Pullout Capacity of Helical Anchors in Soils

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Abstract— **Pull out tests using anchors embedded in soil were conducted in laboratory which gives the pullout capacity of helical anchors.**

***Keywords*— anchors, pullout capacity, helical anchors**

I. INTRODUCTION

The behaviour of helical anchors under uplift and adopt them for tower foundations were studied initially by the investigators. Later investigators showed that spacing of helical anchors was an important parameter in the derivation of failure load. Later studies showed that the spacing of helical plates was an important parameter in the derivation of failure loads.

II. MATERIAL AND METHODS

A. Materials used in Experiment

The experimental investigations on model helical anchors were carried out embedding these anchor piles in soil. The properties of the soil were determined according to the IS methods.

Nine model helical anchors with different diameters of helical plate and with different spacings have been studied. The shaft and the helical plate of model anchors are made with mild steel. The diameter of the shaft of the model anchors is 14mm. The total length of the anchors taken is as 820mm.

The loading frame tested for this investigation is manually operated type. The maximum load to be applied as estimated was less than 60 kg. The depth and diameter of the container were made sufficient enough not to affect the test results due to loading. Considering, the effect of loading, to the soil sideways as well as down wards the size and height of the container are taken as 550 mm x 420 x 550 mm.

B. Anchors specifications

The total length of all the anchor was 820 mm. The helical plates were spaced confirming to pre determined spacing ratios. (Spacing ratio SR) = Spacing of helical plates / diameter of helical plate.

Thus the anchors X1 X2 and X3 had helical plates spaced at a spacing ratio of 4.5, 2.25, and 1.25. The anchors Y1 Y2 and Y3 and Z1 Z2 and Z3 helical plates spacing ratio are given in table 1. The anchor identification details are presented in table 1.

TABLE 1 ANCHOR IDENTIFICATIONS

Designation of anchor	Diameter of anchor (mm)	Height of anchor (mm)	Number of helical plates	Diameter of helical plate (mm)	Spacing of helical plate (mm)	Spacing ratio (SR)
X1	14	820	2	40	180	4.5
X2	14	820	3	40	90	2.25
X3	14	820	4	40	50	1.25
Y1	14	820	2	50	180	3.6
Y2	14	820	3	50	90	1.8
Y3	14	820	4	50	50	1
Z1	14	820	2	60	180	3.0
Z2	14	820	3	60	90	1.5
Z3	14	820	4	60	50	0.83

III. DETAILS OF EXPERIMENTAL SETUP

The experiments were performed on soil (Liquid limit = 50.4% and Plastic Limit = 23.5%). It was carefully placed into the mild steel test tank of size 550 mm x 420 mm and to a depth of 550 mm. Fully saturated soil was placed in layers of 50 mm thickness. Each layer was made with hand packing in the first instance and the same was pressed with a template so as to remove entrapped air.

Initial a layer of soil atleast 50 mm thickness was placed in the bottom of container. The anchor was kept at required angle in the tank (like 0°), until it was in firm contact with the soil. Required angles are achieved through length to height ratios additional soil was then carefully placed in the tank over the sides of the anchor plate and shaft. Totally twelve layers of compaction given to achieving homogenous fill.

Eighteen model tests were conducted. For all the model test the water content of the soil 50 % ± 0.8 % and also the depth of embedment of anchor was 40 cm.

A. Pullout - Test

This test shall be carried out to determine the uplift capacity of anchor. The uplifting force will normally be applied force through the pulley-top connections by means of pulling forces. One end of the top connected to the hanger provided on the anchor top. Another end connected to the hanger with weighing arm.

The measurement of displacement was done by means of dial gauges. Two dial gauges were provided for accuracy.

Loads were applied in gradual steps and adequate time was allowed for displacement to occur before next load was added. The experiment was continued till the ultimate failure took place.

Complete failure was supposed to have taken place when there was continuous increase in displacement with no increase of load. At that time big cracks, also developed on the soil surface approximately circular in plan.

The failure was noted from observations in the dial gauges and simultaneous pullout of the anchor from the clay.

Two dial gauges one from each end of the vertical rods in the pullout frame were made to rest on the top plate of the special hold fast frame. Care was taken to maintain the angle of the dial gauge arms with respect to the angle of location of anchor.

B. Results

Pullout tests on different configuration of anchors embedded in soils were conducted in the Laboratory. The test data collected from each test are presented in this chapter in the form of various charts and tables and are analysed to obtain a meaningful interpretation of the test data.

The results are analysed to understand the effect of spacing ratio (L/D), the diameter of the helical plate, the number of helical plate and the anchor inclination.

The experimental data collected from the various model tests are presented in the Figure. 1.1 to 1.9. The displacement in cm are in the X - axis and load in Kg in the Y - axis. Figure 1.1 to 1.9 shows the pullout load versus upward movement of the anchor pile when the angle of inclination is 0°. This figure represents the movement response of the anchor pile under pull for definite setup helical plates. Thus the figure 1.1 to 1.9 gives the load movement curve for 40 mm, 50mm and 60 mm diameter helical plate for different spacing ratio.

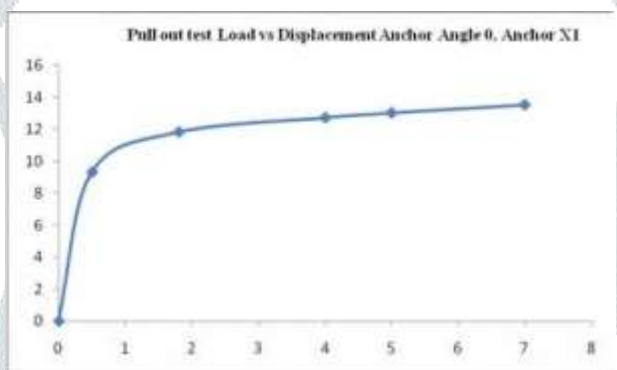

Figure 1.1 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor X1

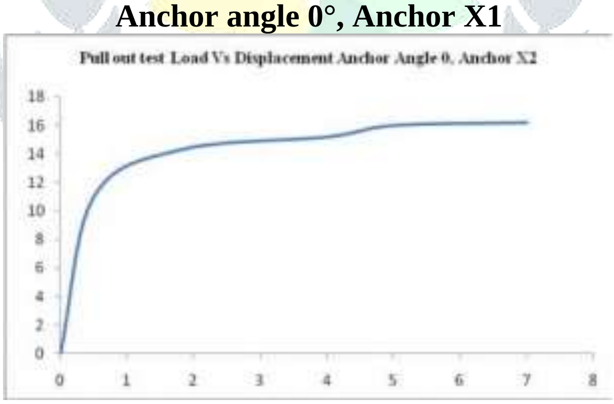

Figure 1.2 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor X2

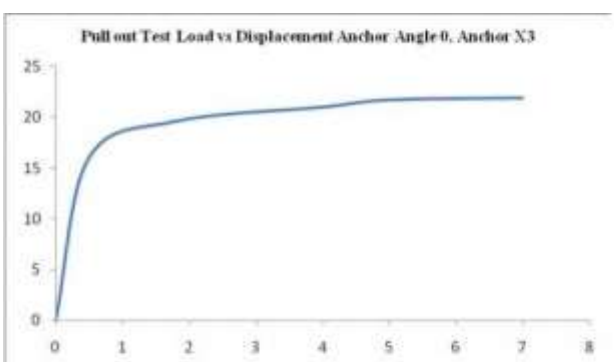

Figure 1.3 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor X3

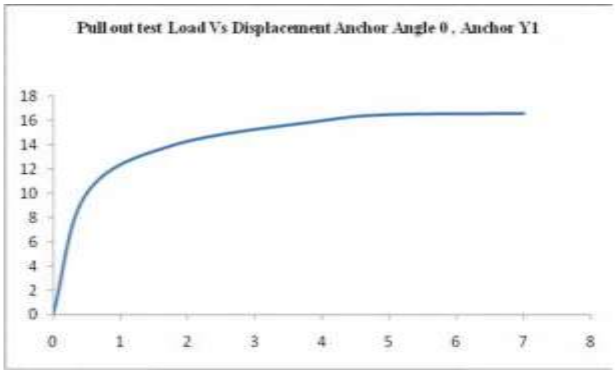

Figure 1.4 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor Y1

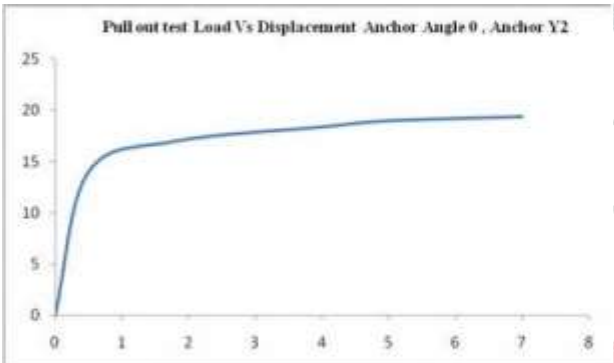

Figure 1.5 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor Y2

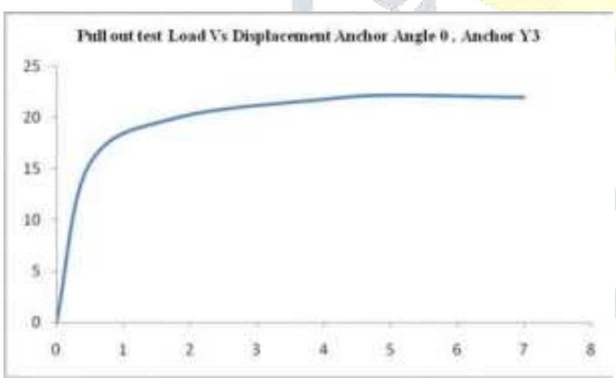

Figure 1.6 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor Y3

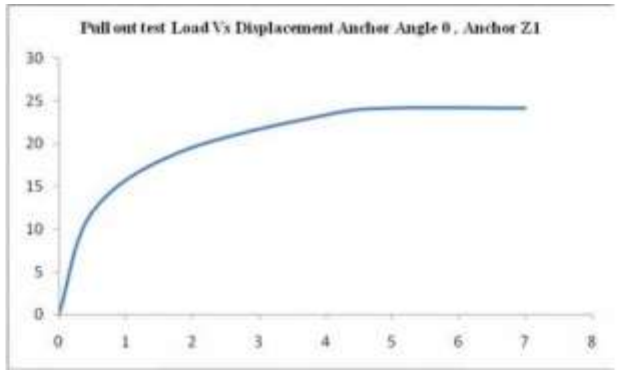

Figure 1.7 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor Z1

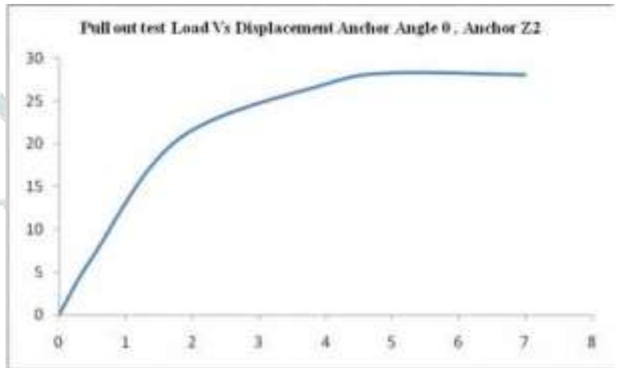

Figure 1.8 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor Z2

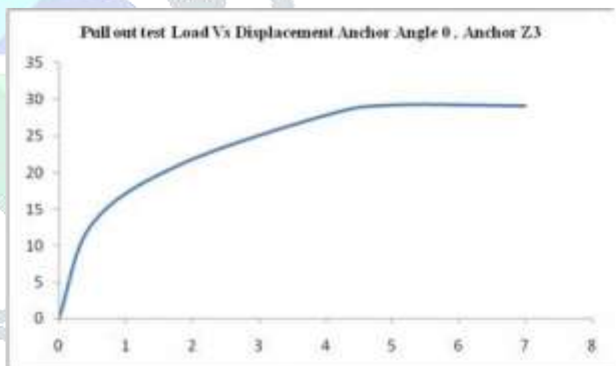

Figure 1.9 PULL-OUT Test Load Vs displacement Anchor angle 0°, Anchor Z3

Model tests using helical anchors in soil have been conducted by continuous increment of loading for pullout test. Model helical anchors have been fabricated and tested for this purpose. From the analysis of the test results as given in the previous chapter, the following important conclusions may be drawn.

IV. CONCLUSIONS

1. The load-displacement curves for all the anchor piles tested in soil of anchors show similar pattern.
2. With increase in the diameter of helical plates, the pullout capacity increases
3. The suggested method appears to give good estimate of pullout capacity of the anchor pile for spacing ratio between 2 and 4.
4. With increase in the diameter of helical plates, the pullout capacity increases.

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