Use of Geosynthetics for Reduction of Swelling Pressures

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ABSTRACT: The paper presents a new use of Geosynthetics (Expanded Polyethelene) to reduce swelling pressures on slab on ground system due to expansive soils. Laboratory tests were conducted using two typess of expansive soil compacted to its maximum dry density(M.D.D.) at the optimum moisture contents(O.M.C.) under light or heavy compaction method. Swelling pressures were measured using constant volume method with different predetermined initial swell. The above tests were repeated using the geosynthetics of different thicknesses over expansive soil and swelling pressures were measured. Probable values of swelling pressures were computed from swelling pressure vs initial swell curve and pressure vs elastic compression of geosynthetic sheet. Comparison between observed and predicted swelling pressures was made.

1 INTRODUCTION

Expansive soils can be defined as those soils which swell on absorption of water and shrink on removal of water. Such soils are found in many parts of the world. In central India so called Black Cotton Soil are expansive soils and cover approximately 51,000 sq. Km.

Expansive soils cause severe damage to structures where no special precautions have been taken while laying foundation.Building footings may get displaced by great amounts due to seasonal or other moisture changes. When the thickness of expansive stratum is more than 3m.resting the foundation involves deep cutting,scaffolding and dewatering. Correct estimation of safe loads on foundation is complicate due to factors such as loading intensity, absolute swelling pressure exerted by soil, position of ground water table, climatic conditions etc.

Most of the buildings on these soils which are designed by assuming low bearin capacity showed signs of cracks due to differential settlement. Cracks in single storey buildings are more predominant than those in double stored buildings.

When an expansive soil attracts and accumulates water it exerts a pressure known as swelling pressure on the overlying materials and structures.

Many methods have been tried to overcome the severe problems and difficulties posed by swelling soils. The most common method is to remove the expansive soil till a hard stratum is met and replace it by a more suitable granular soil. This method is suitable and economical only if the thickness of expansive stratum is less than 2m. Stabilisation of expansive soil can be done by cement/lime grouting and chemical grouting. Process of chemical grouting requires the relatively ex-

pensive chemicals such as sodium silicates calcium chloride,magnesium chloride,ferric chloride and aluminium sulfate. Effectiveness of grouting is limited due to low permeability of expansive soils.

2 SLABS ON EXPANSIVE SOILS

Construction of slabs on expansive soils poses many maintainance problems as these slabs are lightly loaded and dead loads on the slab are negligible. Structural floor slab system comprises a void beneath the slab. Raised slab system is constructed by placing concrete on waxed cardboard boxes over level grade. Concrete between rows of boxes form ribs. In honeycomb system of floor, concrete slab is cast on longitudinally cutsonotubes which disintegrate with passage of time forming voids beneath the slab. It was theorized that as the clay swells, it could expand into these openings and reduce swelling pressure. Texas Highway Department used asphalt membranes between concrete pavement and subgrade to prevent surface water from entering clay subgrade.

3 USE OF GEOSYNTHETICS FOR SWELLING SOILS

Ramanathan Ayyar et al (1989) conducted laboratory tests in which Geogrid and Geomesh were used as reinforcement. It was observed that the Geosynthetics were more effective if they are ribbed or serrated or anchored at ends. It was also observed that friction was not mobilised to resist deformation and discrete fibres of small diameter randomly distributed in soil offer greater resistance to swelling than larger size pieces similarly placed.

Srinaivasmurthay et al (1987) have conducted laboratory experiment using coir fibres mixed randomly in Black cotton soil and reported reduction in heave of Black cotton soil.

4 LABORATORY INVESTIGATIONS

Laboratory tests were conducted to study the effect of Geosynthetics in reducing swelling pressure of expansive soil. Two soils were used in this investigations. One was locally available black cotton soil (BC) and other was mixture of bentonite and flyash(B F) in a ratio of 60:40 by dry weight.

4.1 Sample Preparation

Two types of moulds were used to com the soil. One was standard Proctor mould(SP),100 mm. in diameter and 117 mm in height. Second mould was consolidation ring(CR) 65mm. in diameter and 20 mm. in height. The soil was compacted at its optimum moisture content (OMC) using either light compaction(LC) or heavy compaction(HC) effort as per standard procedure (I.S.2720 parts VII & VIII). Samples for consolidation ring were obtained by extruding soil from standard mould using cutting ring. Properties of the soils used in this study are shown in Table 1.

TABLE 1 Properties of Soils

Property	B.C.Soil	Bentonite +Flyash
Grain Size Analysis		
Gravel %	6.45	00.00
Sand %	10.25	00.00
Silt %	67.30	15.00
Clay %	16.00	85.00
Liquid Limit %	62.00	472.00
Plastic Limit%	27.00	322.00
Plasticity Index %	35.00	150.00
Shrinkage Limit %	16.00	19.00
D.F.S.%	30.00	140.00
Light Compaction		
O.M.C.%	18.00	30.00
M.D.D.(kN/m3)	14.60	12.60
Heavy Compaction		
O.M.C.%	14.00	22.50
M.D.D.(kN/m3)	18.00	15.20

4.2 Swelling Pressure Tests (Without Geosynthetics)

Swelling pressure tests were conducted by constant volume method. In this method soil sample was laterally confined in a mould with porous stones at top and bottom to permit free drainage of water. The mould was placed in a water container. The soil specimen was allowed to swell vertically and change in the height was measured with the help of volume dial gauge. When the specimen swelled to a predermined value the vertical expansion of soil was prevented by applying pressure through a proving ring and mechanical jack attached to a load frame such that volume dial gauge reading was constant. The test was conducted till equilibrium was reached when there was no change in proving ring reading. Swelling pressure for a initial swell was computed from force and area of the specimen. The value of swelling pressure is dependant on the swell allowed. The results of swelling pressure are shown in Figures 1-3.

4.3 Properties of Geosynthetic

The geosynthetic used in this work was expanded Polyethelene(Profeel). The thickness of sheets was 2,4 and 12 mm. The properties of the material as supplied by manufacturer are shown in Table 2.

Table 2 Properties of Geosynthetic

Property	Value	Units
Tensile strength	340-400	kPa
Modulus of elasticity	1000-1400	kPa
Elongation	145	%
Comp.strength (at10% deflection)	19	kPa
Unit Weight	0.35	kN/m^3
Water absorption	Nil	%

4.4 Swelling Pressure Tests (With Geosynthetics)

Swelling pressures tests were also conducted by using geosynthetic sheets of different thicknesses, placed above the soil and without permitting the soil to swell. The results of such tests are shown in Table 3.

Table 3 Swelling Pressure (using geosynthetic)

Soil Compaction Mould	Thickness (mm)	Swelling Pressure Measured (kPa)	Predicted (kPa)
BC-LC-SP	12	8.00	14.00
BC-HC-SP	12	14.00	20.00
BC-LC-CR	4	10.80	15.00
BC-HC-CR	2	30.30	34.00
BC-HC-CR	4	20.50	28.00
BF-LC-SP	12	16.00	30.00
BF-HC-SP	12	25.00	40.00

A compression test conducted on sheet was for obtaining stress - elastic compression graph. The load was appli to the geosynthetic and corresponding change in thickness was measured. A graph is plotted between stress and change in thickness as shown in Figure 1-3.

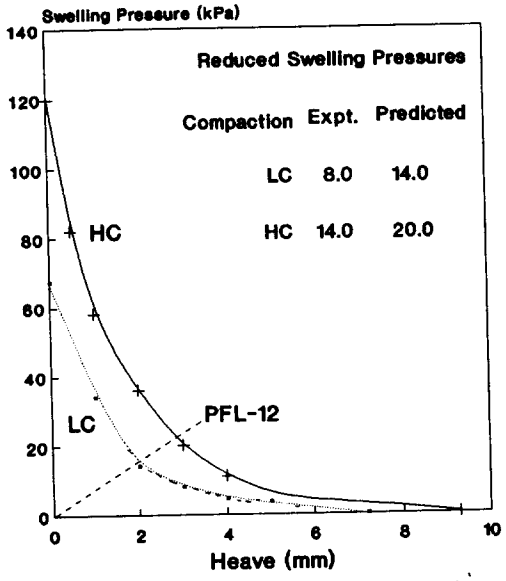

Figure 1 Swelling pressures due to Black Cotton Soil tested using standard mould.

The results obtained for swelling pressures,with/without Geosynthetic are plotted in a graph of swelling pressure Vs initial swell.

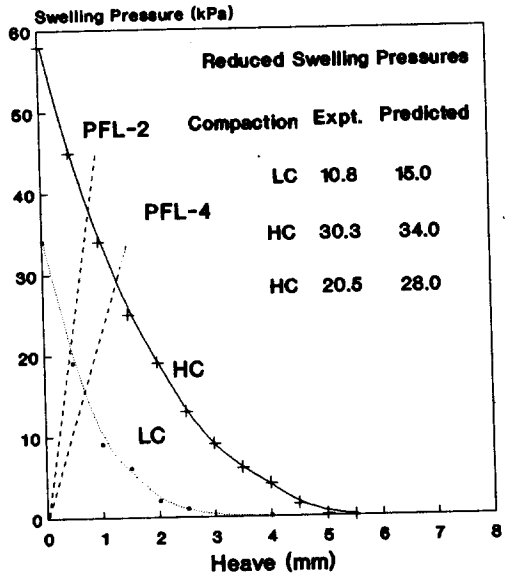

Figure 2 Swelling pressures due to Black Cotton Soil tested using consolidometer.

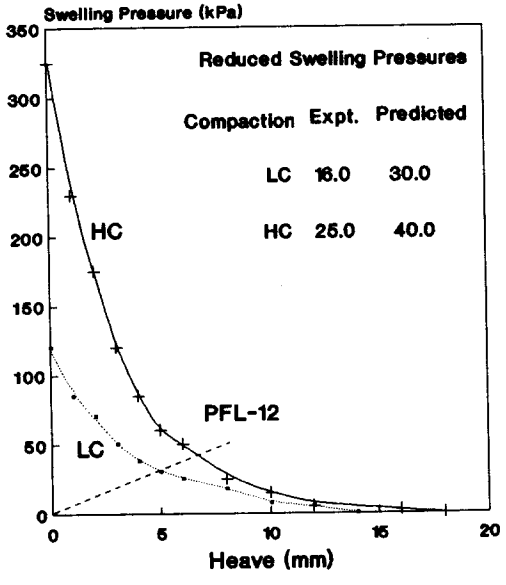

Figure 3 Swelling pressures due to Bentonite - Flyash mixture tested using standard mould.

5 INTERPRETATION OF TEST DATA

Geosynthetic sheet gets compressed when soil exerts pressure on it. The amount by which geosynthetic gets compressed will be equal to swelling of soil. Hence reduced swelling pressure of soil which is measured should be equal to the compressive stress produce in geosynthetic. If stress Vs elastic comression graph of geosynthetic is overlapped over swelling pressure Vs initial swell graph as shown in Figures 1 to 3, the point of intersection of curves will give the theoretical value of reduced swelling pressure. These predicted values are shown in table 3. Pressures measured experimentally compare well with theoretical values.

From the present study it was seen that swelling pressure of soil can be reduced considerably if small amount of free swell was allowed. Test result shows that the percentage reduction in swelling pressure by using 12 mm thick geosynthetic is 90% whereas in 4 mm thick geosynthic it is 69% and in 2 mm thick geosynthetic percentage reduction in swelling pressure is 57%.

6 CONCLUSION

Based on the limited laboratory investigations following conclusions can be made.

1.Geosynthetic material (Expanded Polyethelene) is effective in reduction of swelling pressures of expansive soil for slab on ground type constructions.

2.The magnitude of reduction of swelling pressure increases with the thickness of geosynthetic sheet.

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