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Research Paper

Evaluation of Settlement and Load Carrying Capacity of Footing with Micropiles on Sand

Engineering

KEYWORDS : Micropile, Pile Spacing, Pile Length, Load carrying capacity.

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ABSTRACT

Micropiles are small diameter cast insitu reinforced grouted piles and it has been effectively used in many applications of ground improvement. It increases the load carrying capacity of soil and reduces the settlement. It is used in strengthening existing foundations. In this study, the effect of Micropiles on the load carrying capacity of footing resting on sand is studied. The effect of Micropiles is investigated by conducting experimental model studies. The parameters involved in this study include pile length and pile spacing. Load test was carried out on a model footing resting on sand with and without Micropiles. Load test trial is repeated for footing on micropiles with varying lengths of 10, 20 and 30 times the diameter and spacing 5, 4, 3, 2 times the diameter. The load-settlement behavior of each case is compared. Optimum length and optimum spacing for the micropiles are determined. It is observed that the effect of micropiles in the peripheral of footing resists lateral displacement of soil underneath the footing. The micropiles beyond significant depth becomes redundant.

introduction

In recent years, Micropiles have been installed on many projects in many parts of the world for different purposes like underpinning, seismic retrofitting, slope stabilization and uplift dynamic loads. In addition micropiles are also used for improvement as reinforcement, compaction, and grouting. It helps to increase bearing capacity and to reduce settlements in existing foundations. Frictional resistance between the surface of the micropile and soil are considered as the possible mechanism for improvement. The failure mechanisms of the piles were found to be influenced by the relative density of the sand bed so, the reduction of failure in sand is done by improving the density of sand which requires any ground improvement technique individual or in combination depending on the ground sited.

Shallow foundations are generally designed to satisfy load carrying capacity and settlement criteria. The load carrying capacity criteria confirms that the foundation has adequate safety against bearing capacity failure beneath the foundation, with a factor of safety of three. Settlement criterion is to ensure that the settlement is within tolerable limit prescribed on codes. It is commonly believed that the settlement criterion is more critical than the shear failure criterion in the design of shallow foundations. By limiting the total settlement, differential settlements can be avoided. The small diameter of 300 mm or less results in little influence on buried obstructions and existing structures. Use of small construction equipment enables construction, where even 3.5m overhead clearance is available.

PROPERTIES OF THE MATERIALS

The soil used as foundation medium was collected from cauvery river, karur (Lalakudi) which is located between north latitude $11^0 12'$N and $10^0 00'$N, East longitude $77^0 00'$E and $78^0 15'$E. The Properties of Soil sample is analyzed as shown in Table 1

Table 1 Properties of Sand

Properties	**Value**
Gravel	0%
Fine sand	60.2%
Coarse Sand	35.5%
Medium sand	4.3%
Silt	0%
Clay	0%
Effective Size , D_{10}	0.28mm
D_{30}	0.4mm
D_{60}	0.6mm
Uniformity coefficient of the sand, C_u	**2.15**
Coefficient of Curvature, C_c	0.95
Specific gravity	2.65
γ_{dry} (maximum)	16.85 kN/m^3
γ_{dry} (minimum)	15.23 kN/m^3
Maximum Void ratio	0.706
Minimum Void ratio	0.542

EXPERIMENTAL STUDY Model Footing

A square plate of plan dimension 60x60 mm and thickness 5 mm was used as model footing.

Model Test Tank

The dimension of the model tank was selected based on the dimension of the model footing. As per IS 1888-1982 (METHOD OF LOAD TEST ON SOILS) which includes plate load test, the width of tank was selected as five times the width of footing. A steel tank of plan dimension 300x300 mm and depth 300 mm was used.

Micropiles

Mild steel rod of plain type having diameter 4 mm and varying lengths of 40 mm, 80 mm and 120mm with flat end was used as Micropiles as shown in Fig 1. The diameter and the length were selected based on the width of the footing. The ratio of the width of footing and the diameter of Micropile was selected as 15.

Fig 1 Solid micropiles of varying length

TESTING PROGRAM

Preparation of Foundation Medium

The soil sample of required quantity passing through 4.75 mm and retained in 0.075mm IS Sieve was taken and filled in tank

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following height of fall method in order to achieve the medium dense sand condition. The amount of sand used is checked based on the weight of sand required for medium dense condition.

Loading Setup

The Loading set up includes the Load frame, proving ring of 50 kN capacity and two LVDT (Linear Variable Differential Transformer).

RESULTS

The results of load – settlement cure for the model footing without micropiles is shown in Fig 2. The ultimate load carrying capacity was found to be 52 N from the figure shown.

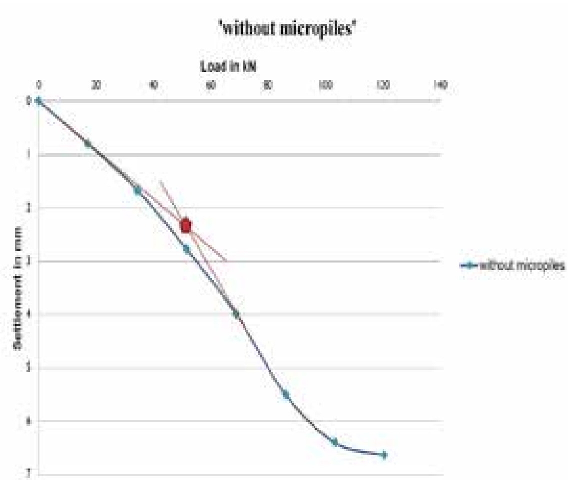

Fig 2 Load-Settlement Graph for the Model Footing Resting on Sand Without Micropiles

The load tests were repeated for footing supported on micropiles by varying the length and spacing of micropiles. The results are shown in Table 2.

Table 2 Ultimate load carrying capacity of footing

Sl.No	Length of Micropiles	Spacing	Load carrying capacity in N	Load carrrying Capacity Improvement Factor(L_f)
1.	10D	5D	62	1.2
		4D	69	1.3
		3D	98	1.9
		2D	90	1.7
2.	20D	5D	69	1.3
		4D	80	1.5
		3D	124	2.4
		2D	115	2.2
3.	30D	5D	57	1.1
		4D	65	1.1
		3D	96	1.8
		2D	88	1.7

The optimum length for micropiles was evaluated from the results shown in Table 2. Load settlement curves were obtained for the model footing on micropiles of optimum length 20D with 4 different spacings. The results are shown in Fig 3.

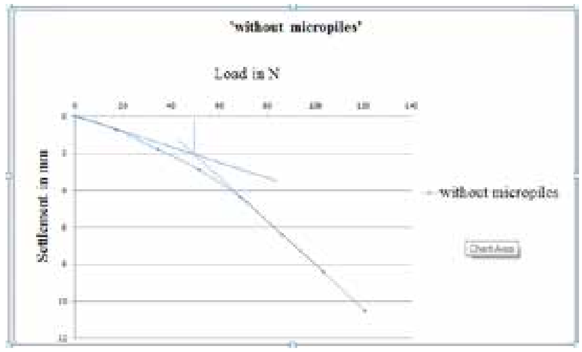

Fig 3 Load-Settlement Graph for the Model Footing

It is observed from Figure 3 that the optimum spacing of micropiles shall be 3d.

6. DISCUSSIONS

The ultimate load carrying capacities of the footing based on load-settlement relationship for footing with and without Micropiles are obtained.

A Load Carrying Capacity Improvement Factor (L_f) is calculated. The Load Carrying Capacity factor is defined as the ratio of the ultimate load carrying capacity of footing with Micropiles and the ultimate load carrying capacity of footing without Micropiles.

The maximum ultimate load carrying capacity of footing resting on sand with micropiles of varying length 30D, 20D, and 10D was determined to be 98N, 124N and 96N respectively for a spacing of 3D. Correspondingly the Load carrying capacity improvement factor was determined for varying lengths of micropiles 30D, 20D, and 10D as 1.9, 2.4 and 1.8 respectively.

The maximum load carrying Capacity Improvement Factor (L_f) is found to be 2.4 for Micropiles of length 20D at spacing equal to 3D. It indicates that the load carrying capacity of footing with Micropiles has been increased by 2.4 times than the load carrying capacity of footing without Micropiles.

CONCLUSIONS

- Micropile has a significant effect on improving the load response of footing supported on sand.
- The settlement of the footing can also be considerably reduced with the Micropiles.
- From the tests conducted, the optimum length and optimum spacing of Micropiles was found to be 20 and 3 times the diameter of the micropile (D).
- Micropiles longer than 20D times the width of footing pose problems during placement and it do not enhance the load carrying capacity.
- As the installation of Micropiles is easy and it involves no alteration in the foundation, it can also be used for existing footing as retrofitting measures.

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