Control of Heave Action Using Micropile with Geotextile Layer in Expansive Soil

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Abstract: Expansive soils are considered as highly problematic soil because of the volume change behavior. When the light weight structure is resting over expansive soil, due to change in moisture content the soil expands, due to this the cracks are developed in the structure. Further these cracks expand and lead to structure failure. To overcome above problem, test series were conducted with micropile and micropile with geotextile to investigate the expansive characteristics of the soil. This paper present the result of experimental investigation carried out for understanding the effectiveness of geotextile micropile system. For this purpose the tank of size 75cm x 75cm x 75cm was used. The test tank was filled with the black cotton soil up to 20 cm depth at optimum moisture content and maximum dry density. Soil was filled in the tank in four equal layers with proper compaction to achieve required dry density and optimum moisture content, then the micropile group in a square pattern with the footing plate of size 15cm x 15cm x1cm is installed and the results are compared with only footing plate without micropiles. (The 30cm layer above compacted soil layer is filled with water) For the second stage the non-woven geotextile layer of the size of footing plate is fixed with the group of micropile in a square pattern with the help of nut and bolt arrangement as a single layer at a depth of 0.33B and as a double layer at a depth of 0.33B and 0.67B from the footing plate. It is observed that there is 62% reduction in heave by using four micropiles and 86% and 93% reduction in heave by using four micropiles with single geotextile layer and double geotextile layer.

Index Terms **- Expansive soil; Heave; Micropile; Geotextile**

I. INTRODUCTION

When any light weight structure built over the expansive soil and for the marine structure, the swelling behavior of soil is dangerous for the structure. Expansive soils are found in the most of the part of India. As the soil is subjected to variation in moisture content, it starts swelling and shrinking, as the soil can't swell in lateral and downward direction it start swelling in upward direction. So the structure built over this type soil get distressed, and the cracks are developed in the structure. Sometimes due to structural cracks the structure is subjected to the collapse. If any structure built over this type of soil the care should be taken that the structure must not fail due to heaving of soil. So, it is necessary to take some action against heaving. To prevent the damage to the structure several laboratory experiments are carried out. For this purpose the group of four micropile in a square pattern, group of micropile with single geotextile layer and with double geotextile layer is installed and the reduction in the heave is noticed.

II Heave control mechanism

Control of heaving is obtained by inserting the micropile of 16mm diameter and 20cm length. Inserting in the soil with the blow of hammer. Two Piles are placed at a distance of 14cm to each other and the third pile is placed at a distance of 15cm from both piles at center of the plate in opposite side. Piles with the footing plate are installed in the soil. As the soil expands in the upward direction the micropiles with footing plate also pull upward. However the micropile reduces the potential of heaving. In the second stage the non-woven geotextile of 136 GSM is attached to the micropile with nut and bolt arrangement. This geotextile layer with micropile act as reinforcement in the soil and pushes the soil downward, And act as a reduction in heaving below the foundation.

III Experimental Methodology

3.1 Materials

Soil: The black cotton soil used for the test of heaving is collected from the village rautalau, nr. Region dholera, Gujarat state. The properties of the soil, known by the laboratory experiments as per IS codes shown in the table 1

Geotextile: Non-woven geotextile used for control of heaving is procured from the manufacturing company and the specifications for the geotextile are given in the table 2.

Table 1 Properties of expansive soil

Sr. no.	Properties	value
1.	Specific Gravity, G	2.54
2.	Grain size distribution (%) Clay Silt	 52 48
3.	Consistency limits (%) Liquid limit, W_L Plastic limit, W_p Shrinkage limit, W_s Plasticity index, IP	 70 33 14.57 37
4.	IS soil classification	CH
5.	Swelling Properties Free swell index (%) Swell potential	 81 High
6.	Compaction characteristics Maximum dry density (gm/cc) Optimum moisture content (%)	 26 1.49

Table 2 Specifications of geotextile

Properties	Unit	Value
Mass per unit area	GSM	136
Mechanical properties		
Tensile strength	kN/m	24
Elongation on specified tensile strength	%	22
Trapezoidal tearing strength	N	250
Puncture strength	N	200
Hydraulic properties		
Apparent opening size	microns	75
Water flow rate	$L/m^2/s$	10

3.2 Experimental setup

The experimental setup is shown in the figure 1, in the height of 75 cm of the tank soil is filled up to 20cm, Pile of length 20cm inserted into the soil, and then the remaining 30cm height of tank is filled with water.

Fig 1 Tank used for experimental work

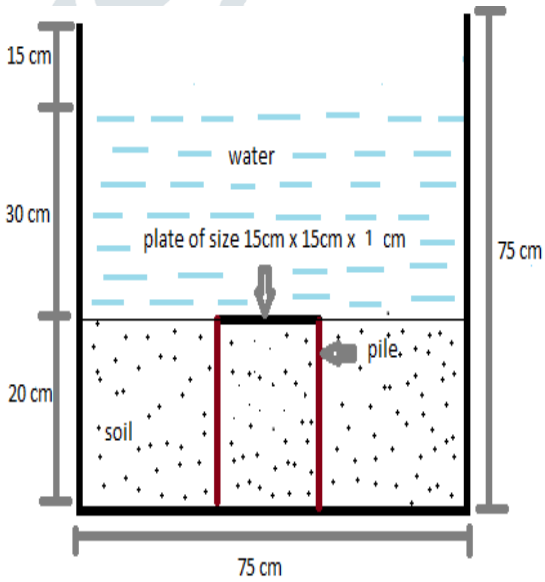

Fig 2 Experimental methodology

IV Experimental procedure for micropile technique

For experiment purpose the tank of size 75cm x 75cm x 75cm is used, Soil which procured from dholera region is first oven dried up to a period of 24hr. then it is passed through a IS sieve of size 4.75mm, the required amount of water is added to the soil to obtain Optimum Moisture Content and mixed thoroughly, then it is stored in a plastic bag up to a period of 5hr. After this the soil is placed into the tank to the depth of 20cm in four equal layer of 5cm. each layer is compacted with 136 blows of standard proctor hammer to obtain Maximum Dry Density. Then the group of four micropiles of diameter 16mm with footing plate of size 15cm x 15cm x 1cm is installed in the soil. Now the remaining 30cm portion of the tank is filled with water. And with the provision of dial gauge, results are observed at different time interval up to 4 days.

Fig 3 Set up for the heaving test with dial gauge Arrangement

Fig 4 Heaving of soil after 4 days

V Experimental procedure for geotextile layer fitted with micropile group

Non-woven geotextile exactly the size of footing is fitted to the micropile with nut and bolt arrangement. First the experiment is carried out with single geotextile layer. Layer is fitted to the micropile at 0.33B and in the second stage for double geotextile later it is fitted at a depth of 0.33B and 0.66B. Where B is the width of the footing.

Fig 5 Four piles with single geotextile layer

Fig 6 Four piles with double geotextile layer

VI Results and discussion

Table 3 Reduction in heave with different pile arrangement

Type of footing	Reduction in heave (%)
Soil with no micropile	0
Soil with micropile in triangular pattern	62
Soil with micropile in triangular pattern with single geotextile layer	86
Soil with micropile in triangular pattern with double geotextile layer	93

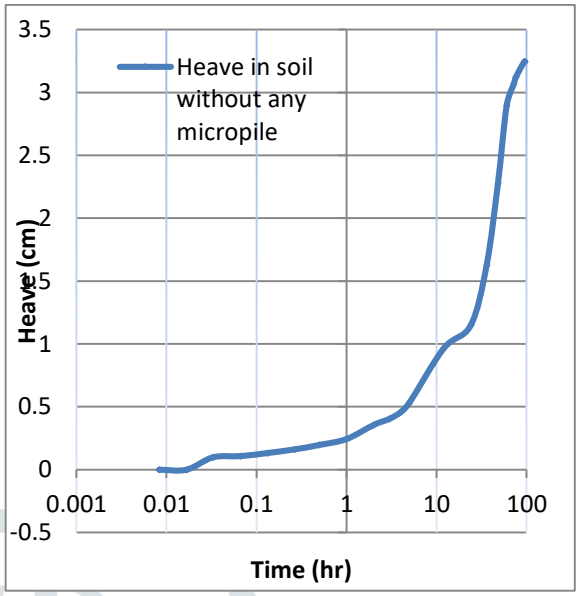

Fig 7 Heave-log time graph For Heave in soil Without any micropile

The heave-log time readings are taken in semi log graph. The readings of heave taken into consideration for above table are for four days period. The reduction in heave can be observed by the formula given below

$$RH(\%) = \frac{\text{Hu} - \text{Hr}}{\text{Hu}} \times 100$$

RH (%) =percentage reduction in heave with reinforcement
Hu= Heaving of unreinforced soil
Hr = Heaving of reinforced soil

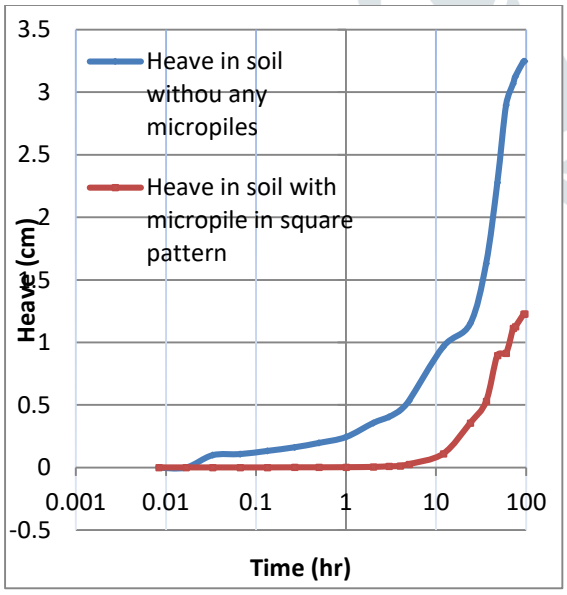

Fig 8 Comparison between heave in soil without any micropile And micropile in square pattern

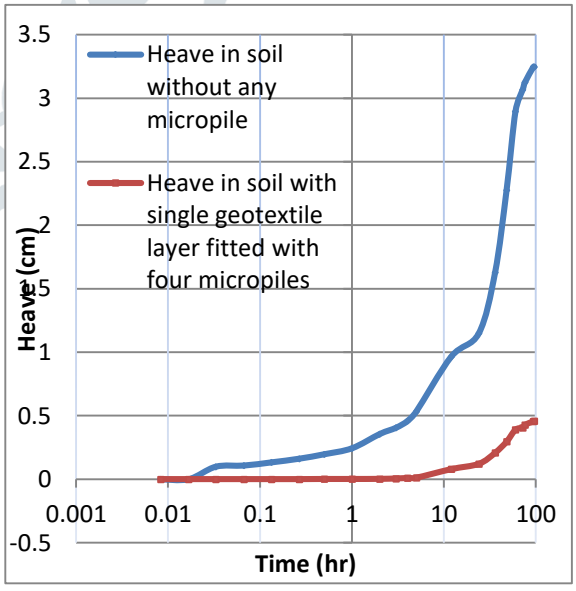

Fig 9 Comparison between heave in soil without any micropile and four micropiles with single geotextile layer

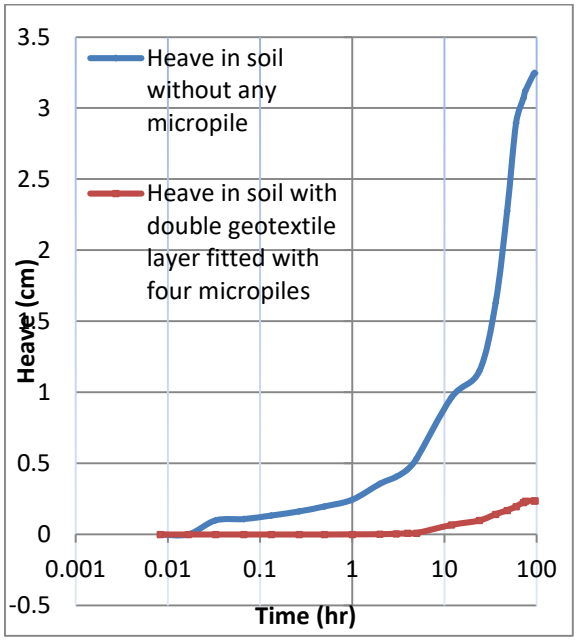

Fig 10 Comparison between heave in soil without any micropile And four micropile with double geotextile layer

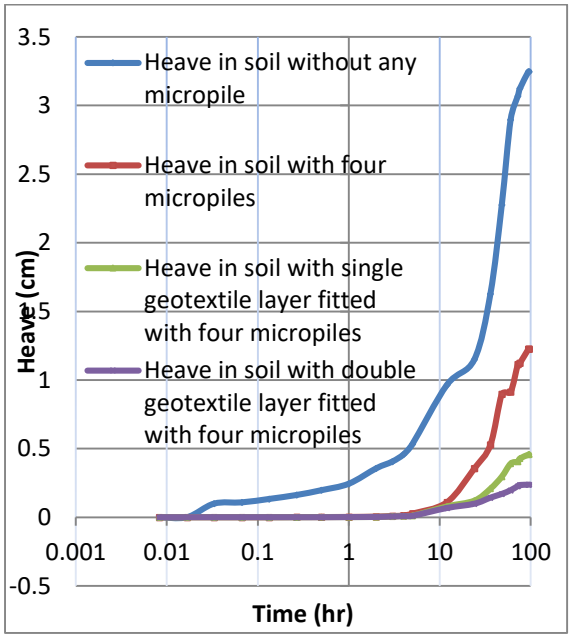

Fig 11 Comparison between all the methods of heave control

Fig.7 shows the heave-log time graph for the soil without any micropile. Heave gradually increase with time and attains equilibrium at 4 days. The heaving at the end of four days observed to be 32.47mm
Fig. 8 shows the comparison between the heaving of soil without any micropile and four micropiles in a square pattern; it is observed that there is a 62% reduction in heave by using three micropiles
Fig. 9 shows the comparison between the heaving of soil without any micropile and the single geotextile layer fitted with micropile in a square pattern; it is observed that there is a 86% reduction in heave by using Single geotextile layer with micropile.
Fig. 10 shows the comparison between the heaving of soil without any micropile and the double geotextile layer fitted with micropile in a square pattern; it is observed that there is a 93% reduction in heave by using double geotextile layer with micropile
Fig. 11 shows overall comparison between the methods used for heave control.

VII Conclusions

The laboratory tests were conducted for the reduction of heave, based on the experimental work following conclusion have been drawn

- Maximum reduction in heave is observed to be 93% by using three micropiles with double geotextile layer.
- Small increment is observed when using double geotextile layer with three micropiles instead of single geotextile layer.
- Percentage reduction in heave increase with increase in number of geotextile

VIII Acknowledgement

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