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A Model Study on Effect of Group Efficiency of Micropile under Axial Loading

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***Abstract*— Micropiles (also called minipiles) are high-performance, drilled and grouted piles with diameters generally ranging from 100 mm to 300 mm. The application of micropiles in retrofitting or as structural support is a technically viable and economically feasible solution in many situations. Micropiles are especially useful in places where heavy machinery cannot gain access in order to lay down conventional piles. As suggested by their name, micropiles have a smaller diameter than conventional pile. These piles comprise of a central steel reinforcement surrounded by grout that fastens the pile with the soil.**

This paper deals with the investigation of a model experimental study of single and group micropile with different spacing between the piles with four numbers of pile in a group. The piles were installed in soft clay and subjected to axial loading condition. Group efficiency of micropile group having 12.5 mm diameter spaced at 2 times the Diameter, 3 times the Diameter and 4 times the Diameter of micropile was determined. The group efficiency was found to be increasing with spacing from 2D to 3D and after that group efficiency found to be decreasing for 4D spacing.

***Keywords*—D-diameter**

I. INTRODUCTION

Micropiles are defined as a small-diameter (less than 300mm) non displacement pile composed of placed or injected grout, and having some form of steel reinforcement to resist high proportions of the design load. The load exerted on the micropile is essentially absorbed by the steel, and transferred through the injected grout to the surrounding rock or soil mass. The steel reinforcement is the major element carrying the load, and the grout serves to transfer the latter, by friction, to the surrounding soil. End bearing contribution is minimal in micropiles, given the nominal geometries involved.

Micropiles provide practical solutions for structural support and for In situ soil reinforcement .Their applications are mainly used in the following domains:

a) Underpinning of existing foundations.
b) Foundation for new structures.
c) Enhancement of bearing capacity for existing structures.
d) Settlement reduction.
e) Soil strengthening and landslide stabilization.
f) Structural stability.

Micropiles can be favored over other piles, because they can be drilled under difficult subsoil conditions and the drilling equipments can function under limited overhead clearance. In addition, they allow minimum settlements to the existing and surrounding structures, and they provide high unit loads ranging from 300 kN to 5000 kN.

II. METHODOLOGY

A. Soft Soil

Soft clay used in this study was collected from Puthuppally region, Kottayam District. Disturbed and undisturbed samples were collected. The undisturbed samples were used for Unconfined Compression Test and Triaxial Compression Test. Various index properties and engineering properties of the soil are found out. Various index properties and engineering properties of the soft are presented in Table 1.

TABLE 1: PROPERTIES OF EXPANSIVE CLAY

PROPERTY	VALUE
Field density	16.2 kN/m^3
Specific gravity	2.06
Moisture content	79.22%
UCC Test results Cohesion Unconfined compressive strength	 8.24 kN/m^2 16.48 kN/m^2
Triaxial test results Modulus of elasticity Cohesion Angle of internal friction Poisons ratio Shear modulas	 1208.33 kN/m^2 11.25 kN/m^2 4° 0.47 410.99 kN/m^2
Percentage of clay particles	9.9%
Percentage of silt particles	71.59%
Maximum dry density	1.4 gm/cm^3
Optimum moisture content	29.1 %
Liquid limit	83 %
Flow index	21.87 %
Plastic limit	71.59 %
Plasticity index	11.41 %
Toughness index	0.52
Shrinkage limit	62.66 %

B Physical Modelling

Physical modeling is performed inorder to study particular aspects of the behavior of prototypes. Full scale testing is in a way an example of physical modeling where all features of the prototype being studied are reproduced at full scale. However, most physical models will be constructed at much smaller scales than the prototype precisely because it is desired to obtain information about expected patterns of response more rapidly and with closer control over model details than would be possible with full-scale testing.

Piles under axial load

An appropriate dimensionless group can be constructed by comparing two characteristics forces ,the axial force and the shaft friction force. Similitude in modelling then requires selection of model dimensions and stiffness so that (length/radius) is identical in model and prototype .

C. Experimental Procedure

A model footing square plate of plan dimension 100 x 100 mm and 6 mm thickness selected and is placed over the casted micropile to carry out the load test.

The clay bed for the tests was prepared in a tank of plan dimensions 280mm x 280mm and 300mm depth. The normally consolidated soft clay bed was prepared by pouring the clay in layers. Clay was thoroughly mixed and filled in the tank in layers by hand with measured quantity by weight. The surface of each layer was provided with a uniform compaction with a tamper to achieve the field density. Care was taken to ensure that no significant air voids are formed in the test bed.

Micropiles are non-displacement piles . Boring is done in the soil filled in the tank using a pipe with corresponding diameter to make the hole where micropile is to be casted. Soil was removed from the hole. The micro piles were casted using 53 Grade cement and sand passing 4.75 mm IS sieve in the ratio 1:1 with water cement ratio 0.5 .The pile was provided with a central reinforcement having a diameter of 2 mm

After preparing the soil bed and casting single and group micropiles having diameter 12.5 mm and the group is formed by varying spacing 2 times diameter,3 times diameter and 4 times the diameter of micropiles is kept for curing for four days of setting and the load deformation behaviour of the soil was studied by applying vertical load in a loading frame. The loading plate used in these tests was square, having side of 100mm, which represents the footing. The load was applied through a proving ring with a constant displacement rate of 3 mm/min. The loads corresponding to different displacements were measured through a pre caliberated proving ring. The settlement readings up to 25mm were recorded .Table 2 shows the load corresponding to various settlement.

Fig 1: Vertical Loading on Micro pile

TABLE 2: LOAD -SETTLEMENT OF GROUP MICROPILE DIAMETER=12.5 MM WITH VARYING SPACING

Settlement (mm)	Load(kN/m^2)			
	Single Micropile	Spacing=2D	Spacing=3D	Spacing=4D
0	0	0	0	0
3	5.909	8.397	11.507	10.885
6	8.086	10.574	14.617	13.062
6.75	8.397	11.196	15.861	14.306
9	9.019	12.129	17.105	15.55
12	9.641	13.373	18.971	17.105
15	9.952	14.306	19.593	17.727
18	10.263	15.239	20.526	18.66
18.75	10.263	15.55	21.148	19.282
21	10.574	15.861	21.459	19.904
24	10.885	16.172	21.9255	20.215
25	10.885	16.483	22.392	20.526

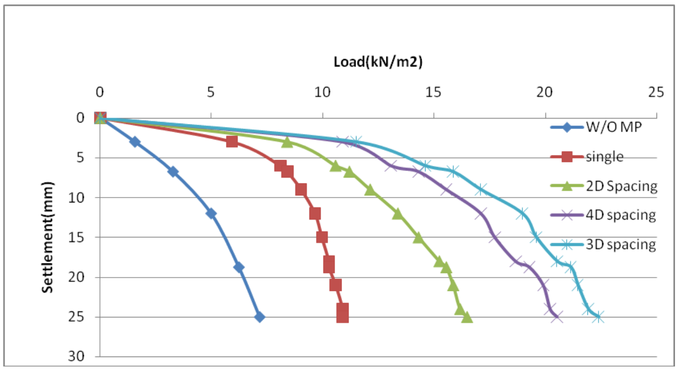

Fig 2: Load Vs Settlement For Group Micropile With Diameter 12.5 Mm Varying Spacing

D. Group Efficiency

In the study of piles under vertical loading, efficiency is often used to evaluate the group effect:

$\eta = Qg/nQs$

where η= efficiency of the pile group;

Qg = axial capacity of pile group;

Qs= axial capacity of single pile; and n = number of pile group.

The group efficiencies of the pile groups at 2D, 3D, and 4D spacing had been determined. Table 3 shows the group efficiency of the various pile groups that studied in experiment.

TABLE 3 GROUP EFFICIENCY FOR DIFFERENT SPACING

Diameter D=12.5 mm	Single Micropile	Spacing		
		2D	3D	4D
Ultimate Load (kN/m^2)	10.885	16.483	22.392	20.526
Group Efficiency		0.37	0.51	0.46

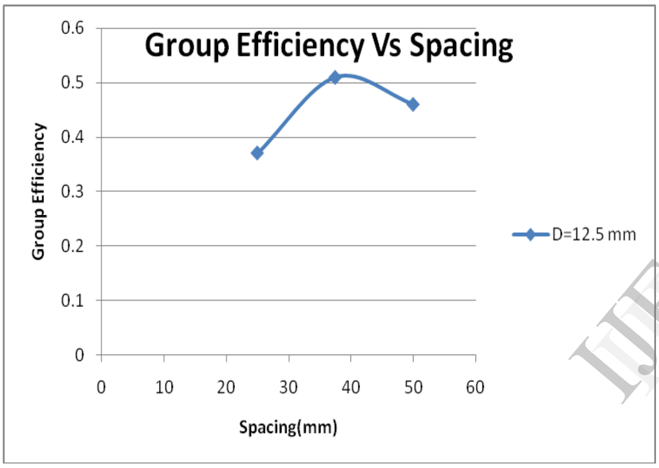

Figure 3 Group Efficiency VS Spacing

III. CONCLUSION

1. The improvement of load bearing capacity is remarkably increased using both single and group micro piles in soft clay.
2. Substantial strength enhancements were observed in the soft clay after pile installation. The magnitude of the strength improvement was noted to be affected by spacing in such a way that the group efficiency increased with increase in spacing from two times diameter to three times the diameter of micropile and found a reduction with four times the diameter spacing.

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