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Uplift Capacity of Long Finned Piles in Sand Stabilized by Geo-jute

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Abstract: The "finned pile" is a modern modification method that is suggested in this thesis to enhance the capability of deep foundations exposed to uplift forces. On which these substantial foundations are built a variety of structures, including dock fendering systems, tower foundations, flooded platforms, and abutments. The alteration entails wrapping the area with two or four fins on the top, middle, and the buttom of the pile. Comparative small-scale model uplift testing was done on both standard piles without fins and piles with different fin designs in the study to enhance the effectiveness of each. The length ratio (Lf/Lp), width ratio (Wf/Wp), number, and shape of the fins were all systematically changed during the research. The studies shows that adding fins close to the pile top greatly increases the capability of the pile to withstand uplift forces. When comparing the two different fin designs evaluated, rectangular fins were found to perform better rather then triangular fins in terms of ultimate lifting capabilities. The ideal arrangement for maximizing the piles' maximum uplift capability resulted as to have a Lf/Lp ratio of 0.4. A higher fin width contributes to a higher capacity, the results also show a clear correlation between width of the rectangluar , triangular fins and uplift capacity of piles.

Keywords: ultimate uplift load, finned piles, load carrying capacity.

I. INTRODUCTION

In foundation system that can enhance both upright and parallel forces is necessary for modern engineering constructions, either by properly transporting stress to the soil or by preventing pullout pressures. Based on their depth, foundations are divided into shallow foundations and deep foundations. When the soil beneath a building cannot take the stress, then the deep foundations are favored. Engineers may make sure that complex engineering constructions are stable and durable in a various types of soil conditions by carefully choosing and building the proper deep foundation type.

Shallow foundations are suggested, since they are easier to build. To ensure reliable weight transfer and avoid hazardous load distribution, a deeper foundation may be necessary if the topsoil is loose, fragile, or prone to swelling. Pile foundations are frequently employed in difficult soil situations. In order to guarantee the stability of the structure, piles might be set in groups. They work on various of building projects, including jetty constructions, high tension towers, sea shore surface or imerged platform anchoring systems, and tall chimneys. In-depth where the experimental reasearch has been done over the past few decades to understand how pile foundations respond to uniaxial and biaxial compressive, partially-inclined, and lateral pressures. Engineers may design and build pile foundations for diverse engineering structures with increased dependability and performance because to the knowledge obtained from this research.

In conclusion, pile foundations are essential for guaranteeing the stability, load-bearing capacity, and general safety of different structures, particularly in difficult soil and environmental circumstances.

II. EXPERIMENTAL WORK

A. Experimental Setup

The piles employed in experimental study had triangular fins, rectangular fins of various diameters, and their embedment lengths were 600 mm. The fins which were constructed from 2 mm thickness of aluminum sheets and attached at the topmost, middle, and bottom layer of the pile at the angle of 180° using detachable screws. Then, at 45°, the pile was shoved vertically straight inside sand bed.

Dial-gauges were positioned on top of pile-head and then adjusted to remove any tensile movement in account to measure the uplift capacity. Then, using a hand jack positioned on the proving ring, uplift loads were applied to the pile head. On one end, the jack was fastened to the loading frame; the other end was left free. The dial gauges measured the uplift deformation for each increment in load as it was applied, and this information was utilized to generate load-deformation graphs.

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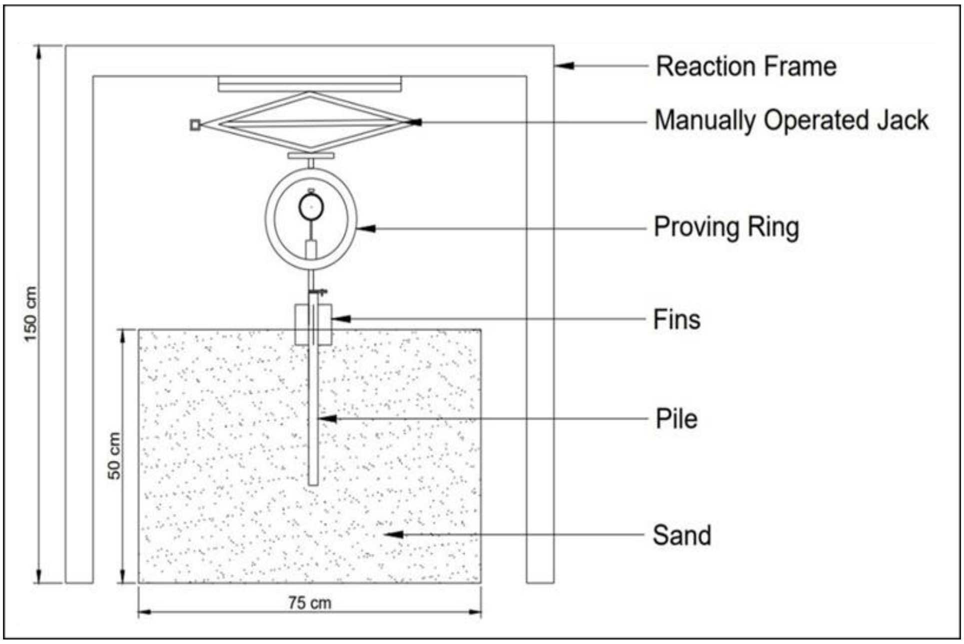

Fig 1: A Schematic Diagram of Setup of Experiment

Fig 2 : Laboratory Test Setup

B. Test Materials

1. Model Tank

The laboratory tests were conducted inside a specially built iron material tank with sections which were 75cm width, 75cm length and 50cm depth. A response frame that is installed in surrounding of the tank is in charge of applying the Mannual Load.

2. Sand

Sand that has been dried out from a river was used for the experiment. The Pycnometer method was utilised in order to ascertain the specific gravity of the soil particles.

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Table 1 : Properties of sand

PROPERTIES	VALUES
Type of Sand	Sand
Specific Gravity (G)	2.42
Water Content, WC(%)	7.5
Grain Size : D10, D30, D60 (mm)	05., 0.32, 0.37
Uniformity Coefficient, C_u	1.4
Coefficient of Curvature, C_c	0.29
Clasification (IS 1498-1970)	SP
Maximum dry weight, Y_{max} (KN/m^3)	18.85
Minimum dry weight, Y_{min} (KN/m^3)	14.37
Maximum void Ratio, e_{max}	0.507
Minimum void Ratio, emin	0.783
Relative Density(%)	1.6
Cohesion (c)	0
Angle of internal friction (ø)	37

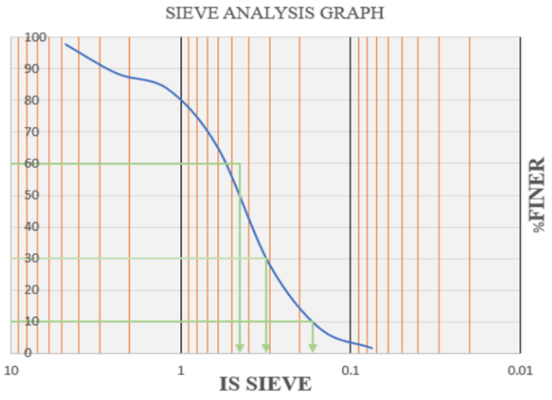

Fig 3 : Grain Size Analysis curve

3. Geojute

Geotextiles are commonly used in geotechnical engineering to enhance soil stability, drainage, filtration, erosion control, and reinforcement. These permeable fabrics are typically made from synthetic materials such as polyester or polypropylene. The term "GeoJutes" is indeed related to geotechnical engineering, it could possibly refer to a specific type of geotextile made from jute fibers or have some unique application or property within the field.

However, without additional context or information, it is challenging to provide a comprehensive explanation. For a more in-depth understanding of "Geo-Jutes" in the contemporary context of geotechnical engineering, it is recommended to consult the latest geotechnical engineering literature or seek insights from experts in the field.

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Fig 4 : Geojute

4. Model Pile

A solid aluminum rod with a 20 millimeter diameter was used to build the pile shaft for the uplift pull-out test. The pile had a length of 600 mm and an embedding length-to-diameter ratio (L/d) of 30, which stayed constant during the course of the testing.

The pile's surface is smooth in its natural state, resembling an aluminum pile without any additional outside treatment. Three holes have been purposefully positioned at the head, middle, and tip regions of the pile as share of an intended design. Along the overall-length of the pile, these holes have been added to permit various fin arrangements.

Fig 5 : A Smooth Aluminum Pile

Table 2 : Dimensions of Pile

Type of Material	Aluminum (Solid)
Diameter of Pile (mm)	20
Length of Pile (mm)	600

5. Fins

The embedment ratio was constant and the number of fins were changed throughout the course of the tests, and the results were compared to those of a standard vertical pile.

Fig 6 : Attachable rectangular 2 fins

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Fig 7 : Attachable triangular 4 fins

Fig 8 : Attachable rectangular 4 fins

C. Sand Bed Preparation

In the studies, a special technique was utilized to generate a homogeneous required density over the bed. Sand was distributed evenly by being dropped from above the controlled discharge-rate and constant acceptable height of fall. The overall depth of the iron tank is 50cms, for every 10cms the geojute is placed. Small cans with precise capacity was used to collect samples of sand and distribute them uniformly throughout test-tank in command to track the relative-density reached during the testing. With a relative density range that accounted for about 35% of the whole range, the sand rain-fall approach indicated loose density circumstances. The sand average unit-weight was caculated to be 14.9 KN /cubic meter, and both the highest and lowest densities met the requirements of IS: 2720-1983.

There were no sign of particles discrimination during the sand rainfall experiment, and the consistency tests verified that the relative-densities found from each of the samples were consistent irrespective of where all the cans were placed. In a direct-shear test, where the sample relative-density was kept at 35% by dry tamping, the internal-friction angle of the sand came out to be 36°. This value, which came about the result of the precise testing methodologies preferred in the study, offers important details about the features and behavior of sand in reference to its density and frictional properties.

Fig 9 : Sand Bed Prepared and Levelled

1. Calibration of height of Fall

Before the experiment, the height of fall for a particular density was calculated using the trial and error method into the bowl with a specified volume. The sand was dispensed from the driving box at a certain mentioned height which was remained constant to achieve a reproducible density. The bowl was located such that it will rest at buttom of the iron tank.

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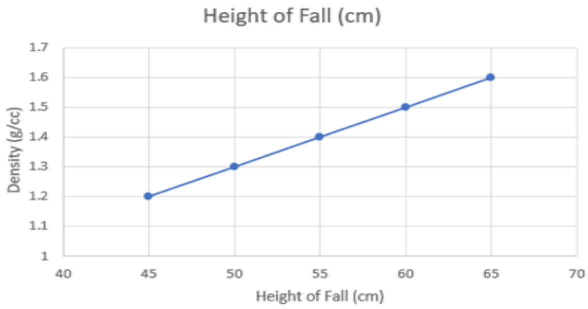

Fig 10 : Calibration curve

2. Rainfall Technique

A crucial method of sand deposition was utilized to produce a repeatable density for the studies. To begin with, loose sand instances were created by continually pouring sand inside the tank through a mesh while maintaining the mentioned height of fall at about 65 cm. The plain pile was pushed inside the sand from one sideway of the tank until it reached the target embedment-length of 600 millimeters, moving in the direction of the tension load. This study's method of sheeting down sand is known as the "Rainfall Technique". It was exposed that it was effective in obtaining good repeatable densities. To maintain uniformity, the sand's surface was meticulously smoothedThe sand was given a dry-density of 1.52 gms/cubic centimeter using the rain-fall method. For uniformity and reproducibility in the studies, absolute density of the sand sample in the bowl was evaluated after each test. A stable and constant foundation for the experimental investigations was provided by this precise method of sand deposition, which assured that the appropriate densities were obtained.

Fig 11 : Sand Poured to the tank by Rainfall Technique

III. EXPERIMENTAL PROCEDURE

- The purpose of this experimental program is to examine the uplift load capacity of finned piles with an embedment length of 600 millimeters. An iron model test tank with specified measurements of 750 mm in length, 750 mm in width, and 500 mm in height is used for the experiments. By pouring sand through a 4.75mm IS Sieve to reach the desired density, either sun-dried or oven-dried sand is used to fill the tank. The tank's bottom needs to be filled with sand that is at least 600 millimeters thick.

- A simple pile without fins with an embedment length of 600 millimeters is pushed into the sand layer once filled to the desired height in command to retain its verticality. Then, by rotating a finned pile clockwise, it is placed into the sandy layer with an embedment length of 600 millimeters as well. A strain-controlled proof ring is attached to the threaded end of the screw, which is used to draw the pile higher and outward. The response frame is supported by a hand-operated loading jack that is fastened to the proving ring.

- The pile head has an aluminum plate that is permanently set to house a travel dial gauge with a 0.01 mm accuracy that detects displacement during the testing procedure. The load is gradually increased, and with each load increment, the pile's deformation is stabilized. When the deformation achieves its higher value, starts to drop, or stays constant, the loading is terminated.

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- The tests involve changing the Lf/Lp ratios for the finned pile structure while keeping the embedment length constant. To determine the maximum load, graphs of load vs. deformation are produced. The number, size, placement, and form of fins, the Lf/Lp ratios, all disturb the pile's ultimate uplift load capacity, with the maximum load serving as a measure of the pile's capacity.

- Finally, the experimental data is examined and contrasted with a straightforward vertical pile to determine the effect of various finned pile parameters on its uplift capability. Understanding how finned piles behave and function under uplift loads will help with pile design and other technical applications, conferring to the research.

IV. RESULTS AND DISCUSSIONS

This chapter focuses on examining the uplift load-displacement behavior of different finned pile structures. Both vertical plain piles and vertical finned piles were set for the experimental studies that varied the fin's specifications while maintaining a constant embedment length. The major goal is to bring the connection between the netultimate load and the angle of deformation for each pile structure. Plots showing the experiment findings show how the applied pressure and the accompanying displacement for each finned pile variation are related. To illustrate how the finned piles behave and perform under uplift stresses, the loose sand condition is graphically depicted in different ways.

A. Behaviour of Plain Pile with respect to Uplift Load

A plain pile with an L/D ratio of 30 were considered for initial research, which was followed by tension loads or pulling forces. The crucial reference data required for comparisons is then provided by this. Fig.12 displays the outcomes of model tests performed on a typical pile buried in the sand. These findings suggest that the piles are capable of taking up an ultimate tension load in terms of deformation. Finally, The use of geojute material increases the stability of the piles.

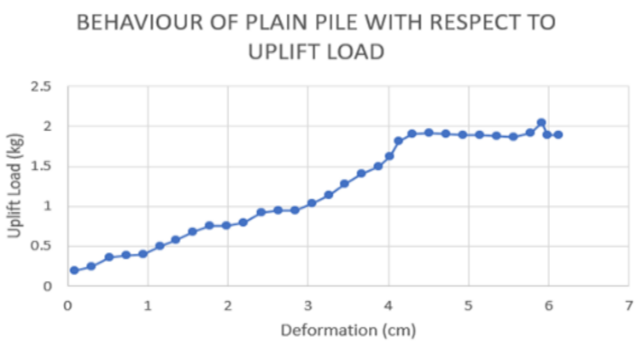

Fig 12 : Load-Deformation curve for a regular pile

B. Effect of the Number of Fins on the UpliftResistance of Finned Pile

Piles that have two distinct fin orientations, such as two finned and four finned oriented piles, behave the same way. However, as shown in Fig. 13, the ultimate uplift capacity of four finned piles is greater than that of two finned piles. A four-finned pile is more rigid than a two-finned pile, which means that the final uplift resistance of the pile will be higher than a two-finned pile. A four-finned feature's improved ultimate uplift resistance may be attributable to the fins' orientation. It is the diagonally-finned feature when compared to straight-finned and star-finned features, that will activate a bigger volume of sand around the pile, which will result in an increase in the uplift resistance of a pile.

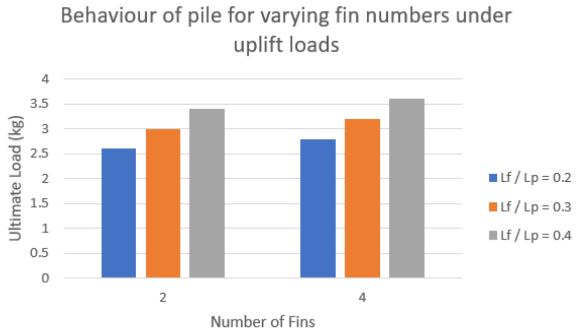

Fig. 13 : Behaviour of pile for varying fins numbers under ultimate loads

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c. Effect of Lf/Lp on Uplift Load Carrying Capacity

Several investigational model revisions were supported out to understand the action of tension-loaded piles with fins. The test was conducted using the 90° angle for rectangular four-fin at the pile's tip position. The experimental testes of various length to pile ratios (Lf/Lp) of 0.1, 0.2, 0.3, 0.4, 0.5 and width of fin (Wf/Dp) of 1.0. The uplift resistance of piles shown in Fig. 14 decreases as in increase with fin lengths. Experiments were done on pile by varying the fin length (Lf/Lp). The uplift capacity of the pile increases with increasing in the Lf/Lp ratio. The increase in the pile ultimate uplift resistance until ratio was equal to 0.4, shown in Figure. 4.3. However, the final uplift-resistance capacity dramatically lowers if Lf / Lp is higher than 0.4. This indicates that the maximum achievable uplift resistance is achieved at the Lf / Lp = 0.4 ratio of lengths of the four-finned piles, which is thought to be ideal fin length for balanced strength and serviceability. Further we'll continue to use the optimal Lf / Lp ratio.

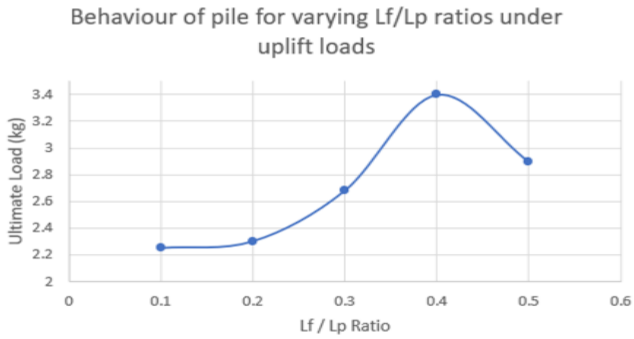

Fig 14 : Behaviour of pile for varying Lf/Lp ratios under uplift loads

D. Effect of Width of the fins with the uplift capacity of finned piles

The soil surface above the pile's uppermost half is very significant component in tension-loaded piles. Thus, it is envisaged that by adjusting the width of fin in relation to pile diameter and amount of pile head deflection may be decreased. As a consequence the impact of Wf/Dp on uplift capacity of the pile when it is under tension loads, a series of experiments were conducted using the ideal Lf/Lp ratio and a Wf/Dp ratio. Varying the width of fin offers substantially the better soil fighting ability and soil holding behavior than traditional heaps because it increases the passive area of earth pressure around the pile. This ultimate tension load for finned-piles increases , which in turn increases the efficiency of the fin. In spite of a lower flow-rate, a wider increase in the fin width than Dp will boost fin efficiency, even when dirt flowed around the standard-pile during testing. The optimal uplift capacity of the pile is showed by various of Wf/Dp combinations. Fig 15.

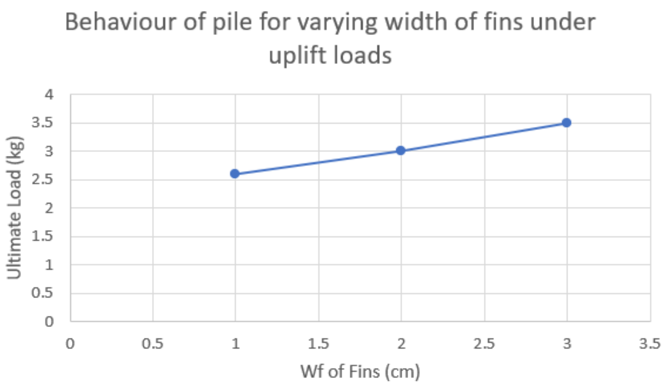

Fig 15 : Behaviour of pile for changing the width of fin under uplift load

E. Effect of the shape of the fins on the uplift resistanc eof finned pile

As the studies continued shape influences their performance,two different fin types - triangular and rectangular are examined for their impact on the uplift-capacity of pile with fins., a Wf/Dp ratio of 1.0, a unique four-finned diagonal feature with a 90°orientation, and Lf/Lp values of 0.2-0.4. Figure 16 depicts the outcome of pile with triangular fins and the rectangular fins respectively. In comparison to triangular fins, rectangular fins contribute more rigidity. This location would become noticeably stiffer if we added more fins. As a result pile's resistance is increased . as it seems that rectangular fins include a bigger surface area than that of triangular fins.

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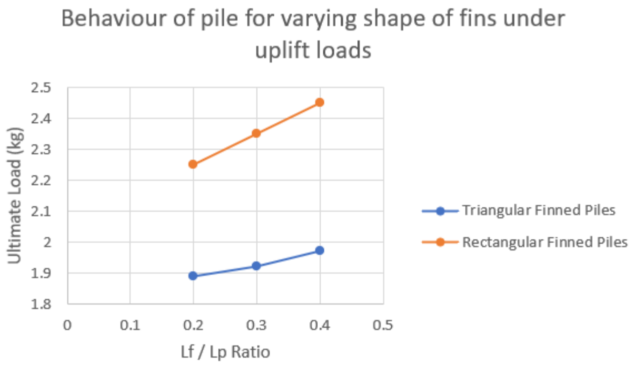

Fig 16 : Behaviour of pile for varying the shape of fin under uplift loads

F. Effect of the position of fins on the uplift carrying capacity

In order to analysis that the fin position on the uplift capacity of the finned pile, many tests were performed on pile with fin parameters of Lf/Lp , Wf/Dp for the three positions of fins along the length of pile, namely pile head, pile middle, and pile bottom. This experiments was performed to find the impact of fin position on the uplift capacity Figure 17 shows the behavior of the pile at various positions of three fin positions. This show that the fines at bottom of the piles will provide the maximum uplift resistance, conferring to the study's findings. As a result, it has been showed that the pile's tip fin position offers the greatest uplift resistance. Further increase in pile stiffness will raise the ultimate uplift-capacity because the uplift force act exactly at tip of a piles.

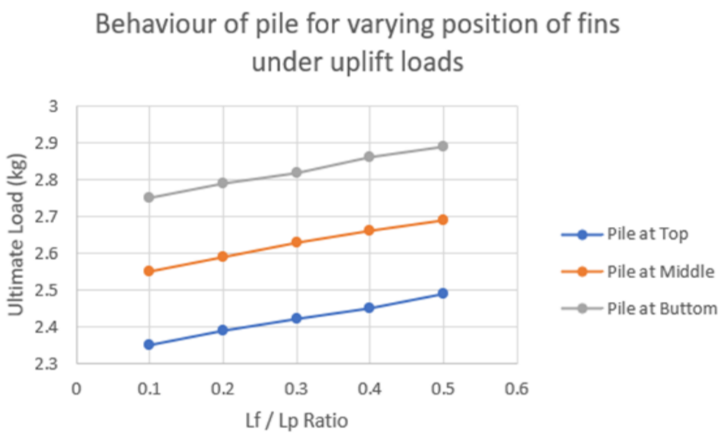

Fig 17 : Behaviour of pile for varying the position of fin under uplift loads

V. CONCLUSIONS

This research's findings directed us to the following conclusions and observations:

1. For finned-piles, the ultimate load-deformation curve exhibit a nonlinear relationship, suggesting that uplift resistance varies over the sequence of the loading process.
2. The ultimate tension load-bearing ability of the finned-pile in sand is greatly prejudiced by the embedment length and soil density. The load bearing capacity originally increases with rising of embedment length, reaches a peak, and subsequently falls.
3. Regular-plain vertical piles in loose sand gives lower resistance compared to finned piles.
4. The Length by Diameter ratios (embedment length to pile diameter ratio), in totaling to the set of fins, affect a finned pile capability to carry loads.
5. Conferring to the test findings, finned piles with ratios of 0.4 for Lf/Lp and 1.0 for Wf/Dp (fin width to pile diameter) are more resistant to deformation and have a massive load capacity.
6. Piles which have four fins show higher load carrying ability in sand related to piles with the two fins.
7. Finned-pile with an Lf/Lp ratio of -0.4 is effective in increasing the load carrying capacity in sand.

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8. Piles whch have rectangular shaped fins exhibit More load carrying capacity in sand compared to piles without the rectangular shaped fins.
9. Piles which have fins at the Bottom of the pile show greater load carrying ability so as that to piles which have fins at the center or head of the pile.
10. Geojute play a bit effective role in getting the acceptable stability. The findings show finned piles capability to increase uplift resistance and offer suggestions for designing finned-piles in sand situations to their best advantage.

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