International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 3, May-June 2024

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Foundation Reinforcement with Inclined Corrugated Micro-Piles: A Practical Perspective

Sarath C S[1], Sudha A R[2]

[1]M. Tech Scholar, Department of Civil Engineering, St. Thomas Institute for Science and Technology, Trivandrum, India

htarascs13@gmail.com

[2]Assistant Professor, Department of Civil Engineering, St. Thomas Institute for Science and Technology, Trivandrum, India

sudha.ce@stisttvm.edu.in

----------**********----------

Abstract:

Micro-pile is a type of pile which acts as a supporting structure to transfer the load from building to the ground. Micro-pile is a deep foundation element constructed using high strength, small diameter steel casing or corrugated bar. By using corrugated bars high bond strength will be developed.The soil chosen for this study is Chenkal clay and the geotechnical properties of the soil were determined. Fe 500 TMT corrugated bars (micro-piles) of 12 mm diameter (D) were purchased for the study and cut to lengths 5D, 10D & 12.5D. The micro-piles were provided at spacing's 2D, 3D & 4D. Inclinations adopted for the study were 15°, 30° & 45°. Square footing in a square pattern and circular footing in a triangular pattern were adopted. The plate load tests were conducted on both square & circular footing.The bearing capacity of soil and settlement of foundation were determined on both square & circular footing and shows a percentage increase of 15.79% & percentage decrease of 62.97% respectively for square footing & a percentage increase of 14.85% & percentage decrease of 56.25% respectively for circular footing. The optimum length, spacing and inclinations were determined on square footing and circular footing respectively. Comparison study on square footing and circular footing were done.

Keywords **—Plate Load Test, Bearing capacity, Corrugated Micro-piles, Settlement**

----------**********----------

I. INTRODUCTION

Strengthening of foundations of buildings prone to earthquake or new floors added to existing buildings due to very high land values in big cities which requires the need for excavation and temporary support systems below the foundation level. This would create a problem due to limited head room and access in congested areas in many places

Micro-piles are small diameter piles usually it's diameter ranges from 100-300 mm, where it is bored cast-in-place piles and most of the applied loads are being resisted by steel reinforcement. They are constructed by drilling boreholes then casing in inserted into the holes, placing steel reinforcement and grouting the holes.

In this project micro-piles are driven into clayey soil at various spacing's and inclinations. Threaded/corrugated bars not only to produce full tension and compression capacity which provides the muchneeded bonding. Inclinations offers increased lateral resistance and improved load-bearing abilities.Inclined angle provides stability, especially in areas prone to sliding or where traditional vertical piles might not be as effective.

II. OBJECTIVE

The objective of this work is to study the effect of corrugated micro-piles in various inclinations. The main objectives are to study the following:

- To find the optimum length, optimum spacing & optimum inclinations of the corrugated
- Micro-piles on both square footing & circular footing.
- To determine the settlement on square footing & circular footing placed on soil with and without micro-piles.
- To determine the bearing capacity on square footing & circular footing on soil with and without micro-piles.
- To compare the results in both square footing & circular footing

III. MATERIALS AND METHODOLOGY

The materials used for the study were clayey soil, micro-piles, model footings and also modeltest tank. The locally available clayey soil was collected. The footings and also the micro-pilesof required dimensions were purchased. A model

test tank is constructed in the laboratory inorder to make the soil bed.The details of the materials, methodology andexperimental setup are explained in the following sections.

A. Materials

The various materials required for the study are listed below:

1) ***Clayey Soil:*** *The clayey soil for the study was collected from Chenkal, Thiruvananthapuram, Kerala.The engineering properties ofthe soil were determined.*

Fig. 1 Clayey Soil

TABLE I
PROPERTIES OF SOIL

Property	Result
Specific Gravity, G	2.219
Liquid Limit , W_L	58%
Plastic Limit, W_P	32%
Plasticity Index, I_P	26%
Soil Classification	CH
Percentage of Clay	53%
Percentage of Silt	46.50%
Unconfined Compressive Strength	50.52kN/m²
Maximum Dry Density	12.62kN/m³
Optimum Moisture Content	25%

2) ***Corrugated Micro-piles:*** *Fe 500 TMT bars are used as micro-piles. Diameter (D) adopted for the study is 12 mm.Length of micro-piles under study were selected as 5D, 10D & 12.5D, i.e. 60 mm, 120 mm &150 mm respectively.Spacing to be provided between micro-piles were selected as 2D, 3D & 4D, i.e. 24 mm, 36mm & 48 mm respectively.Inclinations provided with respect to the vertical micro-piles were selected as 15°, 30° & 45°for each spacings.*

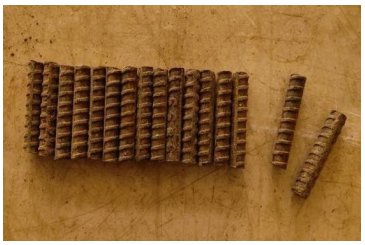

Fig. 2 60mmlengthMicro-piles

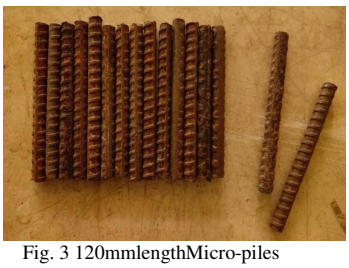

Fig. 3 120mmlengthMicro-piles

Fig. 4 150mmlengthMicro-piles

3) ***Model Square Footing and Circular Footing:*** *A mild steel square plate of dimension 120 x 120 x 10 mm was used as square footing and mild steel circular plate of dimension 120 x 10 mm were used as circular footing.*

Fig. 5 Model Square Footing

Fig. 6 Model Circular Footing

B. Methodology

The soil is being mixed with water at OMC thoroughly and it is then filled in the steel tank. It is being filled in layers where it is being compacted and levelled.Corrugated micro-piles are inserted into the soil by using a plastic sheet having the pattern of spacings to be provided between micro-piles and inclined insertion was done by placing a chart cardboard having the inclinations marked on it. By placing the micro-piles parallel to the lines on the chart inclination was done.After the micro-piles are inserted, a square plate of dimension 120 x 120 x 10 mm and circular plate of dimension 120 mm x 10 mm is placed over the micro-piles. According to IS 1888: 1983, Plate Load Test was conducted and the results were obtained. The flow chart of methodology is given below:

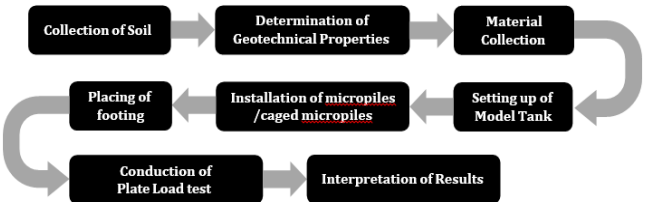

Fig. 7 FlowChartofMethodology

C. Experimental Setup

The plate load tests were conducted on 60 mm length (Set 1), 120 mm length (Set 2) & 150 mm length (Set 3) with 24 mm, 36 mm & 48 mm spacings, each tested at 15°, 30° & 45° on both square & circular footings. The micro-piles were inserted in two different patternsnamely square pattern (on square footing) and triangular pattern (in circular footing) A mild steel square plate of dimension 120 x 120 x 10 mm was used as square footing and mild steel circular plate of dimension 120 x 10 mm were used as circular footing. The loads are applied using hand operated - mechanical jacks of capacity 50kN. The applied loads are measured using load dial gauge of capacity 50kN. The settlements were measured using two dial gauges each of 0.01mm sensitivity kept diametrically opposite to each other. The load is applied in equal increments to the model footings & settlements are recorded simultaneously from both the dial gauges.

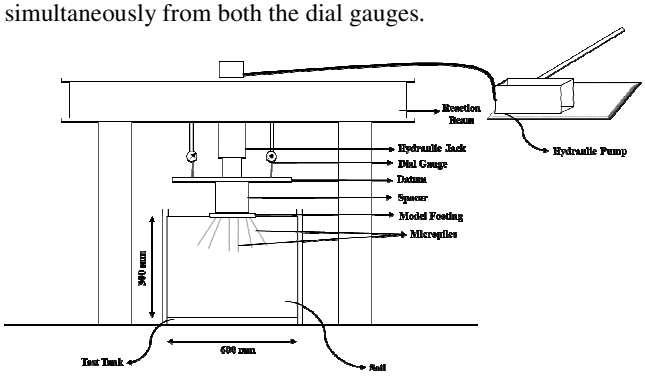

Fig. 8 SchematicDiagramofLoadingSetup

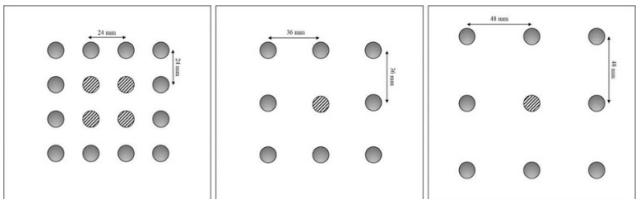

Fig. 9 SquareFootingwithSquarePattern

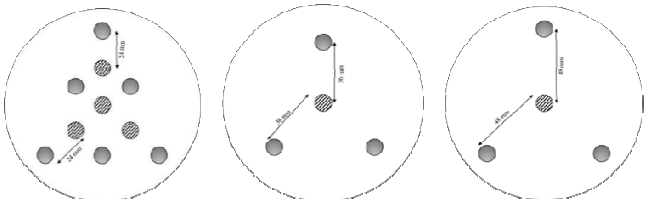

Fig. 10 CircularFootingwithTriangularPattern

IV. Results And Discussion

A. Test on Square Footing and Circular Footing

After the soil gets filled in the tank, square footing was placed inside without micro-piles and the plate load test was conducted. The settlements were noted and the load - settlement curve was evaluated.The load – settlement curves for without micro-piles on square footing and circular footing were studied.The following equation is used for calculation:

$$S_f = S_p \times \left(\frac{B}{Bp}\right)$$

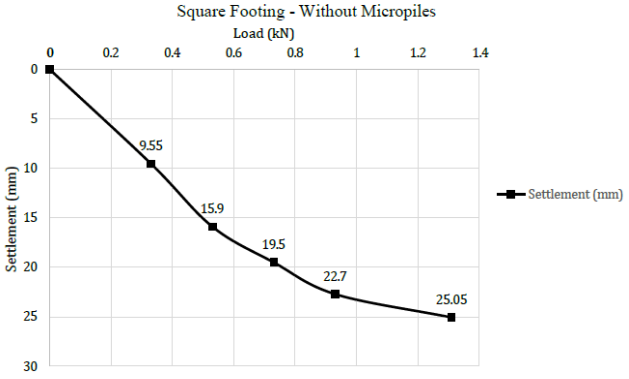

Fig. 11Square Footing without Micro-piles

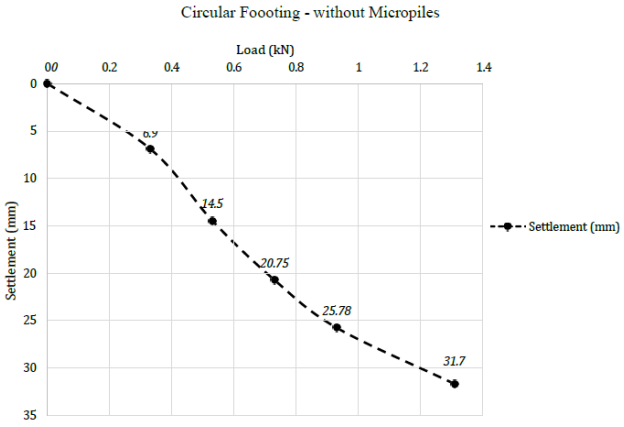

Fig. 12Circular Footing without Micro-piles

The load – settlement curves for optimum spacings of each length on square footing and circular footingwere studied. Micro-piles of length 150 mm (Set 3) is having the least settlement (blue curve) on square footing and Micro-piles of length 60 mm (Set 1) is having the least settlement (red curve) on circular footing.

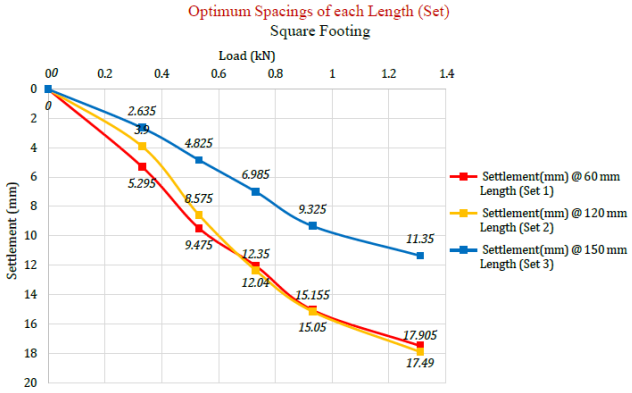

Fig. 13Optimum Spacings of each Length (Square Footing)

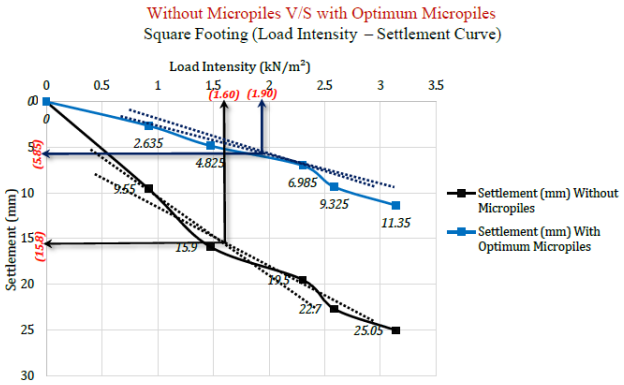

Fig. 14 WithoutMicro-pilesV/SwithOptimum Micro-piles (Square Footing)

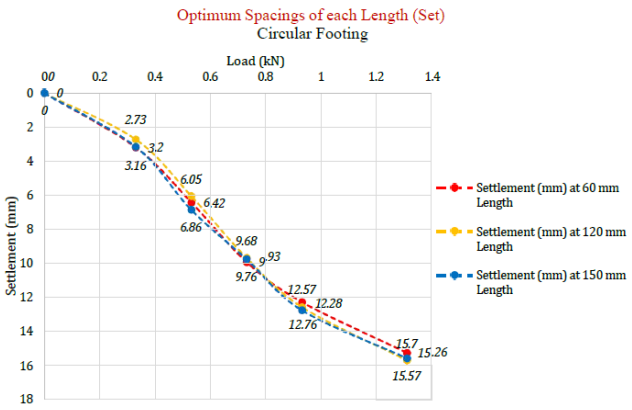

Fig. 15Optimum Spacings of each Length (Circular Footing)

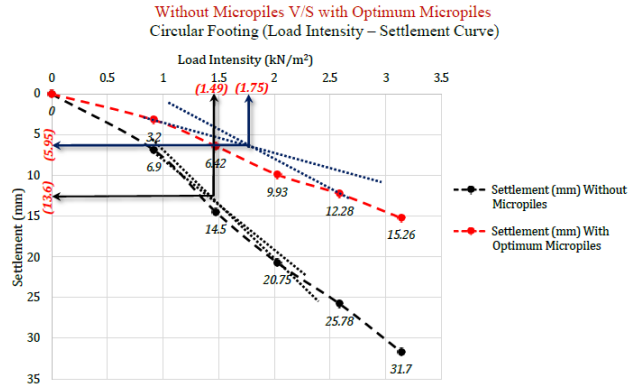

Fig. 16 WithoutMicro-pilesV/SwithOptimum Micro-piles (Circular Footing)

B. Comparison Study

After conducting tests on both square footing and circular footing, a comparison study was done for both without micro-piles and with optimum micro-piles conducted on both model footings. A comparison of final settlement on both square footing and circular footing were studied.

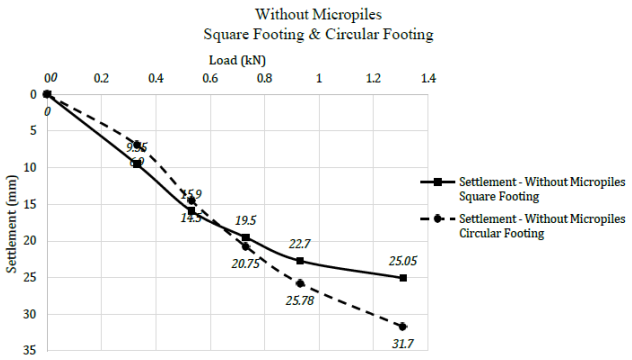

Fig. 17Square Footing and Circular Footing without Micro-piles

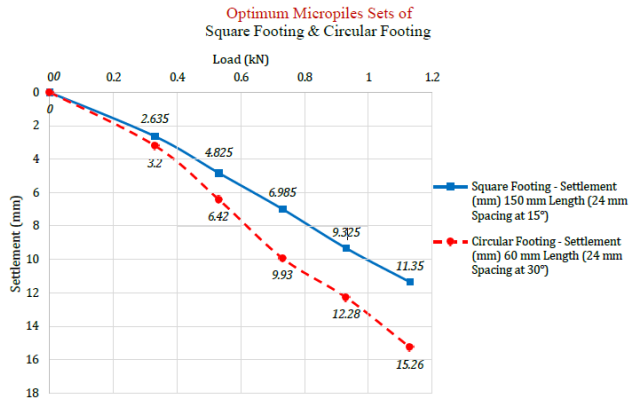

Fig. 18Optimum Micro-piles Sets of Square Footing and Circular Footing

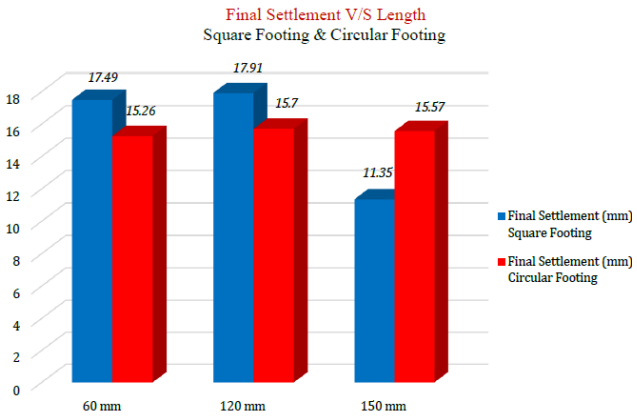

Fig. 19Final Settlement V/S Length of Square Footing and Circular Footing

V. Conclusions

- Optimum length, optimum spacing & optimum inclination of micro-piles were determined for square & circular footings. (150 mm, 24 mm & 15° respectively for square footing & 60 mm, 24 mm & 30° respectively for circular footing)
- Percentage of settlement decreased after conducting the test with optimum micro-piles for square & circular footings. (62.97% decrease & 56.25% decrease respectively)
- Percentage of bearing capacity increased after conducting the test with optimum micro-piles for square & circular footings. (15.79% increase & 14.85% increase respectively).
- From the study, corrugated micro-piles tested on square footing showed better results, which may be due to larger contact area, higher edge stiffness & enhanced load transfer compared to tests on circular footing.

Acknowledgment

First of all, I would like to thank "God Almighty" for his grace, mercy, wisdom and blessing through endeavour without which it would not have been possible.

I at the outset, place a record of my deep appreciation and gratitude to Dr. A.G. Mathew, Principal, St. Thomas Institute for Science and Technology for his kind support throughout the completion of the project.

I would like to express my sincere gratitude to Mr. Asish Prasad, Head of the Department, Department of Civil Engineering, St. Thomas Institute for Science and Technology, for his keen interest, intensive vision, support, excellent guidance and valuable suggestions in completing the project.

I am greatly thankful to Mrs. Sudha A.R (Assistant Professor), P.G Coordinator, Dept. of Civil Engineering for her support and cooperation.

I am deeply indebted to my advisor Mrs. Aishwarya Shaji (Assistant Professor), Department of Civil Engineering, STIST for her excellent guidance, positive criticism and valuable comments.

Finally I thank my parents and friends near and dear ones who directly and indirectly contributed to the successful completion of my project.

References

[1] Ahmed S. A. Al-Gharbawi et al. (2024), "Behavior of soil reinforced with micropiles",Open Engineering 2024; Vol 14: 20220563.

[2] Ahemed Elsawwaf et al. (2023),"The behavior of micropiled raft foundations subjected to combined vertical and lateral loading: numerical study", Springer: Arabian Journal of Geosciences, Vol 16.

[3] Ahemed Elsawwaf et al. (2022), "The effect of combined loading on the behavior of micropiled rafts installed with inclined condition", Environmental Science and Pollution Research, Vol 29:81321–81336.

[4] Arathy M.T and Prof. Aishwarya Shaji (2022), "A Study on Micropiles in Foundation", International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Volume 2, Issue 6.

[5] Aswathy P.A and Meera Manuel (2016), "A Model Study on Effect of Pattern on Group Efficiency of Micropile", International Journal of Science and Research (IJSR), Volume 5 Issue 8.

[6] Binu Sharma and Zakir Hussain (2019), "Behaviour of Batter Micropiles Subjected to Vertical and Lateral Loading Conditions", Journal Geoscience and Environment Protection, Vol 7, pg. 206-220.

[7] Binu Sharma (2011), "A Model Study of Micropiles subjected to Lateral Loading and Oblique Pull", Indian Geotechnical Journal, Vol 41, Issue 4, 196-205.

[8] Diego Bellato et al. (2015), "Behaviour of micropiles in heterogeneous coarse soils",Institution of Civil Engineers (ICE).

[9] Dr. H C Chowde Gowda et al. (2023), "A Model Investigation on Effect of Pattern on Group Efficiency of Micropile in BC Soil", International Journal of Creative Research Thoughts (IJCRT), Volume 11, Issue 2.

[10] Dr. Rahul Patil and Mr. Darshan K R (2022), "A Study Model of Micropile Group Efficiency under Axial Loading Conditions", International Journal of Innovative Research in Technology (IJIRT), Volume 8 Issue 10.

[11] Harish Chand and Jagdeep Singh (2018), "An Experimental Study of Slope Stability with Group Action of Micropiles", International Journal of Civil Engineering and Technology (IJCIET), Volume 9, Issue 8.

[12] 12. MN Elsiragy (2021), "Field Comparative Investigation of Loading Test on Micropiles Installed with Different Technique – (Case Study)", European Journal of Engineering and Technology Research, Vol 6, Issue 4.
[13] 13. Mohit Talwar et al. (2022), "Experimental Study on Behavior of Micropiles on Sand Resting on Footing", International Journal of Innovative Research in Technology (IJIRT), Volume 9, Issue 2.
[14] 14. Morteza Esmaeili et al. (2013), "Experimental and Numerical Study of Micropiles Reinforce High Railway Embankments", International Journal of Geomechanics, Vol 13:729-744.
[15] 15. Natukula Triveni and Suresh Kommu (2023), "Analysis of Soil Behavior by Constructing the Micro Pile", IOP Conference Series: Earth and Environmental Science 1280 012038.
[16] 16. Nihar Gogoi et al. (2014), "A Model Study of Micropile Group Efficiency under Axial Loading Condition", International Journal of Civil Engineering Research, ISSN 2278- 3652, Volume 5, Issue, pp. 323-332.
[17] 17. Priyanka Kulkarni and V.V Shelar (2023), "Analysis and Effect of lateral forces on Micropiles", World Journal of Advanced Engineering, Technology and Sciences (WJAETS), Vol: 09 Issue: 1, pg. 166–181.
[18] 18. Racquel Nottingham and Freddy Lopez (2021), "Reinforcement of a Piled Foundation with Selfdrilling Micropiles", Associazione Geotecnica Italiana, Roma, Italia, ISBN 978-88-97517-16-0.
[19] 19. Shyma Jose et al. (2018), "A Model Study on Lateral Behaviour of Micropile under Inclined Compressive Loads in Sand", International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 04.
[20] 20. Sonu Mathew and Swapna Thomas (2014), "A Model Study on Effect of Group Efficiency of Micropile under Axial Loading", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3, Issue 11.
[21] Tae-Hyun Hwang et al. (2017), "Effective installation of micropiles to enhance bearing capacity of micropiled raft", ScienceDirect, Soils and Foundations, Vol 57, 36–49.
[22] 22. Vikas Kumar and Abhishek Arya (2019), "Literature Review of Micropiles and its Classifications", International Journal of All Research Education and Scientific Methods (IJARESM), ISSN: 2455-6211, Volume 7, Issue 5.

