Volumetric Study on Expansive Soil Stabilized with Expanded Polystyrene Geofoam And Basalt Fiber

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***Abstract* - Expansive soil is a problematic soil which usually swell on the absorption of water and shrink on removal of water, when expansive soil swells cohesion decreases. Expansive soils are predominantly found in arid and semi-arid regions of five continents in the world. These soils are constituted with montmorillonite clay mineral, which is reason for volume changes associated with variation in moisture content. Due to the undesirable volume changes in expansive soils, great distress and damages are caused to the overlying structure built on them. Hence, in this study waste EPS blocks from manufacturing units and moulded packing products from garbage were used in order to a find a possible way to reuse and reduce the waste. The procured and collected waste EPS blocks were converted into beads by hand crushing. The compressible waste EPS beads were acknowledged as recycled geobeads, basalt fiber. It is used to reduce the swelling potential of expansive soils by shallow mixing. The varying percentages of 0.25%,0.5%,0.75% and 1% of EPS and with different percentages of Basalt fiber is added independently to the clay to study the improvement in its compressive strength. The standard proctor's compaction test is conducted on the unreinforced and reinforced clay. The results from these tests revealed that increasing the diameters and number of columns, the swelling potential is decreased due to EPS geofoam and basalt fiber.**

Key Words: soil stabilization, Expanded Polystyrene, Basalt fibre, swell pressure, expansive soil.

1. INTRODUCTION

Expansive soils, also known as shrink-swell soils, are a class of soils with unique engineering properties that make them a significant challenge in the field of geotechnical engineering. These soils undergo significant volumetric changes as a result of variations in moisture content, swelling when wet and shrinking when dry. This dynamic behaviour often leads to various complications in construction and infrastructure projects, including foundation damage, road and pavement cracking, and structural instability.

Soil stabilization is one of the techniques to mitigate the swelling/shrinkage in the expansive soil widely through two approaches viz. chemical and mechanical stabilization.

1.1. Objective

The following are the objectives of the current investigation

- To Collection of two types of expansive soils (referred as Soil A and Soil B) with varying plasticity index in order to get more distinctive swell and shrink behaviour.
- To investigate the effect of soil type on swelling potential (i.e., percent swell and swelling pressure) of expansive soil with and without EPS Geofoam Layer and basalt fiber for shallow stabilization.
- To investigate the effect of moisture content and dry density on swelling potential of soil with recycled Geofoam Granules Column.

2. MATERIALS AND METHODS

1. Expanded Polystyrene:

The expanded polystyrene (EPS) geofoam has been selected and used as a compressible inclusion in the expansive soils. The function of compressible inclusion primarily depends upon the density of EPS geofoam. Generally, the EPS blocks were ultra-lightweight and high compressible with density up to 20 kg/m3 (Horvath 1997). The commercially obtained two different densities of EPS geofoam were used in this study. The EPS blocks with a nominal density of 12 kg/m3 (EPS12) and 15 kg/m3 (EPS15) were classified as Type XI and Type I as per ASTM C578 (2017):

2. Basalt fiber:

Basalt geotextile is a material made from extremely fine fibers of basalt, which is composed of the mineral's plagioclase, pyroxene and olivine. It is similar chemical composition as glass geotextile fiber but has better strength characteristics, and unlike most glass geotextile fibers is highly resistant to alkaline, acidic and salt attack making it a good candidate for concrete and shoreline structures. Basalt geotextile fiber has tensile strength of about 2800 to 4800 N/mm^2. Compared to carbon and aramid geotextile fibers, it has wide applications namely, the temperature range 452° F to 1200° F, higher oxidation resistance, higher compression strength, and high shear strength.

3 LABORATORY STUDY ON PROPERTIES OF SOIL

The following properties of clay soil are experiment studied by using laboratory tests. Specific gravity, Wet sieve analysis, Atterberg limit tests, Standard proctor test and free swell test.

Table 1. Laboratory test results for cohesive soil

DESCRIPTION	SAMPLE
Natural moisture content (%)	11
Percentage of Gravel (%)	Nil
Percentage of Sand	26.61
Percentage of Fines	73.39
IS classification	CI
Liquid limit)	44
Plastic limit	25
Shrinkage limit (%)	22
OMC (%)	20
Max dry density, g/cc	1.609
Specific gravity	2.75
UCS (kN / m2)	48
Cohesive strength	24
Free swell Test (%)	31.70
Differential free swell Test (%)	32

1. Laboratory test figures.

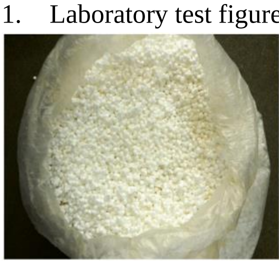

Fig.1 EPS geofoam

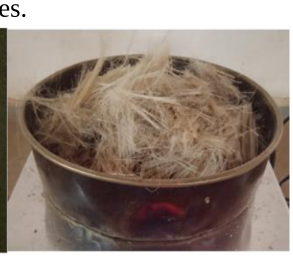

Fig.2 Basalt fibre

2. Experimental Procedure

Preparation Of Expanded Polystyrene Geofoam

The recyclability of EPS geofoam in geotechnical applications using waste EPS blocks is also investigated in this study. The cut pieces of waste EPS blocks of different sizes and densities were procured from non-proprietary at free of cost since the recyclable cost of cutting wastes is highly complex and uneconomical. EPS manufacturers are still finding the feasibility of using cutting-wastage of EPS blocks as a reusable material in manufacturing units. Hence, waste EPS from manufacturing units and moulded packaging products from garbage were used in order to find a possible way to reuse and reduce the wastes. The different sizes and densities of manufacturer wastes and solid wastes EPS blocks were used in the present study to minimize the solid wastes to the landfills. The procured and collected waste EPS blocks were converted into beads by hand crushing.

4. UNCONFINED COMPRESSIVE STRENGTH

The soil is mixed with Basalt fiber, recycled plastic waste and combination of both in varying percentage individually. The soil samples extracted is of size length 74mm and diameter 37mm is placed on the base plate of the loading frame. And the centre line is adjusted such that proving ring and steel balls are in same line. The dial gauge is fixed to measure the vertical compression of the specimen and gear position on the load frame to given vertical displacement. The load is applied and reading is recorded from the proving ring dial for every 5mm compression and the same procedure is carried out for all the sample as per the general specification is given and the sample attains shear failure.

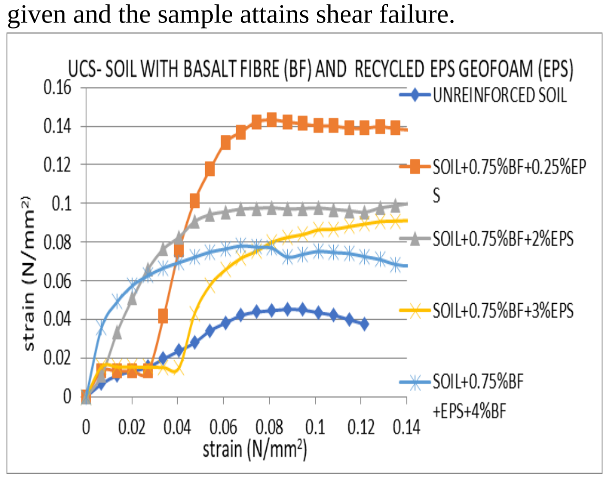

Fig. 3 Unconfined Compressive Strength

5. TEST PROCEDURE

The test involved two stages:
swelling phase and compression. In the first stage, the specimen was inundated with water to swell freely under nominal seating pressure of 6.25 kPa. The swelling strain was recorded at different time intervals to point out the equilibrium state. This resultant state is equivalent to the swelling potential of specimens. This could be attained after 18 days to 22 days of inundation. This is followed by the compression stage, where the swollen specimen was gradually loaded to counteract the build-up swelling strain. The pressure required to bring back the specimen's initial thickness is refereed as the swelling pressure.
where
ΔH = ultimate changes in the soil sample with respect to time intervals
H= actual thickness of the soil sample.
Percent swell (PS) = ΔH/ H × 100

6. EXPERIMENTAL RESULTS

Table 2 Swelling Analysis

Test identifier	Percent swell, ps (%)	Swelling pressure, sp (kpa)	Percent swell reduction factor, psr	Swelling pressure reduction factor, spr
SA	15.69	596	1.00	1.00
gc = 0.25	14.23	464	0.93	0.83
gc = 0.5	12.87	338	0.85	0.65
gc = 0.75	8.44	283	0.66	0.56
gc = 1 %	9.09	260	0.50	0.45

Graphical representation of test results

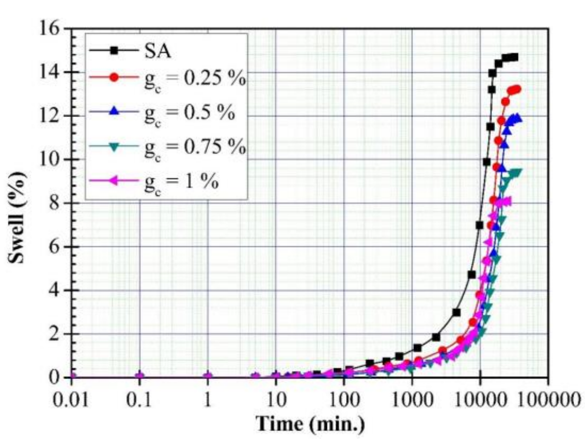

Fig.4 Swelling Analysis

7. CONCLUSION

1. As the percentages of EPS geofoam waste increases, the density of soil decreased and the unconfined compressive strength of soil keeps on increasing upto 4% and then decreases.
2. As the percentage of basalt fiber increases, the unconfined compression strength of the soil keeps on increasing upto 0.75% and then decreases.
3. The stress –strain of reinforced soil has attained more plasticity when basalt fiber added to the soil.
4. As the percentage of combination of basalt fiber and recycled eps geofoam increases, the unconfined compression strength of the soil keeps on increases compared to soil reinforced with EPS geofoam alone upto 0.75%BF+1% EPS and then decreases.
5. As we compare all the combinations of soil reinforcement soil with 0.75% EPS geofoam alone showed the maximum strength

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