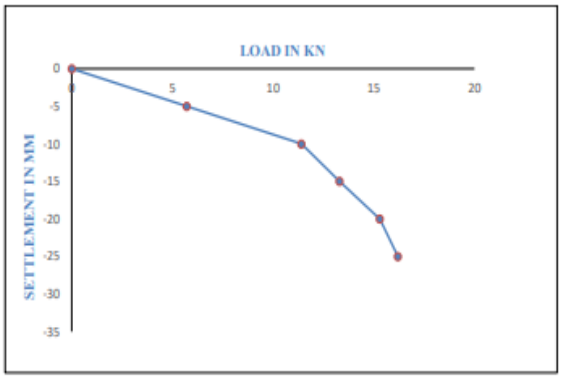


Fig 5.10 Load -settlement plotting on 85% length Micro pile with 2D spacing

The load-settlement graph was drawn from the recorded data. The ultimate load for the 85% (24 cm) length of piles with 2D (4 cm) was 16.2 KN at 25 mm settlement.

5.2.7 Load Settlement Behavior of Group Micro Pile for 45% Length with 3D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 45% of length (12 cm) and at a spacing of 6 cm (3D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

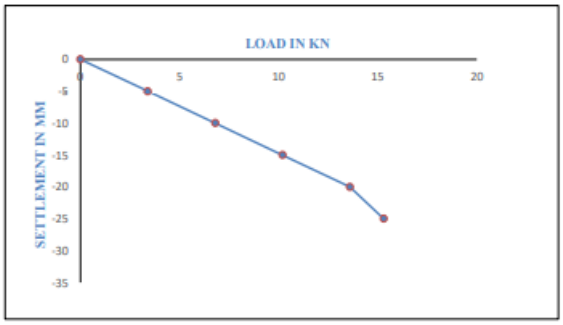


Fig 5.11 Load -settlement plotting on 45% length Micro pile with 3D spacing

The load-settlement graph was drawn from the recorded data. The ultimate load for the 45% (12 cm) length of piles with 3D (6 cm) was 15.3 KN at 25 mm settlement.

5.2.8 Load Settlement Behavior of Group Micro Pile for 65% Length with 3D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 65% of length (18 cm) and at a spacing of 6 cm (3D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

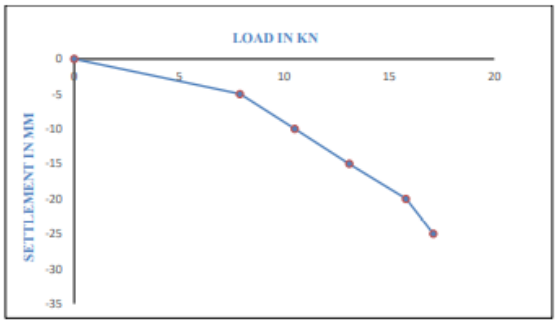


Fig 5.12 Load -settlement plotting on 65% length Micro pile with 3D spacing

The load-settlement graph was drawn from the recorded data. The ultimate load for the 65% (18 cm) length of piles with 3D (6 cm) was 17.1 KN at 25 mm settlement.

5.2.9 Load Settlement Behavior of Group Micro Pile for 85% Length with 3D spacing The test was conducted for the group of micro piles which were inserted into the black cotton soil (density 15.2 KN/cm^3) having 85% of length (24 cm) and at a spacing of 6 cm (3D). The model footing of 120×120×6 mm was placed over the micro piles and load was applied till the total settlement reaches 25 mm.

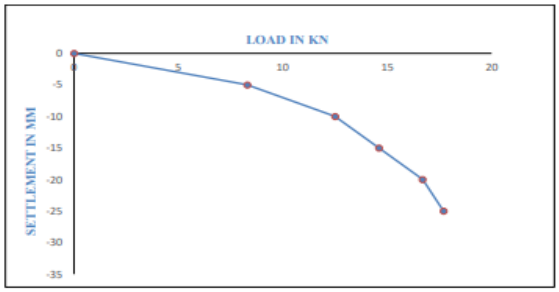


Fig 5.13 Load -settlement plotting on 85% length Micro pile with 3D spacing

The load-settlement graph was drawn from the recorded data. The ultimate load for the 85% (24 cm) length of piles with 3D (6 cm) was 17.7 KN at 25 mm settlement.

5.2.10 ULTIMATE LOAD CAPACITY

The plotting of graph load v/s spacing shows that ,the group of micro pile on the different length and spacing for the ultimate load capacity increases with the increase in Length (45%, 65% and 85%) and spacing (1D,2D and 3D)

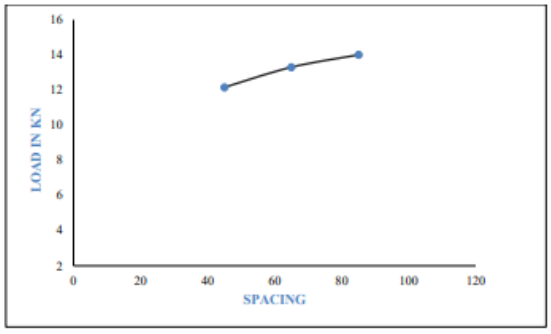


Fig 5.14 Plotting on Load versus spacing with 1D spacing

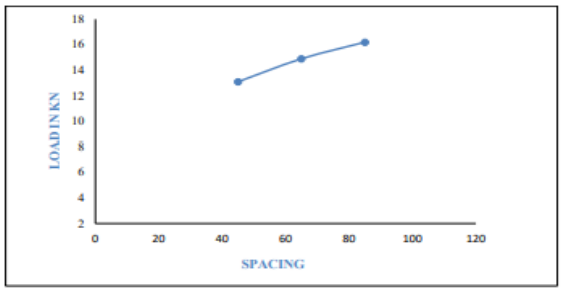


Fig 5.15 Plotting on Load versus spacing with 2D spacing

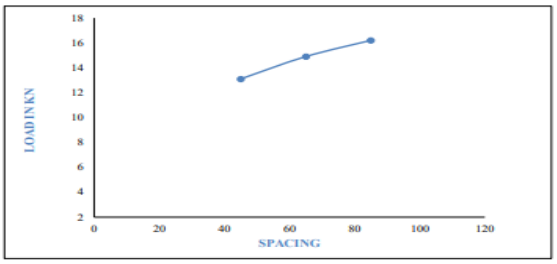


Fig 5.16 Plotting on Load versus spacing with 3D spacing

The above figure shows group of micro pile L/d ratio and spacing 1D 2D and 3D. The ultimate load capacity of all spacing will be increases with the increase to the limited depth of the tank 300mm.

5.3 GROUP EFFICIENCY

The pile group efficiency is defined as the ratio of the actual group capacity to the sum of the individual pile capacities. The group efficiency depends mainly on the spacing between the piles, 2 4 6 8 10 12 14 16 18 0 20 40 60 80 100 120 LOADS IN KN SPACING 2 4 6 8 10 12 14 16 18 0 20 40 60 80 100 120 LOADS IN KN SPACING type of soil in which the piles are installed and the manner of pile installation that is driven, bored, cast in –situ etc... The pile group efficiency, for the piles under vertical loading is calculated from the formula given below.

$$\eta = \frac{Qg}{n \times Qs} \times 100$$

Where η = efficiency of the pile group
Qg = axial capacity of pile group
Qs = axial capacity of single pile
n = number of piles.

The pile group efficiency for the pile at 1D, 2D and 3D spacing had been determined.

Length (cm)	l/d ratio	Single Pile (qu) KN	Group Pile (Qu) KN			Group Efficiency		
			1D	2D	3D	1D	2D	3D
12	6	4.8	12.15	13.3	14.0	0.69	0.75	0.8
18	9	5.9	13.1	14.95	16.2	0.61	0.70	0.76
24	12	7.0	15.3	17.1	17.7	0.56	0.60	0.65

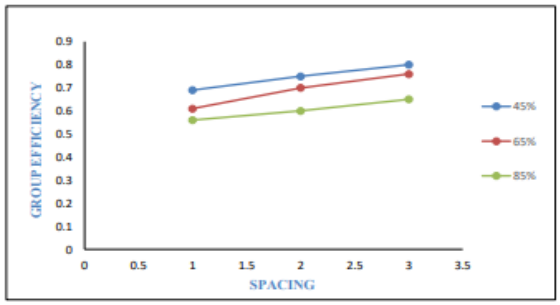


Fig 5.17 Plotting of Group efficiency versus spacing

The pile group efficiency increases with increase in spacing. But group efficiency decreases as the length increases. 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 0 0.5 1 1.5 2 2.5 3 3.5 GROUP EFFICIENCY SPACING 45% 65% 85%

6. CONCLUSION

The model study was conducted to study the performances of single and group piles with a different length and spacing, where the square footing was used for vertical loading. The load v/s settlement graph was plotted from the recorded data, by which the ultimate bearing pressure of the group piles was determined and from the plotting of group efficiency v/s spacing, the group efficiency of the piles was determined.

The specified conclusions can be formed based on the experimental data's,

- Installation of group micro piles in the weak soil is one of the best methods in ground improvement technique.
- The load carrying pressure for the group piles increases with length. Hence the load carrying capacity of the micro piles is directly proportional to their length.
- The load carrying pressure of the piles also increases with their spacing's.
- The pile group efficiency increases with increase in spacing.
- The group efficiency decreases as the length of the pile increases.

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