STUDY ON THE PULLOUT RESISTANCE OF GRANUALR PILE ANCHORS ON EXPANSIVE SOIL

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***Abstract*— Expansive soil shows large volume change behavior when subjected to different moisture condition. Uplift of light weight structures occurs due to the swelling of soil. To increase the uplift resistance granular pile, anchors are used with and without reinforcement. Model studies are performed on granular piles anchors to check the pullout resistance. Study include testing of granular pile anchors with and without reinforcement in unsaturated and saturated condition. Black cotton soil was collected from Palakkad district. The initial test on soil was done and it is found that the soil is silty clay. A model test tank of 50cmx50cmx60cm dimensions are made. Pullout test is done to determine the pullout capacity of GPA, pullout test is done with different l/d ratio in unsaturated condition with and without reinforcement. From the result obtained it is seen that, when the l/d ratio increases the pullout resistance also increases and the maximum result obtained is 99.7N for l/d ratio equal to 2.5 without reinforcement and 102.24N for l/d ratio with 2.5 with reinforcement.**

Keywords—granular pile anchor, pullout

I. INTRODUCTION

Expansive soil shows large volume change behavior when subjected to different moisture condition. When expansive soil absorb water, they swell and thereby increase their volume, and when water evaporates from them they shrink and thereby reduce their volume. Due to this alternate swelling and shrinkage, lightly loaded civil engineering structure such as residential buildings, pavements and canal linings, founded in these soil are severely distressed causing financial losses. Replacement of expansive material by non-expansive material like sand, gravel and mixture of these are can avoid these expansive nature. Different foundation technique has suggested to mitigate the problem of expansive soil are belled piers, friction piers, physical alteration and chemical stabilization. Another innovative technique is Granular Pile Anchor Foundation (GPAF) system.

Granular piles are effective and efficient over various other methods of ground improvement because of its ability to improve the performance of different soil varying from soft loose sand deposit to waste fill site. Granular pile anchor (GPA) and is an innovative modification to the conventional granular pile. In GPA the foundation is anchored to an anchor plate (base plate) at the bottom of granular pile through a mild steel anchor rod. As a result of anchor attached to the granular pile the system become tension resistant and thereby increasing the pullout capacity of soil. The uplift resistance of GPA depends on the (i) weight of GPA (ii) the shearing resistance along the soil-granular pile interface.

II. MATERIALS

The test material involves black cotton soil collected from Palakkad district, aggregate of size 6mm and river sand

A. Black cotton soil

The soil used in this study is black cotton soil, collected from Palakkad district of Kerala. The soil was collected from a depth of 1m below the ground level. Figure 1 shows the black cotton soil used in this study.

Figure 1: Black Cotton Soil

B. Sand

The sand was collected from Kottayam district. From initial test, it is found to be well graded.

C. Geotextiles

Nonwoven synthetic geotextiles are used as soil reinforcement in this study

Figure 2: Geotextiles

III METHODOLOGY

Here in this study granular pile anchors with different l/d ratio is used and in the order 1.5, 2 and 2.5 with diameter fixed as 8cm and length of 12cm, 16cm, and 20cm. The test is done in both saturated and unsaturated condition with and without reinforcement and the reinforcement used here is woven geotextiles.

A. *Variables Studied*

In this study the expansive clay bed is filled in the maximum dry density and optimum moisture content. The model tank dimension is 60cm x 60cm x 50cm in dimension. By keeping the diameter of pile constant and by changing the length of pile ie with different l/d ratio as 1.5, 2 and 2.5. The diameter of pile is kept constant as 8cm with varying length of 12cm, 16cm and 20cm.The effect of length of pile is studied in the pullout resistance in unsaturated condition. The same effect is studied in the case of pile with reinforcement and the effect of reinforcement is studied in the pullout resistance of pile.

B. *Model Tank Preparation*

A model test tank of dimension 60cm x 60cm x 50cm is used here and it is shown in figure 3. GPA of varying l/d ratio is used in this study. Black cotton soil is filled in the tank in optimum moisture content and maximum dry density of 1.5g/cc. The soil to be filled in the tank is taken and it is divided into five equal parts and filled in maximum dry density and optimum moisture content, casing pipe of dimension equal to the dimension of GPA is inserted into the tank and the space surrounding the casing is filled with black cotton soil. After filling the soil the anchor pile is inserted into the casing and the casing is filled with granular pile material in case of without reinforcement and in case of with reinforcement the casing is surrounded with reinforcement and pile is inserted and it is filled with granular pile material.

C. *Pullout Test*

After the preparation of expansive clay bed the next step is to conduct the pullout test, for this the pulley arrangement is connected to the pile. A dial gauge is kept at the top of the foundation plate to measure the deflection corresponding to the applied load. The loading procedure is repeated until the the pile is fully uplifted from the soil.

IV RESULTS AND DISCUSSION

A. *Initial Test On Soil*

Initial test on soil was done and the basic soil properties were determined. From the test it was determined that the soil is silty clay. The liquid limit is 61%, plastic limit is 17% and the shrinkage limit is 13.2%..The maximum dry density obtained is 1.55g/cc and optimum moisture content is 28%. From hydrometer analysis the soil is found to be silty clay. The initial soil properties are shown in table 1 given below

TABLE .1

No	Property	Value
1	Natural moisture content	26.64%
3	Specific gravity of the soil	2.5
4	Maximum dry density	1.55g/cc
5	Optimum Moisture Content	28%
6	Liquid limit	61%
7	Plastic limit	17%
8	Shrinkage limit	13.82%
9	Plasticity index	104.9%
10	Swell Index	100%

B. *Pullout Load Behaviour*

a) Unsaturated Condition Without Reinforcement

Pullout test on soil is done on specially prepared tank of dimension of 60cm x 60cm x 50cm with special pulley arrangement. Pullout test is done in both saturated and unsaturated condition, with and without reinforcement. The reinforcement used is woven geotextiles. Figure 3 shows the pullout graph of unsaturated condition without reinforcement with l/d ratio of 1.5 and the maximum pullout resistance obtained is 49.77N. Figure 4 shows the pullout graph of with an l/d ratio of 2 and the maximum pullout resistance obtained is 66.45N. Figure 5 shows the pullout graph obtained for an l/d ratio of 2.5 and the maximum pullout resistance obtained is 99.72N.

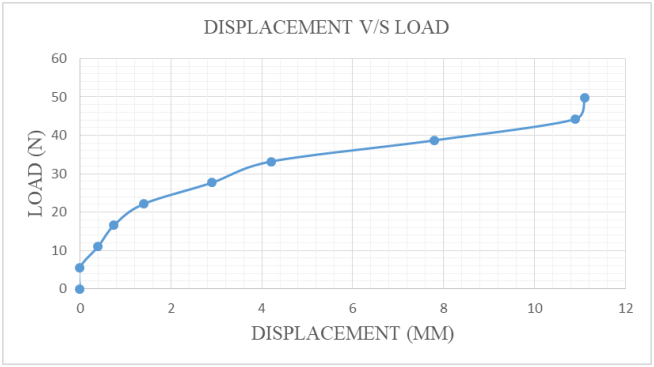

Figure 3: Displacement v/s load graph with l/d ratio 1.5

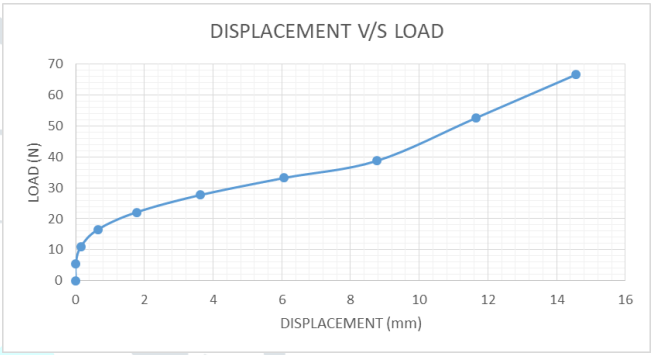

Figure 4: Displacement v/s load graph with l/d ratio 2

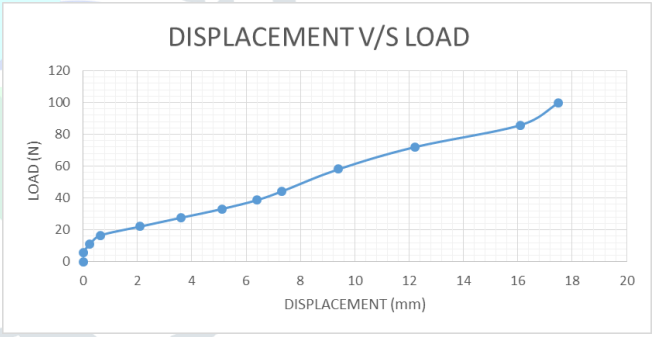

Figure 5: Displacement v/s load graph with l/d ratio 2.5

b) Unsaturated condition with reinforcement

pullout test on soil is done on specially prepared tank of dimension of 50cm x 50cm x 60cm with special pulley arrangement. Pullout test is done in both saturated and unsaturated condition, with and without reinforcement. The reinforcement used is woven geotextiles. Figure 6 shows the pullout graph of unsaturated condition with reinforcement with l/d ratio of 1.5 and the maximum pullout resistance obtained is 63.64N. Figure 7 shows the pullout graph of with an l/d ratio of 2 and the maximum pullout resistance obtained is 88.5N. Figure 8 shows the pullout graph obtained for an l/d ratio of 2.5 and the maximum pullout resistance obtained is 102.4N.

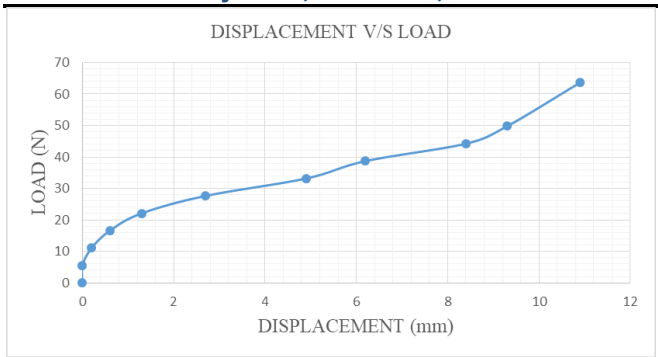

Figure 6: Displacement v/s load graph with l/d ratio 1.5

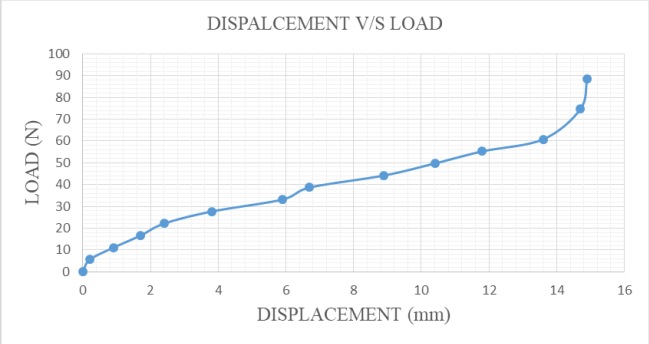

Figure 7: Displacement v/s load graph with l/d ratio 2

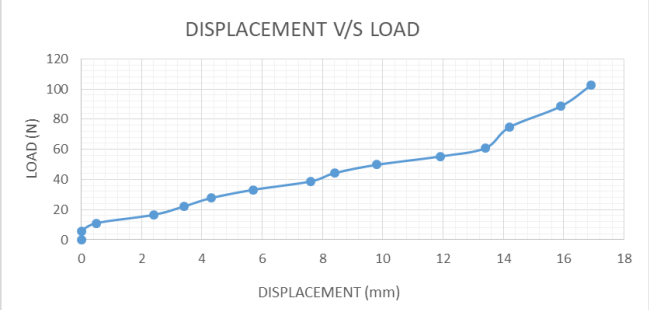

Figure 8: Displacement v/s load graph with l/d ratio 2.5

V CONCLUSIONS

Expansive soil shows large volume change behavior due to its swelling and shrinkage characteristics. In this study soil was collected from Palakkad district and from the initial soil study it was found that the soil shows 100% swelling. The soil is silty clay. From the result obtained on the pullout test done on unsaturated soil with and without reinforcement it is seen that the pile with l/d ratio of 2,5 shows greater pullout resistance in both reinforced and unreinforced condition. The pullout value obtained for l/d ratio 2.5 for unsaturated condition without reinforcement is 99.72N. And the pullout value obtained for with reinforcement is 102.44N. From the result obtained it is seen that the pullout resistance increase with the increase in length of pile.

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