PERFORMANCE OF A GROUP OF HELICAL SCREW ANCHORS IN SAND USING INCLINED LOAD

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ABSTRACT

Helical Anchor piles are a steel screw-in piling and ground anchoring system used for building deep foundations. Helical steel plates are welded to the pile shaft in accordance with the intended ground conditions. Helices can be press-formed to a specified pitch or simply consist of flat plates welded at a specified pitch to the pile's shaft. The number of helices, their diameters and position on the pile shaft as well as steel plate thickness determine the total capacity of the Helical Anchor.

This paper will give a brief review of the experiment to determine the pullout capacity of anchors using inclined load.

Keywords – Deflection, Helical Anchors, Inclined loading

I. INTRODUCTION

Helical Anchor piles or Screw Piles are a steel screw-in piling and ground anchoring system used for building deep foundations. Screw piles are manufactured using varying sizes of tubular hollow sections for the pile or anchors shaft.

The pile shaft transfers a structure's load into the pile. Helical steel plates are welded to the pile shaft in accordance with the intended ground conditions. Helices can be press-formed to a specified pitch or simply consist of flat plates welded at a specified pitch to the pile's shaft. The number of helices, their diameters and position on the pile shaft as well as steel plate thickness are all determined by a combination of:

1. The combined structure design load requirement
2. The geotechnical parameters
3. Environmental corrosion parameters
4. The minimum design life of the structure being supported or restrained.

Screw pile steel shaft sections are subjected to design parameters and building codes standards for the region of manufacture. Screw piles were first described by the Irish civil engineer **Alexander Mitchell** in a paper in *Civil Engineer's and Architects Journal* in 1848 - however, helical piles had been used for almost a decade by this point. Screw foundations first appeared in the 1800s as pile foundations for lighthouses, and were extensively used for piers in harbours. Made originally from cast or wrought iron, they had limited bearing and tension capacities. Modern screw pile load capacities are in excess of 2000 kN, (approx. 200 tonne). Large load capacity screw piles may have various componentry such as flat half helices, Bisalloy cutting tips and helices, cap plates or re-bar interfaces for connection to various concrete or steel structures.

Figure 1. Helical Screw anchors

More recently, composite technology has been developed and patented for use in small screw piles. Composites offer significant advantages over steel in small screw pile manufacture and installed performance.

Screw pile design is based on standard structural and geotechnical principles. Screw pile designers typically use their own design software which has been developed through field testing of differing compression pile and tension anchor configurations in various soil profiles. Corrosion is addressed based on extended field trials, combined with worldwide databases on steel in ground corrosion.

II. LITERATURE REVIEW

The helical anchor systems have been widely used in our construction site for resisting the tension load. However, the increasing of using the helical screw anchor system was slow down by the reasons of the lack of techniques to estimate the uplift capacity of helical anchors accurately and consistently. The inaccurate and inconsistent estimating of uplift capacity of these anchors caused by the uncertainties in the failure mechanism and some geometry factors of these anchors. To solve this problem, a number of researches and theories have conducted to estimate the ultimate uplift capacity of anchor in various types of soil during the last twenty years. Therefore, a literature review has carried out to indicate the theories proposed by several researchers to design the helical anchors subjected to pullout forces.

Mitsch and Clemence (1985) proposed a semi empirical solution to predict the ultimate uplift capacity of multi helical anchor in sand. They introduced values for coefficient of lateral earth pressure as a function of H/D ratio and relative density. Their values were 30 to 40% reduction compared with those proposed by **Meyerhof and Adams (1968**). They indicated that this reduction caused by the shearing disturbance of the soil during anchor installation.

Clemence and Pepe (1984) studied the effect of installation and pullout of multihelix anchors on the lateral stress in the sand layer. The values of lateral earth pressure measured before and after the installation of anchor, at the failure of anchor and continuously during the application of the uplift loads. From the test, they indicated

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that the installation of helical anchors in dry sand causes an increase in lateral earth pressure around the anchor and the pressure was significantly increase in dense sand. They concluded that the increase of lateral earth pressure was depending on the relative density of sand and the embedment ratio (H/D).

Based on the result from a laboratory test, **Ghaly and Hanna (1994)** 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.

From the experiment result, a theoretical model developed by using the limit equilibrium technique and **Kotter's** differential equation. In this model, they assume the failure surface in log-spiral shape. In their model, they have reduced the complexity of model by developing the weight and shear factors for shallow and deep anchors. These factors presented in graph that plotted with the friction angle and embedment depth ratio.

III. EXPERIMENTAL STUDY

Laboratory tests were conducted to determine the uplift resistance of helical screw anchors. Although laboratory tests are not substitute to the full-scale field tests but tests at laboratory have an advantage of allowing a close control on some of the parameters affecting the uplift resistance of helical screw anchors. In this way behaviours of the small size anchor models in the laboratory could be of immense help in asserting the behaviour of full scale anchors in the field in actual condition.

3.1 Anchor Used – Helical screw anchors having same geometrical properties of helical blade have been used in the present work. These anchors having 4 helical blades are termed as 'quad helical screw anchor'. These are shown in Fig.1. These anchors were machine made of mild steel as one unit with no welded, riveted or bolted joints. The diameter of the shaft and helix of the helical screw anchor were 25 and 65 mm respectively. The thickness of blade was very thin (approximately 2 mm). All the anchors were having conical end of an apex angle of 90°. Length of each anchor was 650 mm. The weight of whole anchor assembly was negligible as compared to pullout load assembly, hence neglected in analysis.

3.2 Test Procedure - Firstly, dry sand was weighed in batches and was laid in this test tank in 50 mm thick layers. Dry sand was laid around the anchor which was held in position in the center of the tank by removable clamp attached to the steel channel. Each layer of sand was compacted using wooden and iron hammers in a measured quantity of blow to achieve the required unit weight of 15.7 KN/m^3 throughout the testing program.

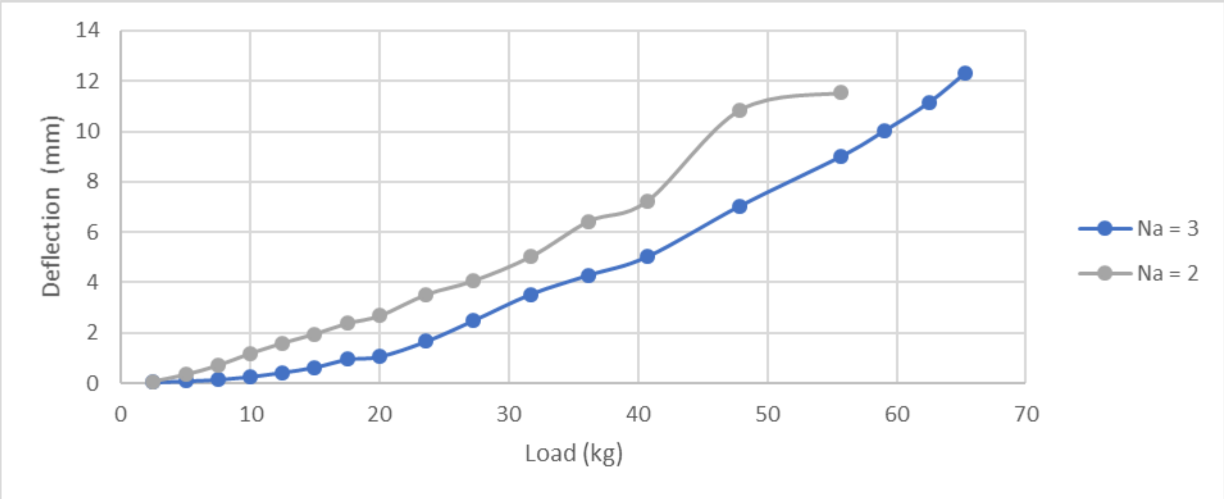
A) Pullout Tests with group of Anchors- Pullout tests with a group of anchors were conducted for 2 and 3 number of helical screw anchors. For test with 3, triangular pattern of anchors was used for the experiment in which the clear distance between the anchors were kept as 2.5B. After placing the soil for first 150 mm of depth, two channels were kept at a distance of at the center of the tank. Then the rod of the helical screw anchors was placed at the holes made in the channels. The anchors were placed by applying torque to the top of the anchor's shaft. Vertical thrust is also applied here to avoid rotation of anchor in its place without advancement into the soil. After placing the anchors, the prepared soil was compacted in the test tank for remaining depth in the similar manner as done before.

On the top of the anchors, a plate was kept and dial gauges were fixed on top of it. The magnetic base of the dial gauge was kept on a datum bar. Inclined pullout force at an angle of 30^o was applied to the anchor and the load was increased in increments until failure occurred. The pullout force and the corresponding upward displacements were recorded during the testing process. The failure point was defined as the point at which there was no further increase in the pullout load while the upward displacement was continuously increasing.

IV. TEST RESULTS AND DISCUSSIONS

1. No. of anchors (Na = 2 and 3)
2. No. of blades in the anchor = 4

Fig. 2. Effect of number Anchors (Na)



As seen in case of conventional piles, if more than one anchor is provided, its cumulative capacity is increased. Though it does not increase linearly as per number of anchors, but overall increase in combined capacity of group of anchors is quite substantial. Fig 2 illustrates a typical plot of load versus deflection number of anchors maintaining number of screws in anchor and depth ratio constant while varying number of anchors. It is observed that though ultimate pullout load increases with increase in number of anchors.

V. CONCLUSIONS

Experimental work presented is for the ultimate pullout capacity of vertical helical screw anchors in sand. Consideration is given to the effect of number of anchors and number of helical screw blades in anchor. The shear strength mobilized along the failure surface of the breakout soil mass is the main resisting factor against the pullout load. The direct weight of the failing soil mass is a small fraction of the actual maximum pullout load. The following conclusions can be drawn from the results presented in this paper:

Ultimate pullout capacity of helical screw anchor increases with increase in the number of anchors. For initial increase in N_a; the increase in Q is 27% (i.e. for increase in N_a from 2 to 3).

The above values indicate that with further increase in embedment depth or number of anchors, no significance gain in pullout capacity will take place.

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