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A Study on Heave Reduction of Expansive Soil by Coir Geotextile

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Abstract:

Expansive soil is prone to large volume changes. The engineering properties of these soils are highly sensitive to changes in water content. Expansive soil will heave and cause lifting of a building or other structure constructed on it during periods of high moisture.

The main purpose of this study is to determine the effectiveness of using coir geotextiles as a technique to control heave. Geotextiles are natural fabrics used in conjunction with soil or rock as an integral part of a man-made project. In this paper the upward heave movement of expansive soil reinforced with geotextiles below the footing at a vertical spacing of 0.1B and 0.3B as single and double layers was measured. The percentage reduction in heave is also identified.

Keywords **—:*Expansive soil, Geotextile, Heave***

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I. INTRODUCTION

Expansive soils are the soils which swell significantly when come in contact with water and shrink when the water squeezes out. They are also referred as swelling soils. Because of this alternate swell - shrink behavior of the soil, the change in soil volume will occur and it can cause shifting and cracking in different civil engineering structures founded on them. This can ultimately lead to the failure of foundation and structure laid on it.Cracked foundations, floors, and basement walls are typical types of damage done by swelling soils. Damage to the upper floors of the building can occur when motion in the structure is significant. Expansive soils cause damage to structures founded on them because of their potential to react to changes in moisture regime. Therefore, estimation of potential heave is essential for the selection of a treatment technique to minimize the volume change.

To prevent damages to the structures over expansive soil, numerous methods have been proposed for the measurement and prediction of potential heave of expansive soils against swelling.

Reliable prediction of in situ heave is a prerequisite in developing more effective and economical design of structures laid on expansive soils. The choice of stabilization procedures or soil improvement techniques for the purpose of minimizing the effect of soil volume change on the integrity of structure may also be guided by the magnitude of predicted heave.

In this study geotextile reinforcement is used as a technique to control upward movement of footing over expansive soils was investigated experimentally. The soil was reinforced with the layers of geotextile into the soil at predominant optimum depth which reduces swelling of expansive soil due to their pushing action.

Geotextile is a synthetic or natural permeable textile material used to improve the soil characteristics. It has the ability to separate, filter, reinforce, protect and drain when used in association with soils. Geotextiles are ideal materials for many infrastructure works such as roads, harbours, landfills, drainage structures, and other civil projects.

In this study coir geotextile was reinforced into the soil at predominant optimum depth which reduces swelling of expansive soil due to their pushing action.

II. LITERATURE REVIEW

Yoshida et al., (1983) was studied the effect of prediction of the total heave of a slab on-grade floor on Regina clay. In their study maximum heave was measured based upon a general theory of unsaturated soils. Heave measured for the zero pore-water pressure. Their study provides a practical method to assess total heave.

Mosleh et al., (2002) was conducted an experimental study of lateral restraint effects on the potential heave of expansive soils. In their study the effect of lateral restraint conditions on the predicted heave of expansive formations was experimentally evaluated. The Oedometer and triaxial data were evaluated based on their applicability in predicting accurately measured field heaves.

Kumar et al., (2000) conducted an experimental study on increasing pullout capacity of granular pile anchors in expansive soils using base Geosynthetics. In their experimental study Pull out load, rate of heave, and relative movement near the pile surface was obtained. They found that heave can be reduced by using granular piles.

Osama et al., (2004) conducted an experimental study on micropile technique to control upward movement of lightweight structures over expansive soil. In their study they found that miropile technique can be used to controls upward movement of lightweight structures, for which a simplified analytical formulation was presented. They also found that a larger number of micropiles of smaller diameter are better than a smaller number of micropiles of larger diameter. They also found that the amount of reduction in foundation heave was found to be increased.

Ali et al., (2011) used the micropile technique to control heave on expansive soil. In their study percentage heave reduction can be obtained by using micropile on expansive soil. They found that percentage reduction in heave decreases with increasing the number of micropile. The main purpose of their study was to examine the effectiveness of using micropiles as a technique to control upward movement of lightweight structures resting over expansive soils. Their study shows that the percentage reduction in heave due to micropile reinforcement was more for micropiles surrounded by sand in predrilled holes.

III. EXPERIMENTAL STUDIES

A. Methodology and materials

1) Bentonite

Bentonite is a form of clay which comprises of montmorillonite. Bentonite consists chiefly of crystalline clay minerals belonging to the smectite group, which are hydrous aluminum silicates containing iron and magnesium as well as either sodium or calcium. In this study sodium bentonite was used. The bentonite clay was collected from Associate Chemicals, Kochi.

TABLE 1: PROPERTIES OF BENTONITE

PROPERTIES	VALUE
Specific Gravity	2.57
Liquid Limit %	336
Plastic Limit %	47
Shrinkage Limit %	12
Plasticity Index %	289
Particle Size Distribution % Percentage of clay Percentage of silt	 92 8
Optimum Moisture Content %	40
Maximum Dry Density g/cc	1.19
Soil Classification	CH
Free Swell Index %	120
UCC KN/m^2	112.7
Coefficient of Permeability m/s	$3.2x10^{-10}$

2) Coir Geotextile

The coir geotextile was collected from Geonet Envirosolutions Pvt Ltd. Kochi.

TABLE II:PROPERTIES OF COIR GEOTEXTILE

PROPERTIES	VALUE
Mass Per Unit Area GSM	400
Width cm	100 or as required
Length cm	50 or as required
Thickness at 20kPa (mm)	6.5
Break load, wet (kN/m) Machine direction Cross machine direction	 7 4
Peak load, dry (kN/m) Machine direction Cross machine direction	 3 2
Peak load, wet (kN/m) Machine direction Cross machine direction	 7.5 4
Trapezoidal tearing strength at 25mm gauge length (kN) Machine direction Cross machine direction	 0.18 0.15
Mesh size (cm^2	20 x 16.75

B.Experimental Setup for Coir Geotextile Reinforcement

The complete experimental setup with the bentonite soil reinforcing with coir geotextile layers is shown in fig 1. The soil used for investigating purpose was prepared by pulverizing air dried soil using hammer, and then sieved by 4.75 mm IS sieve. The prepared soil for testing was mixed thoroughly with calculated optimum moisture content. The surrounding wall and bottom of steel box was lubricated using waste oil to reduce side wall friction. Then soil was compacted by placing it in steel box with 136 blows per each layer and height of fall of hammer was 100mm with standard proctor compaction hammer to achieve required density, compacted thickness of clay was 10cm of five layers. After this, geotextile layer was placed at a depth of 0.1B (2cm) and 0.3B (6cm) respectively, where B is width of footing. The footing was placed above the compacted soil. To measure the heave dial gauge was placed over the footing. The sufficient amount of water was allowed in compacted soil in box.Heave readings were monitored with time to reach maximum swell percentage. Initially, heave readings were recorded at an interval of 5 min for first one hour. After that readings were noted for every 30 min up to 3h and then subsequent to every 24h up to 4 days.

Fig 1: Experimental Setup

IV. RESULTS AND DISCUSSION

A. Results of Coir Geotextile Reinforcement

Table III shows the comparative result ofmaximum heave reduction in sodium bentonite using coir geotextile. Two cases are studied: -

In first case the bentonite soil was reinforced with one layer of coir geotextile which was placed at a depth of 0.1B.

In second case the bentonite was reinforced with two layer of coir geotextile which was placed at a depth of 0.1B and 0.3B.

TABLE III: RESULTS OF COIR GEOTEXTILE REINFORCEMENT

Number of layers	Depth of placing	Heave of unreinforced soil (mm)	Maximum heave reduction (mm)
One	0.1B	37	28
Two	0.1B and 0.3B		10

Figure 2 shows the heave (mm) plottedagainst time (min) for clay bed without any reinforcement methods. Heave gradually increases with increase in time and attained equilibrium. Maximum heave recorded was to be 37 mm.

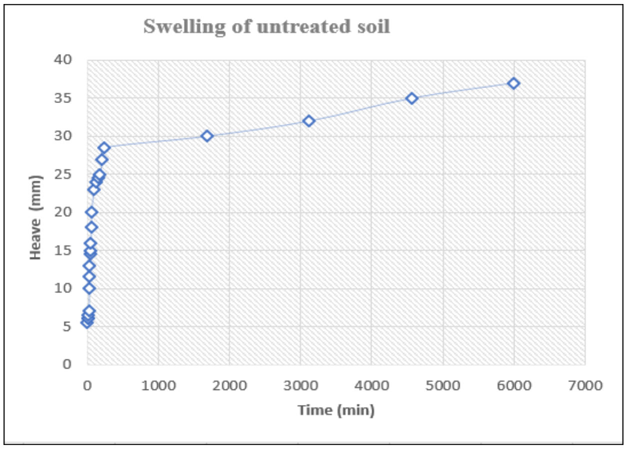

Fig 2 Swelling 0f Untreated Soil

Figure 3 shows the bentonite soil was reinforced with one layer of coir geotextile which was placed at a depth of 0.1B where B is width of footing. The footing was placed above the compacted soil. To measure the heave dial gauge was placed over the footing. The sufficient amount of water was allowed in compacted soil in box. Heave readings were monitored with time to reach maximum swell percentage.

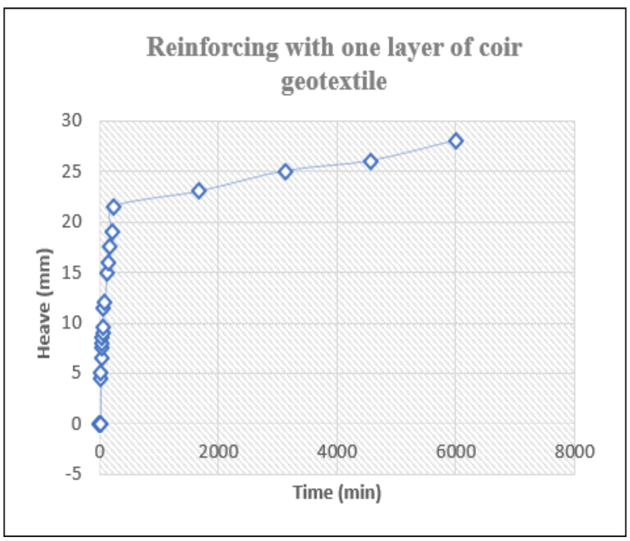

Fig 3Reinforced with one layer of coir geotextile

Figure 4 shows the bentonite soil was reinforced with two layer of coir geotextile which was placed at a depth of 0.1B (2cm) and 0.3B (6cm) respectively, where B is width of footing. The footing was placed above the compacted soil. To measure the heave dial gauge was placed over the footing. The sufficient amount of water was allowed in compacted soil in box. Heave readings were monitored with time to reach maximum swell percentage.

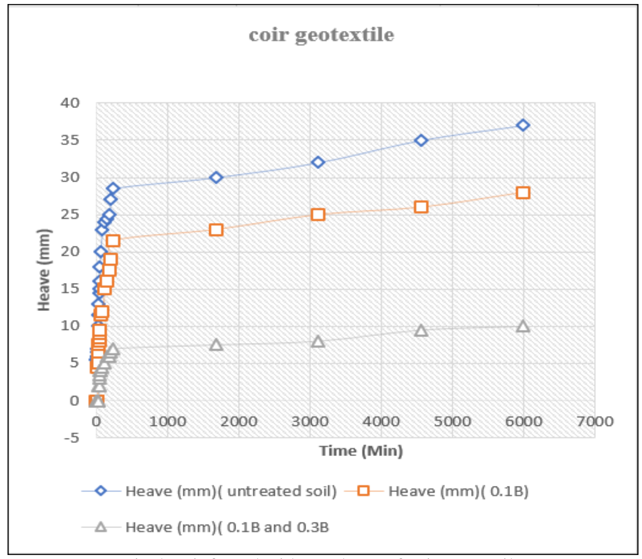

Fig 4 Reinforced with two layer of coir geotextile

Figure 5 indicates the proportional results for the swelling assessment conducted on the bentonite soil by reinforcing coir geotextile layers. The percentage reduction in the swelling by using one and two layers of geotextile at optimum depths (0.1B) and combination of (0.1B and 0.3B) 24 and 73 % respectively.

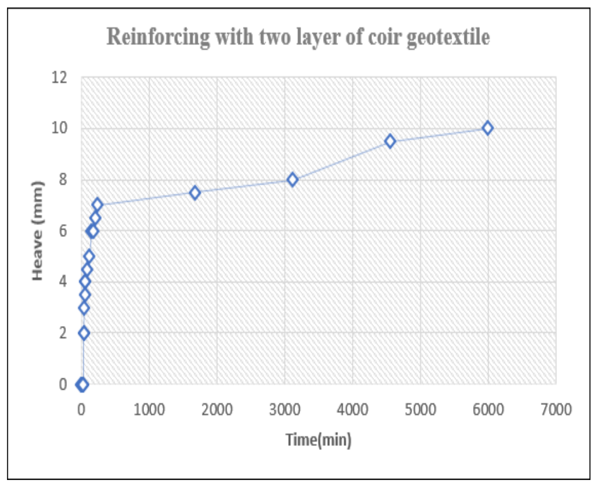

Fig 5Comparative results of coir geotextile layer

B.Discussion

The increase in number of layers of coir geotextile swelling is increases. For one and two layers of coir geotextile at depths the reduction in swelling from 24 to 73%. From this we can understand that coir geotextile is more suitable for percentage heave reduction. As it has more tensile strength. The heave reduction also increases withincrease in properties of coir geotextile such as tensile strength and thickness.

V. CONCLUSIONS

An intensive laboratory tests were conducted to evaluate the effectiveness and performance of coir geotextile in reducing the heaving of expansive soil. Based on their experimental results following conclusions had been drawn.

The maximum heave reduction is 73 %, when use of two layers of coir geotextiles at optimum depths of 0.1B and 0.3B.

The minimum heave reduction is 24 %, when use of one layers of coir geotextile at optimum depths of 0.1B.

Percentage reduction in heave increases with the increase in the number of coir geotextile layers at optimum depths.

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