

# The Experimental Study on Uplift Bearing Capacity of Helical Piles in Silt Deposits

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**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. There are few studies about helical pile foundations, for this reason the aim of the work is to study how to improve the uplift capacities of helical pile, study the effect of the embedded depth and the helical area of the piles in silt deposits on the uplift bearing capacities.

Model steel piles with and without helical plate are embedded in silt soil are tested to study the effect of uplift loading on the behavior of piles in tensions. 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. The tests were conducted for each embedment ratio (L/d) of 5 to 30 inside the model tank with varying diameter of helical plates. The experimental results shows that the uplift bearing capacity of the piles with helical plates offers more resistance compare to pile without helical plates. The Uplift load carrying capacity increases with increasing the embedment ratios and diameter of helical plate.

**KEYWORDS:** helical pile, silt soil, uplift load, experimental work.

## I. INTRODUCTION

Helical pile foundation systems are increasing its widespread use in geotechnical market. Helical foundation systems are easy to install without generating the spoils and can take load immediately after installation that offer the cost-reducing alternative methods to reinforced concrete grouted anchors and driven piles. These advantages of helical piles lead to the development in helical pile design and analyze procedure based on the national geotechnical engineering that can be used as solutions for helical pile foundation design.

The helical piles are driving into the soil using truck mounted auguring equipment. The helical piles are twisted into the ground by applying required pressure or force (may be tensile, compressive, shear, or combination of forces) to achieve the helix pitch distance per revolution. The helical pile is advanced till the required bearing stratum is reached and the extensions are added to the pile shaft as required.

### 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.

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- 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. 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).

2. Hari Krishna p and Ramana murty v (2013): The stability of structures founded in expansive soil mainly depends on their uplift capacity or resistance. The pile foundations resting on expansive soils fail due to their inadequate uplift capacity. An attempt is made to develop a simple, easy to install and cost effective alternative foundation system to the conventional concrete piles, the feasible use of granular anchor piles below shallow footing was studied by conducting pullout tests in the field and laboratory. From these studies, it is found that the uplift resistance of granular anchor piles is more than concrete piles in both unsaturated and saturated states.

3. Sharif m.a (2005): He studied the behaviour of the helical piles in cohesion less soil and he found that for any size of helical piles installed in the sand with different embedded depth the capacities of helical pile in dense sand is estimated.

## III. MATERIALS AND METHODOLOGY

**1. Soil:** The Soil used in the study was obtained from Tumkur Road, Bangalore. 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	2.55
Water content	10.70%
Liquid limit	43%
Plastic limit	28.07%
Plasticity index	14.93%
Optimum moisture content	12%
Maximum dry density	18kN/m <sup>3</sup>
Angle of internal friction	27 <sup>0</sup>
cohesion( c )	0.25kg/cm <sup>2</sup>

**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

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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).



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.

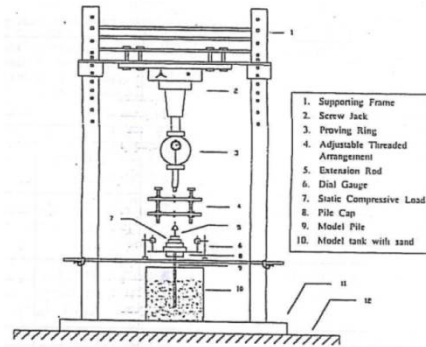


Fig. 3.4 Experimental setup schematic representation

- ▶ The tank with the soil and the pile is then placed on the Universal Testing Machine as shown in fig 3.4
- ▶ The universal testing machine is set in reverse order and then the uplift load is applied on the pile. The applied uplift on the pile is noted using proving ring readings and simultaneous deformations are noted from dial gauge.
- ▶ The application of uplift load has been continued till the proving ring reading become constant or starts decreasing or up to a minimum displacement of 15 mm.
- ▶ 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 off helical plate as 2.5, 4.5 and 6.5 cm with increasing embedment ratios, D/d to 5 to 30.

#### IV. EXPERIMENTAL RESULTS

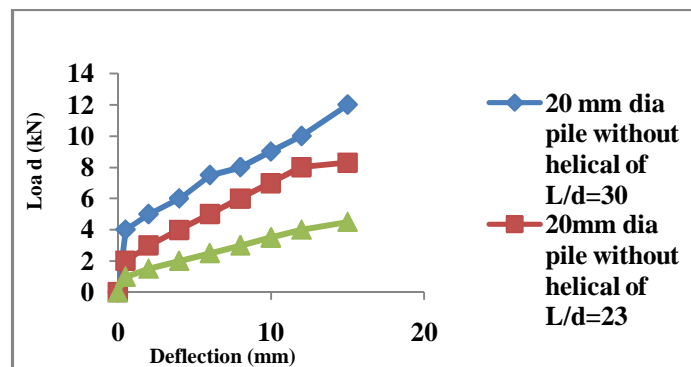


Fig. a: Comparison between L/d 30, 23, 15 of 20mm diameter pile without helical

The fig.a shows that , in case of 20mm diameter pile without helical plates of  $L/d = 30$ , the ultimate uplift load is 12.5kN, where as in case of  $L/d = 23$ the ultimate load is 8.3kN, similarly for  $L/d = 15$  the ultimate uplift load is 4.5kN. here it is seen the effect of embedment depth to diameter ratio ( $L/d$ ) is predominant.

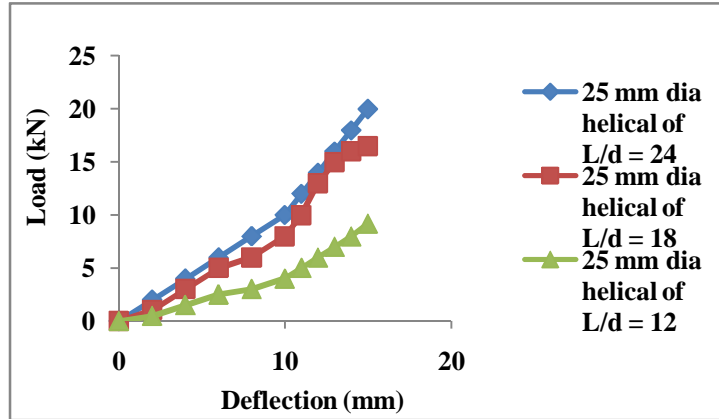


Fig.b: Comparison between L/d 24, 18, 12 of 20mm diameter Pile with helical of diameter 25mm.

The fig.b it can be noted that, in case of 20mm diameter pile with 25mm helical plates of  $L/d = 24$ , the ultimate uplift load is 20kN, where as in case of  $L/d = 18$  the ultimate load is 16.5kN, similarly for  $L/d = 12$  the ultimate uplift load is 9.2 kN. Here it is observed that the effect of embedment depth to diameter ratio ( $L/d$ ) is predominant. The ultimate uplift bearing capacity of pile increases as the embedment ratio increases.

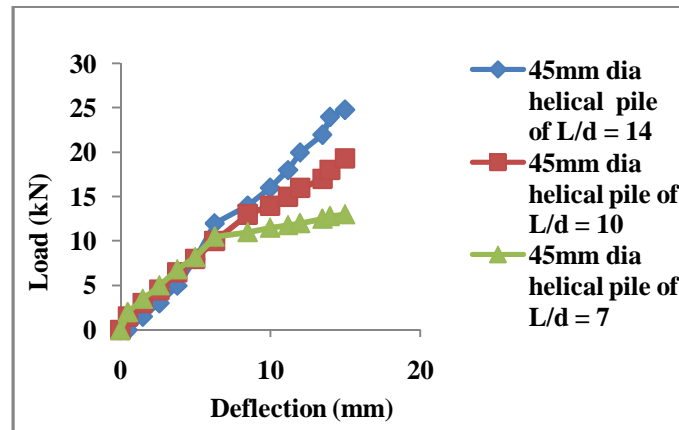


Fig.c: Comparison between L/d 14, 10, 7 of 20mm diameter Pile with helical of diameter 45mm.

The fig.c shows that, in case of 20mm diameter pile with 45mm helical plates of  $L/d = 14$ , the ultimate uplift load is 24.8kN, where as in case of  $L/d = 10$  the ultimate load is 19.3kN, similarly for  $L/d = 7$  the ultimate uplift load is 13 kN. In the above figure it is noted that the effect of embedment depth to diameter ratio ( $L/d$ ) is predominant. The ultimate uplift bearing capacity of pile increases as the embedment ratio increases.

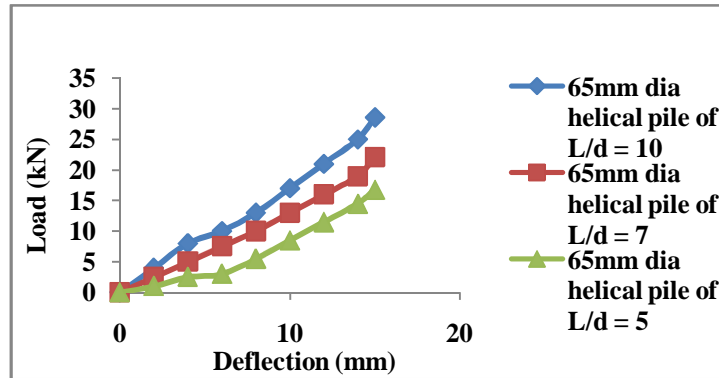


Fig.d: Comparison between L/d 10, 7, 5 of 20mm diameter Pile with helical of diameter 65mm.

The fig.d shows that, in case of 20mm diameter pile with 45mm helical plates of  $L/d = 10$ , the ultimate uplift load is 28.6kN, where as in case of  $L/d = 7$  the ultimate load is 22.1kN, similarly for  $L/d = 5$  the ultimate uplift load is 16.8 kN. Here it is seen that the effect of embedment depth to diameter ratio ( $L/d$ ) is predominant. The ultimate uplift bearing capacity of pile increases as the embedment ratio increases.

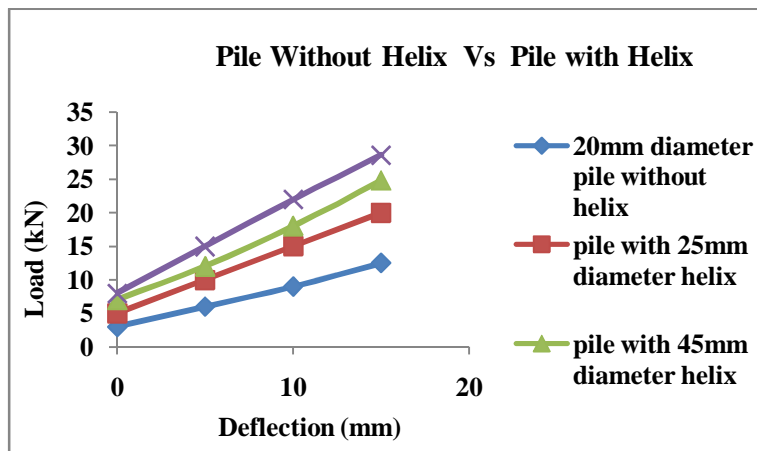


Fig. e: Comparison between 20mm diameter pile with and without helical plate of diameter 25mm, 45mm and 65mm at its full embedment.

The fig.e shows the comparison of 20mm diameter pile with and without helical plates of different diameter, in case of 20mm diameter pile without helical the ultimate uplift load is 12.5kN, where as in case of pile with helical plates of 25mm, 45mm and 65mm the uplift load is 20kN, 24.8kN and 28.6kN respectively. From the above figure it can be seen that the ultimate uplift bearing capacity of the piles with helical plate is more than the pile without helical plate and in case pile with helix the uplift load increases with increases in the diameter of helical plates.

#### V. CONCLUSION

- The uplift bearing capacity of pile depends on embedment length to diameter ratio ( $L/d$ ) and the ultimate uplift load carrying capacities of the piles are influenced by the embedment ratios.
- From Experimental results it is observed that, the uplift capacities of the pile increases as the embedment ratio ( $L/d$ ) increases. That is larger the embedment ratio, higher is the uplift load resistance capacity of pile.
- The experimental result clearly shows that the pullout bearing capacity Pile varied with the helical plate diameter. Pile with the larger diameter helical plate found to be more resistant to uplift load.

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- The test results proves that, the helical pile foundation is an ideal deep footing to supports a tall structure which are affected by wind pressure and also to support heavily loaded structures.
- From the tests results it can be clearly said that the piles with helical plates are more resistance to uplift loads than the piles without helical plate.
- The uplift load to displacement behavior of helical pile is controlled by the diameter of the helical plate.

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