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The Uplift Bearing Capacity of Helical Piles in Black Cotton Soil

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ABSTRACT

Helical piles as deep foundations are a traditional solution for supporting structures such as residential construction, communication tower installations, static or seismic structural retrofitting and reconstruction. Helical piles are widely used in engineering applications providing stability against compression, tension, and horizontal loads. Although the use of helical piles is increasing, the proper design and the effect of helices parameter on the ultimate load are still under investigation. Helical piles are environmentally friendly and economical deep foundations that, due to environmental considerations, are excellent additions to a variety of deep foundation alternatives available to the practitioner. Helical piles performance depends on soil properties, the pile geometry and soil-pile interaction. Helical piles can be a proper alternative in sensitive environmental sites if their bearing capacity is sufficient to support applied loads. The stability of structures founded in expansive soil depends on their pullout capacity or resistance. Hence it is necessary to estimate the pullout capacity of this pile

To study the effect of pullout loading on the behavior of piles in tension, steel piles with and without helical plate are embedded in black cotton soil are tested. 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, Uplift load, Helix diameter

INTRODUCTION

Helical piles consist of one or more helical shaped circular plates welded to a central steel shaft at a certain depth and specified spacing. Helical foundation systems are ideal foundation alternative for weak soils, expansive soils, high ground-water projects, hillsides, creeksides, bay mud Helical piles have been widely used in engineering applications to provide structural stability against axial compression, uplift tension, overturning moment and lateral force.

The fast installation, the instant use, and other advantages over the traditional pile system have widened the use of screw anchor piles as deep foundation for various structures. Helical screw piles have many advantages. For example, the installation cost is relatively low, with a typical installation requiring only two people per crew. They are fast and easy to install.

The use of helical piles as an alternative to conventional deep foundations has increased in recent years. This is due to several advantages over conventional cast-in-place bored piles: cost effective; versatile (can be used in countless applications where a deep foundation is required); faster and quieter installation than driven piles; produces no soil cuttings; can be installed in most soil profiles; loads can be transmitted to the piles immediately upon completion of installation; can be installed in most weather condition (rain, sun, snow); in some cases the piles can even be reusable.

Helical piles however, cannot be installed in competent rock, or hard clays. Very dense soils and soil profiles containing gravels, cobbles and boulders pose challenges for the installation of helical piles.

1.1 Advantages of Helical Pile Foundation Systems

- **High capacity deep foundation**: Ultimate torque-rated capacities on the order of 130kN may be achieved with helical shaft of sizes up to 4.5 inches in diameter.
- **Weather conditions**: Helical piles can be installed through inclement weather and freezing temperatures.
- **Installed in the limited areas**: Helical piles can be installed with manual equipment, mini-excavators, skid steers, backhoes and larger track.
- **Equipments**: The equipment and the drive heads are available according to the project design loads, as well as site access.
- **Vibration-free installation:** Rotary installation of helical piles does not produce ground vibrations, unlike traditional driven piles or rammed aggregate soil improvement options.
- **Install quickly without generating spoils:** Helical piles do not auger soils to the surface. Therefore, there are no hauling or disposal costs for spoils similar to auger-cast piles or drilled shafts.
- **Supporting the temporary structures:** Helical piles can be removed from the ground by reversing the installation process and provide support to the temporary structures.
- **Tests can be conducted immediately after installation:** helical piles do not require a curing period like drilled shafts or auger-cast piles after installation hence laboratory or field tests can be conducted immediately after the installation.
- **The concrete can be placed immediately after installation:** Installed helical piles do not require any curing period. In case of sensitive projects, the reinforcing steel and concrete is placed directly behind the helical pile installation.
- **Clean and neat installation:** installation of helical piles does not include concrete or grout, thereby reducing the equipment, vehicles and mess on the construction site.

LITERATURE RVIEW

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 word 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.

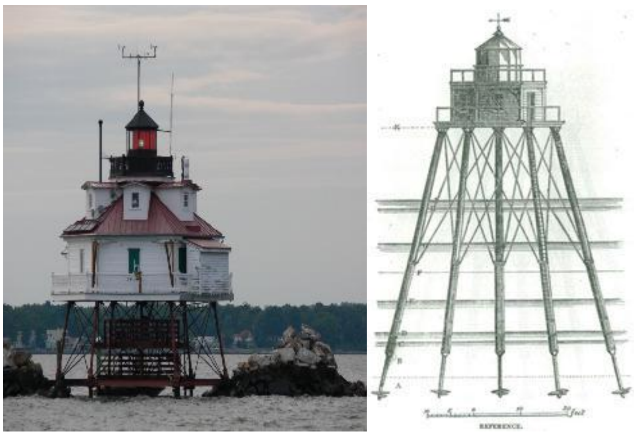

Fig.1 Mitchell's Helical Pile

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2. Likhitha.H and B.R Ramesh (2016): This paper aims at determining the uplift capacity of helical piles in silt deposits and how to improve these capacity. From experimental test results, concluded that the uplift capacity of helical piles is influenced by embedment ration, L/D ratio and ultimate pullout resistance increases with increase in diameter of helix ie; diameter of helical plate.

3. Hari Krishna P and Ramanamurty 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.

4. Dr. Mohammed Sakr (2011): This paper presents the first full scale axial compression and tension (uplift) testing program executed on large capacity helical piles installed in cohesionless soils. A total of eleven pile load tests using either single or double helix piles with shaft diameters that varied between 324mm to 508mm were carried out, The results of the axial compressive and tensile pile load tests as well as field monitoring data of helical piles installed in dense sand are presented in this paper. Based on the results of this study it was found that helical piles have developed significant resistance to axial compressive loads up to about 2920kN and tensile load up to 2900 kN.

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.
2.

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.

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Fig.2 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. 3.1 Model pile without helical

Fig.3.2 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.

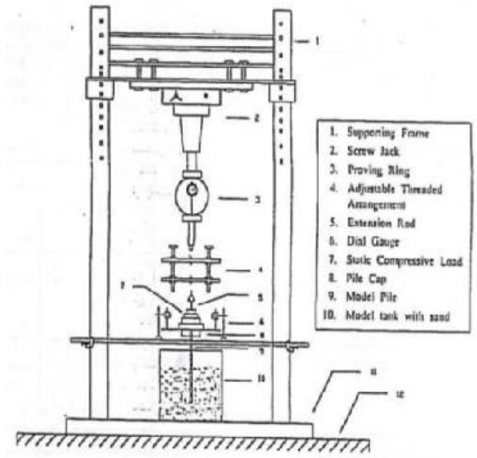

Fig. 3.3 Experimental setup schematic representation

- The tank with the soil and the pile is then placed on the Universal Testing Machine as shown in fig 3..
- The uplift load is applied on the pile, proving ring readings and simultaneous deformations are noted from dial gauge.
- The pullout load is applied on the pile, proving ring readings and simultaneous deformations are noted from dial gauge.
- The application of pullout 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.

EXPERIMENTAL RESULTS

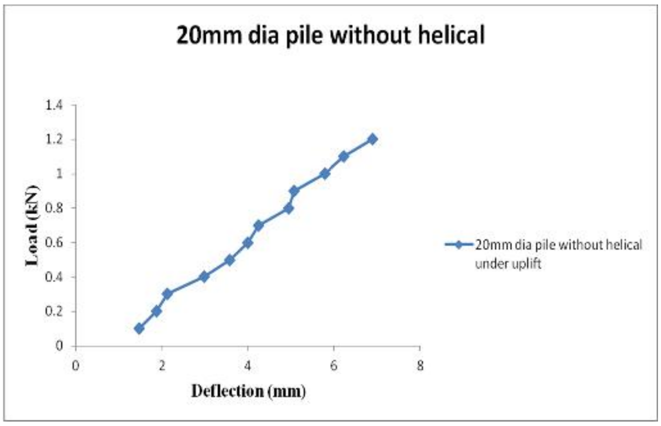

Fig.a: Load-displacement curve for 20mm diameter pile without helical under pullout load

The figure.a represents uplift capacities if 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 6.89mm for 1.2kN ultimate uplift capacity of pile.

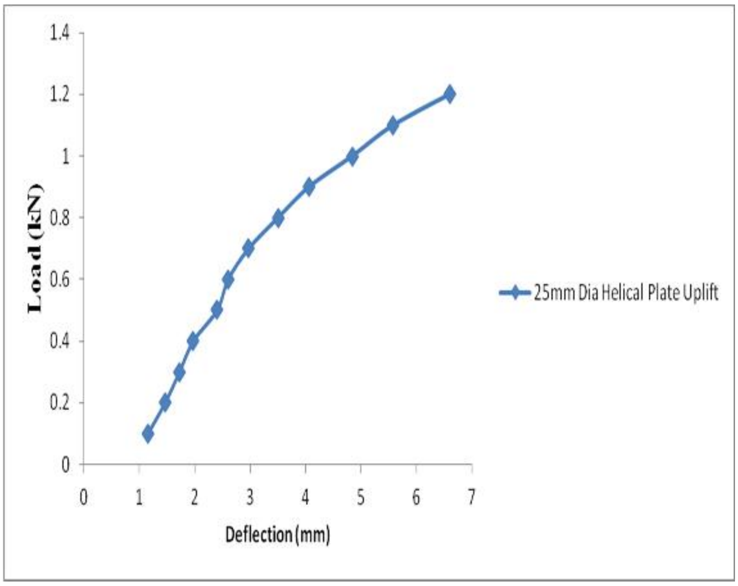

Fig.b: Load-displacement curve for helical pile of 25mm diameter helix under uplift load

The figure.b represents uplift capacities of 20mm diameters pile with helical plates of diameters 25mm respectively. The compaction density (MDD) was 1.37 g/cm^3 and optimum moisture content was 30%.It can be seen that for ultimate pullout capacity of pile 1.2kN for 25mm diameter helical plate, the deflection is 6.6mm.

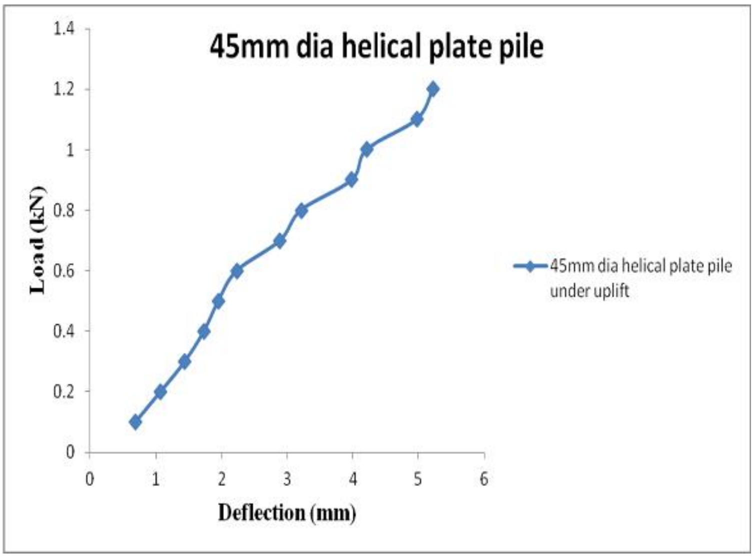

Fig.c: Load-displacement curve for helical pile of 45mm diameter helix under uplift load

The figure.c represents the uplift capacity of helical pile of 45mm diameter helical plates. The soil was compacted to its maximum dry density 1.37g/cm^3 and optimum water content of 30%. For ultimate load of pile 1.2kN the deflection 5.23mm. It can be noticed that uplift capacity of pile increases with increasing the diameter of helical plate.

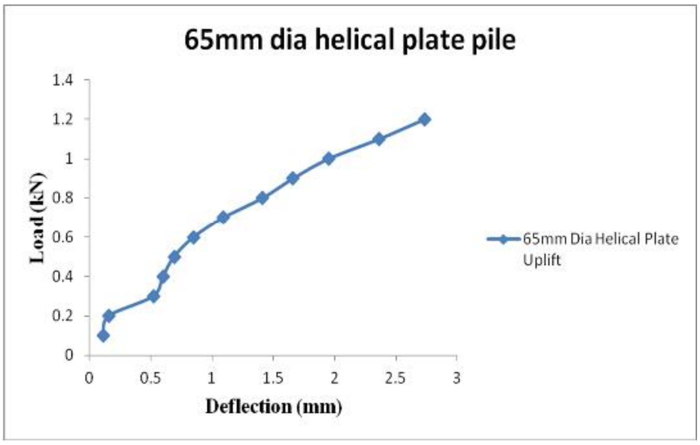

Fig.d: Load-displacement curve for helical pile of 65mm diameter helix under uplift load

The figure.d represents the uplift capacity of helical pile of 65mm diameter helical plates. For ultimate pullout load of pile 1.2kN the deflection 2.73mm. From the graph it can be seen that uplift resistance of pile increases with increasing the diameter of helical plate of pile.

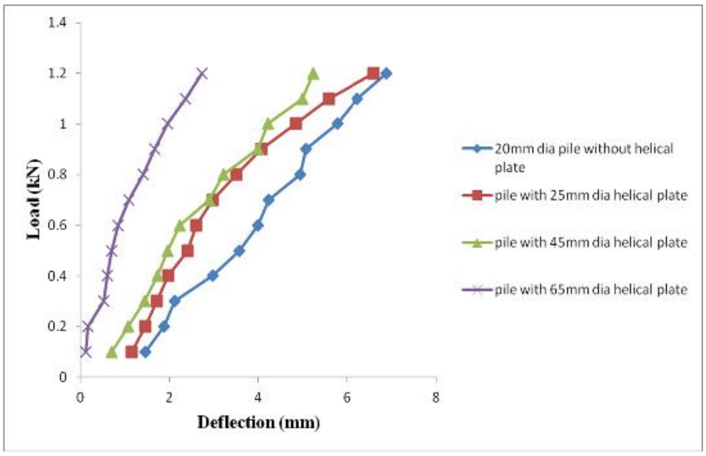

Fig.e: Comparison between pile with and without the helical plate under pullout load

From the figure.e it can be observed that, in case of 20mm diameter pile wihout helical plate for ultimate uplift capacity of 1.2kN the deflection is 6.89mm, the pile with 25mm helical plate the deflection is 6.6mm for the ultimate uplift load 1.2kN, in case of pil with 45mm dia helical plate deflection is 5.23mm and for 65mm dia helical plate pile, deflection is 2.73mm for ultimate load of 1.2kN. Here it is seen that the uplift capacity of pile increases with increase in diameter of helical plate.

Table.2 Comparison between 20mm diameter pile with and without helical plate of diameter 25mm, 45mm and 65mm

Type of pile	Diameter of pile (mm)	Diameter of helical plate (mm)	Uplift load (kN)	Deflection (mm)
				Uplift
Pile without helix	20	0	1.2	6.89
Pile with helix	20	25	1.2	6.6
		45	1.2	5.23
		65	1.2	2.73

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CONCLUSIONS

The helical pile foundation system is known for its ease and speed of installation. Installation generally requires no removal of soil, so there are no spoils to dispose of. The designer simply uses soilstate around the helical plate depending on the compression or uplift load values.

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

REFERENCES

1. [1]Hamdy H.A. Abdel-Rahim (2013) – "The Compression and Uplift bearing capacities of helical piles in cohesion less soil"- Journal of Engineering Sciences, Vol.41, No.6.Pages. 2055-2064.
2. [2] Likhitha.H and B.R.Ramesh (2016) – "The Experimental Study on Uplift Bearing Capacity of Piles on Silt Deposits" – IJIRSET Journal, Vol.5, Issue 6, June 2016 ISSN(Online) : 2319-8753.
3. [3]Braja M. Das and Enu C. Shin (1992) – "Ultimate uplift capacity of metal piles in sand" – international journal of Offshore and polar Engineering, Vol.2, No3, September 1992 (ISSN1053-5381).
4. [4]Chattopadhyay B.C, Pise P.J (1986**)** **-** "Uplift capacity of piles in sand"- Journal of Geotechnical Engineering, Vol 112, No 9, September 1986, pages 888-895.
5. [5]Chance (1993) **-** "Bearing and Pullout Capacity", Helix Pier Engineering, Hand book 2000, pages.5-6.
6. [6]Dash B.K, Pise P.J (2003) **-** "Effect of Compressive Load on Uplift Capacity of model piles"- Journal of Geotechnical and Geo Environmental Engineering (ASCE), 2003, Vol 129, pages 987-992.
7. [7]Das, B.M. (1980) **-** "A procedure for Estimation of Uplift Capacity of Foundations in Clay" Soils and Foundation, Japan, Vol.20, No.1, Pages. 77-82.
8. [8]Ghaly A. and Hanna A.(1994) **-** "Ultimate Pullout Resistance of Single Vertical Anchors"- Canadian Geotechnical Journal. Pages. 661-671.
9. [9]Mitsch, M.P and Clemence, S.P. (1985): "The uplift capacity of helical anchors in sand", "Uplift Behavior of Anchor Foundations in Soil", ASSC, Michigan, USA, Pages.26-27.
10. [10]IS 2911(Part-4) –1985, Indian standard code of practice for design and construction of pile foundation – Load tests on piles stimulates an experiment on pile pull out test.