AN EXPERIMENTAL STUDY ON GEOPILE INSTALLED IN EXPANSIVE CLAY

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Abstract. Clayey soils which are expansive will swell and can cause lifting of buildings or other structures through the ingress of high moisture. Conversely during evaporation will shrink and can result in building settlement. The vertical cylindrical cells reinforced with geogrid referred as Geopiles in which expansive soil is compacted at 95% optimum moisture content in rigid tank. This research work presents the heave behavior of expansive clay through the provision of geogrid encased with different materials viz., fine sand, coarse and gravel. We studied that the heave behavior of expansive clay is by using single, two and four geopile of same diameter filled with above said materials. The results indicated that heave decreased with increasing diameter particles size of the fill materials. The comparison between unreinforced clay and reinforced clay using geogrid were analyzed.

Keywords: clay soil, geopiles, geomaterials, heave, geogrid.

1. Introduction

High plasticity, excessive heave, and high swell-shrink potential are the parameters used for identification of expansive soil made up of clay, shale or marl [1, 6]. Ground heave is the upward movement of the ground usually associated with the expansion of clay soils which swell when wet and shrink when water evaporates from them [2,3]. Soil cannot expand downwards or sideways, thus the exposed upper surface of the soil rises up. An expansive soil can be identified by various means such as by the mineralogical composition, correlation of swelling characteristics with index properties and direct measurement of swelling characteristics. The Montmorillonites, kaolinites and illites are the three major types of clay minerals which are responsible to cause the expansiveness. Geogrid material cylinder form is installed in a vertical position into the expansive soil through removal of compacted material replaced by geomaterial to counteract heave. A geogrid cylinder installed in an expansive soil forms a geopile similar to a perforated pipe pile filled with a geomaterial sand [4,7].

It is observed that, with the increase in the initial moisture content, swelling potential decreases and the increase in dry density causes decrease in swelling potential [5,8]. The results indicate that heave decreased with increasing diameter of the geopiles and increase in the particles size of the fill materials in the geopile is more effective in heave control. Geopiles filled with gravel showed the most effective in heave control both in isolation and in a group. In the case a group of geopiles, spacing between the geopiles was varied and its effect on heave was studied. Heave decreased with closer spacing between the geopiles. No group effect of geopiles was observed when the spacing was four times bigger than the diameter of the geopiles [4].

2. EXPERIMENTAL INVESTIGATION

2.1 Test materials

The expansive soil was collected from Coimbatore district, Tamilnadu. The Sand (Fine to medium), coarse sand and Gravel were collected from Cauvery basin, Tiruchirapalli District, Tamilnadu. Biaxial geogrid was purchased from the local market. The properties of the above material were presented in table I to V and laboratory test were conducted based on the Bureau of Indian standard.

Table 1. Sandy clay

Properties	Value
Specific gravity	2.72
Gravel	6%
Sand	12%
Silt & clay	82%
LL	65%
PL	28%
PI	37%
Free swell index	81%
Maximum dry density, kN/m^3	15.2
Optimum moisture content	21%
Cohesive strength, kN/m^2	0.12
Friction angle	0º
IS Classification	CH

Table 2. Sand (Fine to Medium)

Properties	Value
Specific gravity	2.65
Gravel	3%
Fine	48%
Medium	34%
Coarse	12%

Silt & clay	3%
Maximum dry density, kN/m^3	18.5
Optimum moisture content	9.1%
Cohesive strength, kN/m^2	0
Friction angle	28º
IS Classification	SW

Table 3. Sand (Coarse)

Properties	Value
Specific gravity	2.65
Gravel	3%
Fine	14%
Medium	35%
Coarse	46%
Silt & clay	2%
Maximum dry density, kN/m^3	18.5
Optimum moisture content	5.80%
Cohesive strength, kN/m^2	0
Friction angle	29º
IS Classification	SW

Table 4. Gravel

Properties	Value
Specific gravity	2.62
Gravel	48%
Fine	12%
Medium	6%
Coarse	34%
Silt & clay	0%
Maximum dry density, kN/m^3	19.1
Optimum moisture content	4.60%
Cohesive strength, kN/m^2	0
Friction angle	32º
IS Classification	GW

Table 5. Properties of Geogrid

Properties	Range
Mesh aperture size	30mm x 30mm

Mesh thickness	3mm
Structural weight	0.73kg per square meter
Polymer	High density polymer
Tensile strength	7.68kN/m
Elongation at maximum load	20.2%

2.2 Test setup

Heave effect was studied on both unreinforced expansive clay beds and clay beds reinforced with geopiles. Different granular fill materials such as fine sand, coarse sand, and gravel were used to study the effect of fill material on heave through single, two and four geopile. The 400mm diameter and 115 mm height rigid tank was selected to compact the clayey soil. The compaction density is 95% of optimum moisture content obtained in standard proctor compaction test.
The fig. 1, 2, 4 and 5 shows the test and experimental setup for single and group of geopile respectively encased with fine sand, coarse sand gravel. The inner surface of the tank was oiled to overcome the friction between the clay and tank. The circular plate of slightly larger diameter was kept over the geopile. The tank was kept wetted by pouring water over the clay surface. A small steel plate was covered over the geopile, in which heave was measured through 0.01mm least count dial gauge fixed above the plate. A plot was made between the heave in Y axis and time in X axis. Finally, water content of clay sample was observed at different depth to verify the saturation condition. The water content of the fill materials was also verified after completion of test. In group of geopile, heave observation was made on one geopile to study the heave behavior of other geopiles.

2.3 Heave effect on single Geopile

The 57.6mm diameter of the geopile was taken for the research. The schematic diagram and experimental setup for single geopile was shown in fig. 1 and fig. 2 respectively.

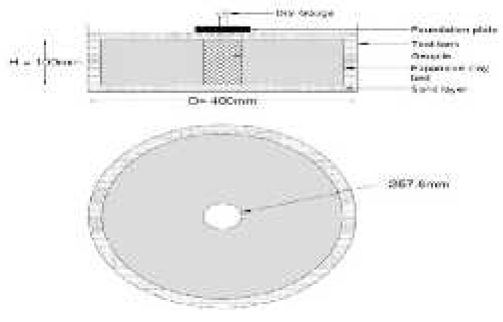

Fig. 1. Schematic diagram for single geopile

Fig. 2. Test setup for single Geopile

The laboratory observation was made on the heave effect of fine sand, coarse sand and gravel encased with single geopile plotted semi log in abscissa and heave in y axis shown in fig 3. It has been found that plot (fig. 3) the geopile filled in gravel controls higher than other materials viz., coarse and fine sand. Because of free flow of water, the particle is fine and finer specific surface area increase it holds the moisture and hence the heave effect is higher than in the coarser materials. The percentage reduction of fine sand and coarse sand compared to gravel has been found 21 and 13% respectively.

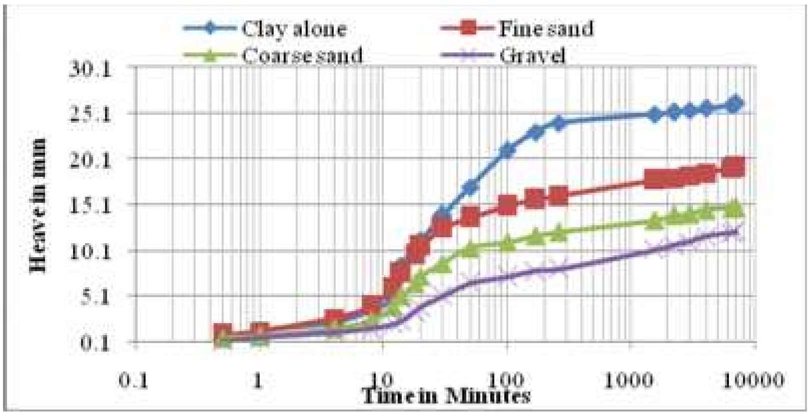

Fig. 3. Heave effect for different fill materials of Single Geopile

2.4 Heave Study for Two Geopile Filled with Different Material

The schematic diagram and experimental setup for two geopile was shown in fig.4 and fig. 5 respectively. The clear spacing between the geopile was kept as 115mm.

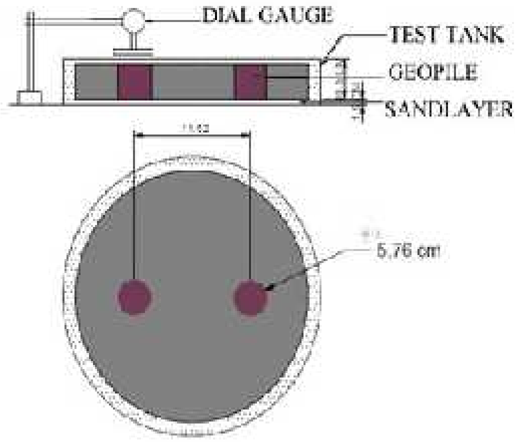

Fig. 4. Schematic diagram for two geopile

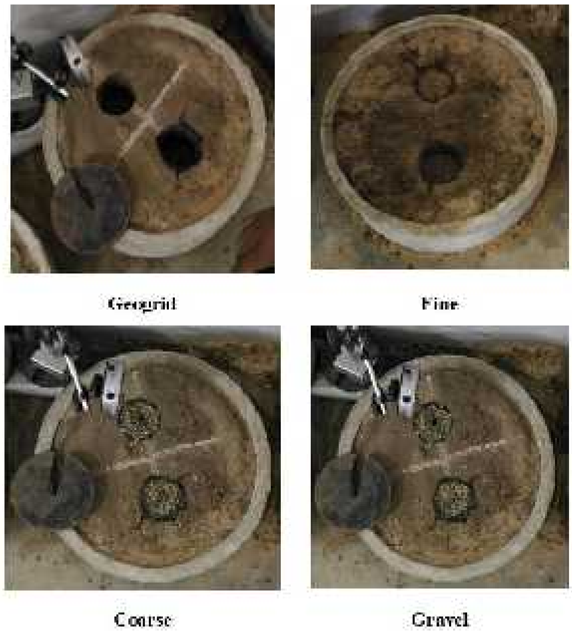

Fig. 5. Test setup for two piles with Fine sand, coarse sand and Gravel

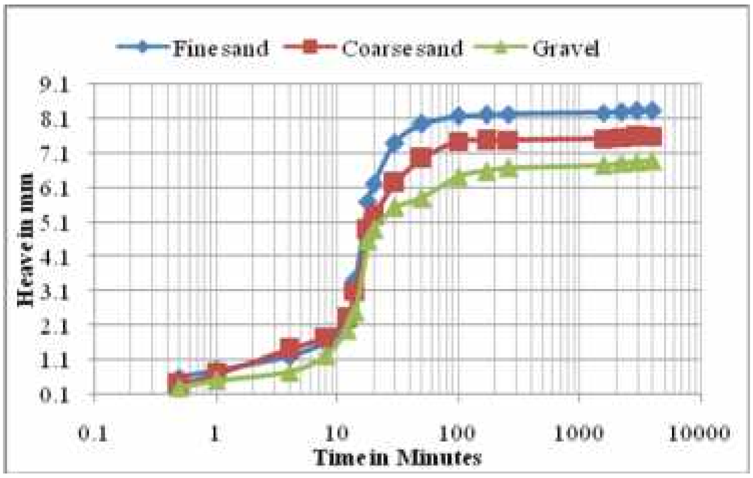

Fig. 6. Heave effect for different fill materials with two Geopiles

Both two and four geopiles were placed symmetrically spaced in the mould. In two number geopile, the reduction in heave was almost same as single geopile, where as it was double the time which is in four configuration system heave reduction when gravel material encased with geopiles.

2.5 Heave Study for Four Geopile Filled with Different Material

The fig 7 shows the experimental setup for four geopiles encased with the same identical materials were used in the sample geopiles.

Fig. 7. Test setup for four piles with Fine sand, coarse sand and Gravel

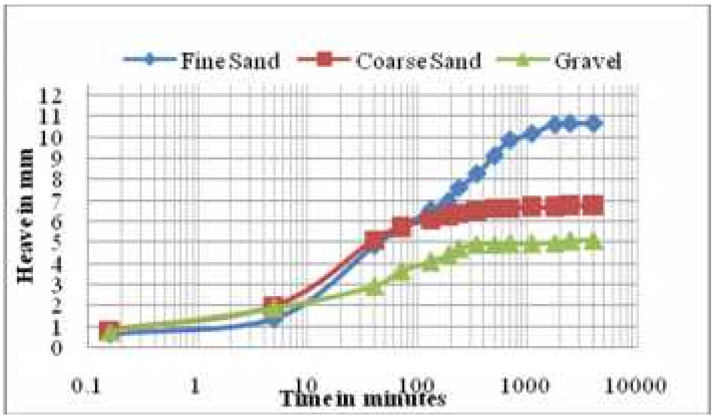

Fig. 8. Heave effect for different fill materials with four Geopile

3. Results and Discussion

Table 6 shows the percentage of reduction of single, two and four geopiles on the materials encased by geopile with respect to the unreinforced condition. The amount of heave measured for the unreinforced condition was 26.2mm. It is clearly observed that for single geopile heave reduction was almost doubled when geopile was encased with gravel. Similarly, for two and four geopile the amount of heave was about 6.8mm and 5.07mm respectively when gravel was encased. The reinforced geopile encased with filling material shows the more time reduction on heave compared to unreinforced geopile given in fig 3 clay alone.

Table 6. Effect of unreinforced and geopile fill materials with amount of heave

Material	% of heave reduction		
	Single geopile	Two geopile	Four geopile
Clay	-	-	-
Fine sand	27	68	59
Coarse sand	44	71	74
Gravel	54	74	80

4. Conclusion

The following conclusions were made

- The reinforced geopile encased with filling material shows the more time reduction on heave compared to unreinforced one.
- More percentage reduction of heave, when the gravel as fill materials was placed in the geopile.

- To increase the order of percentage reduction of heave through the placement of geo material as fine sand, coarse sand and gravel.
- For same fill materials, the four geopile controls higher heave under same time.

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