PERFORMANCE OF ANCHORED GEOFOAM FOR HEAVE REDUCTION IN EXPANSIVE SOILS

S. W. Thakare¹, A. P. Kapare²

ABSTRACT

Expansive soil is a very common cause of foundation settlements. Various techniques are available to reduce damages to the structures standing over expansive soils. Problems arising due to presence of expansive soil to a large depth are minimized by various methods proposed by various researchers since past few decades. Heave of expansive soils can be reduced up to 73% by provision of geopiles in the expansive soil bed which are the vertical cylindrical cells made of geogrid and filled with geomaterials. Swelling pressure can also be reduced by providing horizontal layer of geofoam below footing at certain depth. Electro kinetic techniques can also be used to reduce heave of expansive soils. Provision of micropiles can also be used to reduce heave of expansive soil. Combination of geofoam with micropiles reduces heave of expansive soil even to more extent. Anchor plate system can also reduce heave of expansive soil effectively. Anchor plate system is the system to reduce heave in expansive soils wherein the foundation body is anchored to the plate below it at certain depth by means of anchor rods. But in this method corrosion of anchor plates may reduce the effectiveness of the technique.

In the present study, a new concept, ‘Anchored Geofoam’, is introduced as shown in Fig., in which geofoam sheet is attached to the foundation plate by means of anchor rods. Using the Anchored Geofoam, heave tests were conducted on locally available black cotton soil in a laboratory model setup. The various parameters of the anchored geofoam system such as depth ratio (D/b) and width ratio (B/b) of geofoam sheet were varied and heave was measured in each case. The heave was then plotted with respect to the selected parameter to obtain the optimum value of that parameter.

The anchored geofoam system is found to be effective in reducing the heave of clayey soil bed and heave reduction to the extent of 50% may be achieved by providing such system with optimized parameters. The anchored geofoam system provided at a depth of two-third width of footing and width equal to twice the width of footing is found to be most effective in reducing heave. The anchored geofoam system is also found to be effective in reducing swelling pressure of clayey soil bed. The reduction of about 50% in swelling pressure may be obtained by providing anchored geofoam system with suitable parameters.

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D- Depth at which Geofoam layer is placed
B- Width of Geofoam Layer
b- Width of footing

**Keywords:** Black Cotton Soil, Heave, EPS geofoam, Anchored geofoam
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ABSTRACT: Expansive soil is a very common cause of foundation settlements. Various techniques are available to reduce damages to the structures standing over expansive soils. In this paper, a concept called ‘Anchored Geofoam’ has been proposed to control the heave of expansive soil, in which Geofoam sheet of appropriate dimensions and provided at appropriate depth is anchored experimentally to the footing by means of small diameter anchor rods. From the study, it is concluded that the provision of anchored geofoam at a depth of two-third the width of footing and width equal to twice the width of footing is most effective in controlling the heave of expansive soil and heave reduction up to 50% may be achieved. This system also reduces the swelling pressure of expansive soils by as much as 55%.

INTRODUCTION
Problems arising due to presence of expansive soil to a large depth are minimized by various methods proposed by various researchers since past few decades. Swelling pressure depends on various physical parameters of soil mass and can be calculated from magnitudes of those parameters approximately [1]. The expansive soils possess high values of Atterberg’s Limits and has high free swell index [2]. Heave of expansive soils can be reduced up to 73% by provision of geopiles in the expansive soil bed which are the vertical cylindrical cells made of geogrid and filled with geomaterials [3]. Swelling pressure can also be reduced by providing horizontal layer of geofoam below footing at certain depth [4]. Electro kinetic techniques can also be used to reduce heave of expansive soils [5]. Provision of micropiles can also be used to reduce heave of expansive soil. Combination of geofoam with micropiles reduces heave of expansive soil even to more extent [6,7]. Anchor plate system can also reduce heave of expansive soil effectively [8]. But in this method corrosion of anchor plates may reduce the effectiveness of the technique. In the present study, a new concept, ‘Anchored Geofoam’, is introduced, in which geofoam sheet is attached to the foundation plate by means of anchor rods. Using the Anchored Geofoam, heave tests were conducted on locally available black cotton soil in a laboratory model setup. The various parameters of the anchored geofoam system such as D/b ratio and width ratio (B/b) of geofoam sheet were varied and heave was measured in each case. The heave was then plotted with respect to the selected parameter to obtain the optimum value of that parameter.

EXPERIMENTAL INVESTIGATIONS
Experimental investigations were carried out using locally available soil in Amravati (M.S.), India, called Black Cotton Soil. Various laboratory tests were performed on the soil to determine its index properties. These are given in Table 1. Based on its liquid limit and plasticity index, the soil was classified as ‘CH’ according to IS classification.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Properties of Clay</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Liquid Limit (%)</td>
<td>59.60</td>
</tr>
<tr>
<td>2</td>
<td>Plastic Limit (%)</td>
<td>26.98</td>
</tr>
<tr>
<td>3</td>
<td>O. M. C.</td>
<td>25 %</td>
</tr>
<tr>
<td>4</td>
<td>M. D. D.</td>
<td>14.5kN/m³</td>
</tr>
<tr>
<td>5</td>
<td>Free Swell Index (%)</td>
<td>81 (Very High)</td>
</tr>
</tbody>
</table>

The experimental setup used is shown in Fig. 1.
The assembly for the model test setup consisted of a perforated inner tank of size 50 cm x 50 cm x 50 cm, which was placed in an outer tank of size 65 cm x 65 cm x 65 cm. Clay bed was prepared in the inner tank by compacting the soil at O.M.C. in six no. of layers of 5 cm each. Total thickness of the clay bed was thus 30 cm. MS model footing plate of size 15 cm x 15 cm x 0.3 cm was then placed centrally over the prepared clay bed. A Dial gauge was placed centrally on the footing to measure heave of clay bed.

In case of soil with Anchored Geofoam, the soil was first compacted up to the level at which the Geofoam layer was to be kept. The Geofoam layer of the selected size, along with anchor rods connected to it with the help of washers and bolts, was then placed centrally over the prepared clay bed. M. S. anchor rods of dia. 4 mm were used for anchoring. The preparation of clay bed was then continued for the total depth of 30 cm, so that the geofoam layer remained buried in the clay bed. The footing plate was then kept over the clay bed, with the anchor rods passing through the holes made in it near its corners. The footing was then connected to the anchor rods with the help of washers & nuts. The model footing plate and the E.P.S. Geofoam sheet used in the experimental investigations are shown in Fig 2 & 3 resp.

After preparation of clay bed, the outer tank was filled with water so that the water level is at the same level as the footing. The heave of the soil was then measured till the dial gauge readings became nearly constant. The various parameters of the anchored geofoam system such as Depth ratio (D/b) and width ratio (B/b) of geofoam sheet were varied and heave was measured in each case, to study the effect of these parameters on the heave reduction. [B – width of Geofoam layer, D- Depth at which Geofoam layer is placed, b – width of footing]

RESULTS AND DISCUSSION

Fig. 4 shows the result of heave test on clay soil without anchored geofoam system. Heave steadily increased with increase in time and attained equilibrium in a period of about 7 days. Maximum heave was observed to be 27.32 mm.
Fig. 4 Test Result for Heave Test on Original Soil

Fig. 5 shows the result of heave test on clay soil with anchored geofoam system with varying width ratios (B/b).

Fig. 5 Heave Reduction with Anchored Geofoam System for Various Width Ratios

It was observed that heave reduction was maximum for width ratio of two. Thus the anchored geofoam system with width equal to twice the width of footing is found to be most effective for heave reduction of the clayey soil bed in the experimental investigations.

Fig. 6 shows the result of heave test on clay soil with anchored geofoam system with varying depth ratios (D/b).

Fig. 6 Effect of D/b Ratio on Heave Reduction

It was observed that, for all width ratios, the anchored geofoam system provided at a depth of two-third the width of footing was most effective for heave reduction.

From the results of the swelling pressure tests conducted on clayey soil provided with anchored geofoam system with optimized parameters viz. D/b = 2/3 and B/b = 2, it was found that the swelling pressure reduced by as much as 55%. Thus, there is a significant effect of the anchored geofoam system towards reduction in swelling pressure.

CONCLUSIONS
Following conclusions are drawn from the experimental investigation done by using anchored geofoam system:

i) The anchored geofoam system is found to be effective in reducing the heave of clayey soil bed; and heave reduction to the extent of 50% may be achieved by providing such system with optimized parameters.
ii) The anchored geofoam system provided at a depth of two-third the width of footing is found to be most effective in reducing heave.

iii) The anchored geofoam system with width equal to twice the width of footing is found to be most effective for heave reduction.

iv) The anchored geofoam system is found to be effective in reducing swelling pressure of clayey soil bed. The reduction of about 50% in swelling pressure may be obtained by providing anchored geofoam system with suitable parameters.

REFERENCES


