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The Compression Bearing Capacity of Helical Piles in Black Cotton Soil

Likhitha.H¹, Raghavendra.H.N², Rakesh.K.P³, Uday Shrihari.P⁴

Assistant Professor, Department of Civil Engineering, Global Academy of Technology, Bangalore, Karnataka, India¹

U.G. Student, Department of Civil Engineering, Global Academy of Technology, Bangalore, Karnataka, India²

U.G. Student, Department of Civil Engineering, Global Academy of Technology, Bangalore, Karnataka, India³

U.G. Student, Department of Civil Engineering, Global Academy of Technology, Bangalore, Karnataka, India⁴

ABSTRACT: Helical piles foundation systems have been extensively used in engineering application. Helical pile foundation system are commonly adapted to resist the compression, uplift force, overturning moment and lateral forces. Now a day, helical pile foundation systems have become commonly adapted in many countries. The use of helical piles as a deep foundation option has considerably increased in the recent years to support variety of loads, from small loads for several applications such as residential housing, solar farms, and utilities and retrofit projects, to large loads for many applications such as commercial, power transmissions lines, oil facilities and industrial applications. Therefore, it is necessary to know the axial compression capacities of these piles under vertical loads, for this reason the aim of the work is to study how to improve the compressive capacities of helical pile in black cotton soil.

Model steel piles with and without helical plate are embedded in black cotton soil are tested to study the effect of vertical loading on the behavior of piles in compression. Laboratory experiments were conducted on the pile of 20mm diameter with and without helical plate and with varying helical plate diameters as 25mm, 45mm and 65mm respectively.

KEYWORDS: Helical pile, Black cotton soil, Compressive load, Helix diameter.

I. INTRODUCTION

The earliest helical anchor created by a blind English brick maker names Alexander Mitchell for designing a foundation support of a lighthouse in 1833. The concept of “screw pile” was very successful in the designing but the development of helical plate foundation was not progress. Until 1950’s, a power-installed screw anchor for resisting tension load was found in US and this type of anchor was starting popular and widely used in the construction site. The helical anchor formed by a steel shaft which one or more helical plates welded to the shaft to create a “screw anchor”. Helical anchors are primary designed and constructed to provide the compression resistance to the foundation of a structure. However, helical anchor system also can provide the uplift support to the structure.

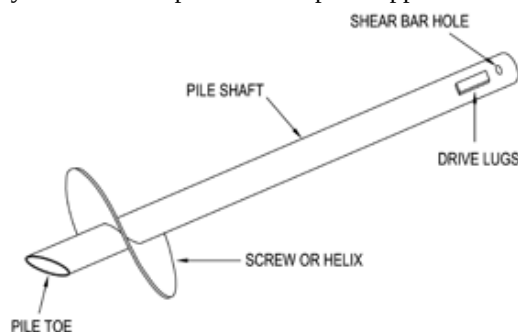


Fig.1 Helical pile model

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In the construction site, the helical anchor are installed by applying a rotating and axial forces to the shaft of anchor and screw the anchor into the ground with power augering truck. The helical anchor can be installed rapidly and minimize the soil disturbance in the installation. This anchor system always install to the maximum torque values that recommended by the manufacturers. The helical anchor system is not suitable for the foundation in stiff soil or soil containing gravel because the helixes may be damage in installation process. Therefore, this type of anchor system always applied in the sand, silt and clay.

1.1 Advantages of Helical Pile Foundation Systems

- Type of deep foundation: Helical pile foundation systems are considered as deep foundation system. It can be adapted to the greater depth more than 2meters.
- Climatic conditions: Helical piles are suitable to all weather conditions and can be installed in high temperature weather and freezing temperatures.
- Easy and Rapid Installation: Light weight helical piles can be easily installed with manually handled equipments and heavy weighted helical piles are easily and rapidly installed by using advanced equipments Such as mini-excavators, skid steers, backhoes and larger track.
- Equipments: For easy and fast installation of helical piles variety of equipments are with different sizes are Available in market according to the design loads, as well as limited space in site and also its access.
- Installation techniques without producing vibrations: Installation of modern helical piles does not produce any vibrations on ground, like traditional piles such as driven piles and some soil improvement techniques.
- No curing and Immediate testing after installation: Helical piles does not require any curing period like drilled shaft piles and auger-cast piles after installation hence laboratory or field tests can be conducted immediately after the installation.
- Immediate placing of concrete after installation: Installed helical piles do not require any curing period. In case of major projects, the reinforcement and concrete is placed immediately after the helical pile installation which reduces construction time.

II. LITERATURE REVIEW

1. 1st Recorded Helical Pile was by Alexander Mitchell (fig. 1) in 1836 for Moorings and then applied by Mitchell to Maplin Sands Light house in England in 1838. This work has been followed up by several researchs. Wilson has done a very good work on the bearing capacity of these piles. Meyerhof suggested the "Theory of plasticity for determining the bearing capacity of helical piles". Skempton also suggested formulation to predict the capacity of the helical pile and reported field test results with supported the formulations.



Fig.2 Mitchell's Helical Pile

2. Hamdy H.A. Abdel-Rahim (2014): This paper aims at presenting the compression and uplift bearing capacities of helical piles in cohesion less soil and is to study how to improve the provision of the compression and uplift capacities of the helical piles, and also studied the effect of embedment depth. From the laboratory tests results they concluded that the compression and pullout resistance of helical piles is strongly affected by the area and composition of helical plates welded to the pile steel shaft. From the laboratory results they concluded that the compression and uplift load carrying capacities increases with increasing the embedment ratio (D/d).

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3.Ghaly.A and Hanna.A (1994): Based on the laboratory tests results, they indicated that there are three components mainly contribute to the uplift capacity of shallow anchor, which are the self weight of anchor, weight of sand within the failure surface and the friction along the failure surface.

III. MATERIALS AND METHODOLOGY

1. Soil: The Soil used in the study was obtained from Kangrali, Belgaum. The soil sample was collected at 1.5 m depth from ground surface by eliminating the surface soil (top soil) to avoid the presence of organic materials. The laboratory tests were conducted on the soil to determine the various properties of the soil as given below table no 1.

Table No.1: Properties of soil

Specific gravity	2.71
Water content	42.06%
Liquid limit	70%
Plastic limit	39.177%
Optimum moisture content	30%
Maximum dry density	1.37 kg/cm ³
Cohesion(c)	0.2kg/cm ²

2. Model Test Tank: The model tank used in this study for conducting experiments is of steel tank is of cylindrical shape of height 600mm and diameter is 330mm (fig.3.1). The model test tank was reasonably large to taking care of the confinement effect of the pressure bulb of the helical pile and the area of influence of the pile due to loading is mentioned as 2.5 times the pile diameter, according to IS 2911 part 4.



Fig.3.1 Model tank

3.Model Test Piles : In this work the piles are of mild steel rods of 20mm diameter of height 80mm were fabricated as model piles without helical plate (fig.3.2) and helical plates of varying diameters as 25mm,45mm, and 65mm are welded to the steel shaft of 20mm diameter are the model piles with helical plates (fig.3.3).

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Fig. 3.2 Model pile without helical



Fig.3.3 Model piles with helical

4.Experimental Procedure

- The pile was placed in the testing tank and the silt soil was filled and compacted in the model tank at its maximum dry density.
- The total quantity of the silt soil required for the test was divided into three equal parts of 200 mm depth. Each 200mm layer of soil is compacted to the required height.

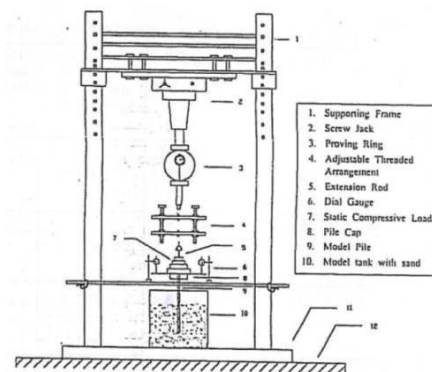


Fig. 3.4 Experimental setup schematic representation

- The tank with the soil and the pile is then placed on the Universal Testing Machine as shown in fig 3.4
- The compressive load is applied on the pile, proving ring readings and simultaneous deformations are noted from dial gauge.
- The application of compressive load has been continued till the load becomes 1.2kN.
- The noted proving ring and dial gauge readings were tabulated and graphs were plotted with load verses displacement readings.
- The laboratory tests were repeated by changing the pile with varying diameter of helical plate as 2.5, 4.5 and 6.5 cm
- For each model test, the soil was removed from the tank and was replaced by the required depth and density.

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IV. EXPERIMENTAL RESULTS

Compression tests were conducted on the model pile of with and without helix of varying diameter which are embedded in black cotton soil with the constant deflection of 5mm. The following results were observed by plotting the compressive load versus deflection graphs

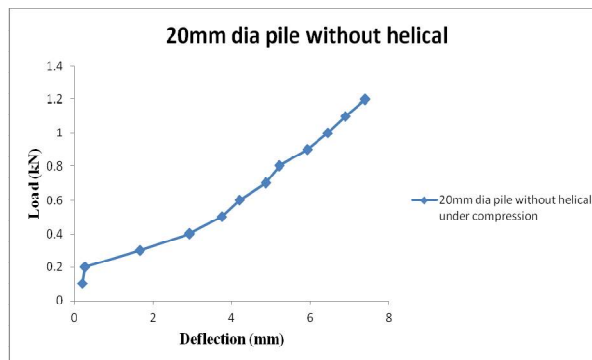


Fig. a: Load-displacement curve for 20mm diameter pile without helical under compressive load

The fig.a represents compressive capacity of 20mm diameters pile without helical. The compaction density (MDD) was 1.37 g/cm^3 and optimum moisture content was 30%.It can be seen that the deflection is 7.2mm for 1.2kN ultimate compressive capacity of pile.

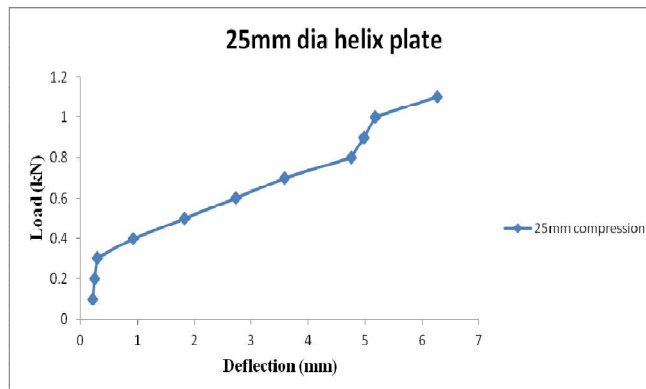


Fig. b: Load-displacement curve for helical pile of 25mm diameter helix under compression

The fig.b represent compression pile with helical plates of diameters 25mm. The compaction density (MDD) was 1.37 g/cm^3 and optimum moisture content was 30%.It can be seen that for ultimate capacity of pile 1.2kN the deflection is 6.6mm. It can be noticed that compression capacity of pile increases with increasing the diameter of helical plate.

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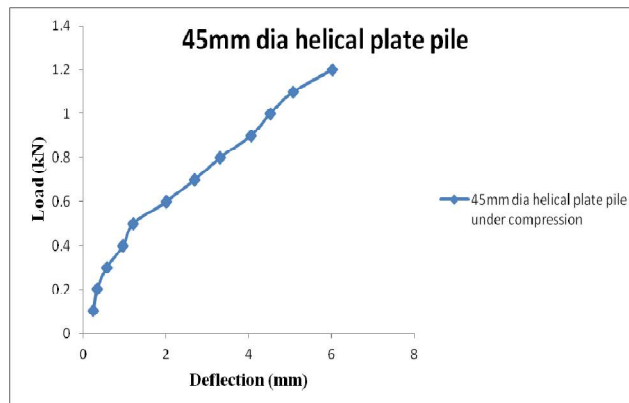


Fig. c: Load-displacement curve for helical pile of 45mm diameter helix under compression

The fig.c represent pile with helical plates of diameters 45mm. The compaction density (MDD) was 1.37 g/cm^3 and optimum moisture content was 30%.It can be seen that for ultimate capacity of pile 1.2kN the deflection is 6.03mm. It can be noticed that compression capacity of pile increases with increasing the diameter of helical plate.

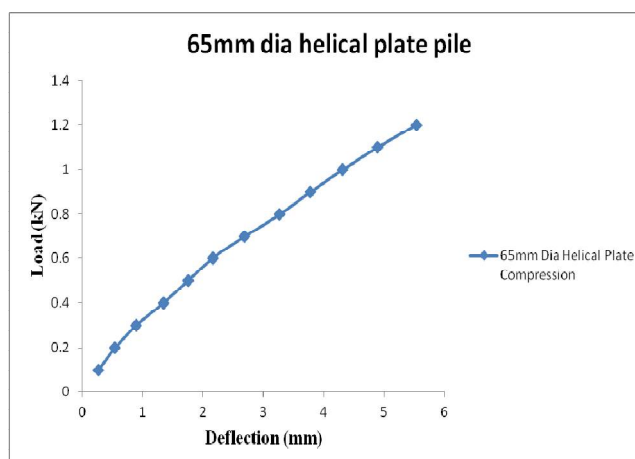


Fig. d: Load-displacement curve for helical pile of 65mm diameter helix under compression

The fig.d represents pile with helical plates of diameters 65mm. The compaction density (MDD) was 1.37 g/cm^3 and optimum moisture content was 30%.It can be seen that for ultimate capacity of pile 1.2kN the deflection is 5.54mm. It can be noticed that compression capacity of pile increases with increasing the diameter of helical plate

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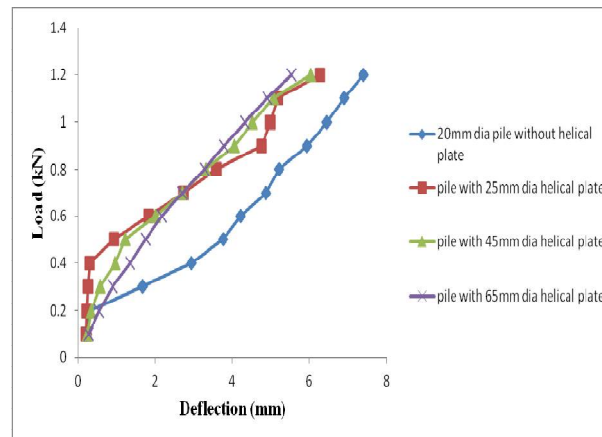


Fig.e: Comparison between pile with and without helical plate under compressive load

From the fig.e it can be observed that, in case of 20mm diameter pile without helical plates for the ultimate compressive load of 1.2kN the deflection is 7.4mm, where as in case of piles with helical plate of 25mm, 45mm and 65mm, the deflection is 6.27mm, 6.03mm, 5.54mm respectively for ultimate compressive load of 1.2kN. Here it is seen that as diameter of helical pile increases the resistance against compression also increases.

V. CONCLUSIONS

The helical pile foundation system is known for its ease and speed of installation. Installation generally requires no soil removal, so there are no spoils to dispose of. The designer simply uses soil sand state around the helical plate depending on the compressive and uplift load values. Helical piles are effective in transporting the compression and pullout loads of construction to the soil.

Helical foundation systems are ideal foundation alternative for weak soils, expansive soil, hill sides and high ground water projects. Helical piles have been widely used in engineering application to provide structural stability against axial compression, uplift tension, overturning moment and lateral force.

From the experimental investigation the following conclusions were drawn:

- The compressive capacity under axial load and load-displacement response depends on diameter of helix. The net compressive capacity of pile improves significantly with an increase in helix diameter.
- The compression capacities of pile increases with increase in the diameter of the helical plate, that is larger the helical plate, higher is the load.
- The result clearly shows that the load carrying capacity pile varied with the helical diameter. Pile with the larger diameter helical plate found to be more resistant to compressive load.
- The test results confirm that the helical pile is a viable deep foundation options to support of heavily loaded structures..
- The results of compressive load test carried out in this study confirmed that helical pile or the pile with helical plate can develop significant resistance to compression loads.
- The compressive load versus deflection behaviour of helical pile is controlled by the size of the helical plate (i.e. diameter of pate).

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