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The effect of using a sand column on the expansive soil's swelling characteristics

*Note: Sub-titles are not captured in Xplore and should not be used

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***Abstract*— Expansive soil is a type of soil that experiences volume fluctuations as a result of changes in the moisture content that is present in it. The volume of the soil will rise as a result of water absorption, and vice versa. The structural damage caused by soil swelling includes kerb swelling, border cracking, reinforced foundation damage, and eventually deformation of floors and doors. Depending on the amount of soil swelling, these deformations may be small, moderate, or substantial. The expansive soil used in this study came from the state of Maharashtra and had initial plasticity index (PI) values of (98), liquid limit (LL) values of (160), and plastic limit (PL) values of (62). Sand columns were employed with three sizes of sand (0.6mm, 1.18mm, and 2.36mm) and varied diameters (1cm, 1.5cm, and 2cm), with each sample being completed by three types of diameters and three distinct sizes of sand. Free swell and swell pressure will decrease as sand column diameter, size, and utilization all increase.**

Keywords—Sand column, Expansive soil, Free Swelling, Swelling Pressure.

I. INTRODUCTION

Numerous conferences, symposiums, and studies have been done to examine the behaviour of expansive soil under various conditions because of its importance to people all over the world because it is responsible for heave issues. The fascination in expanded soil dates back to the new phase of soil mechanics. Figure 1 shows the extent of expansive soil around the world and the serious effects it has on various types of structures, including highway fills, highway subgrades, building foundations, canal linings, and other types of structures. This forces nations to be cautious in how expansive soil is treated in order to minimise these adverse effects. Fig. 1 depicts a map of the global distribution of expansive soil.

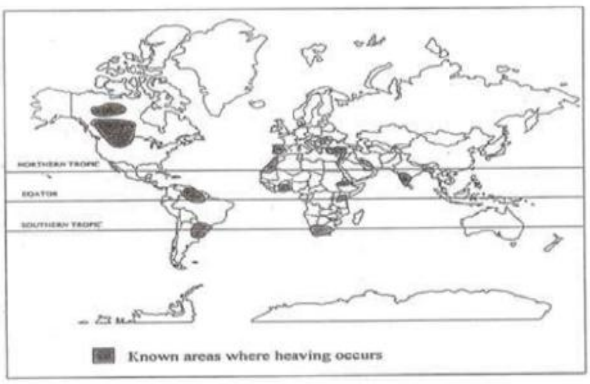

Fig 1. Distribution of heaving cases that have been reported [2].

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Chemical stabilisation of soils is one of the options for solving geotechnical engineering issues, and it can be used to [1]

1. lessen the buildings' tendency to settle.
2. Increase the soil's shear strength to increase the shallow foundation's bearing capability.
3. Increase the earth dam and embankment safety factor against potential slope failure.
4. Reduce the soil's ability to contract and expand.

Therefore, the goal of the earlier studies was to identify the free swell and swelling pressure that a soil might demonstrate in the extreme case of total flooding. Cycles of wetting and drying, which cause cycles of soil swelling and contraction, can cause a change in the soil's moisture status in the field. Thus, the need for expanding ways to improve the engineering qualities of soil has developed significantly in recent years, particularly in developing countries [3]. One of the most popular types of chemical stabilisation is the stabilisation of cement and lime [2, 3]. By adding an additive that causes a chemical reaction within the soil, the qualities of the soil are altered. This has been used to stabilise clay soils during pavement construction [4].

The primary goal of the current work is to show the effects of used sand columns of various diameters (1 cm, 1.5 cm, and 2 cm) and three sizes of sand (0.6 mm, 1.18 mm, and 2.36 mm), on the properties of expansive soil, including consistency limits, compaction characteristics, free swell, and swelling pressure. Each sample was done by three types of diameters and three sizes of sand.

II. RESEARCH SIGNIFICANCE

A. *Expansive Soil*

The term "expansive soils" mainly refers to those clay minerals that significantly alter in volume while wet and dry. Swell often gets bigger when the plasticity index is higher [5]. According to Fredlind's [6] analysis, Korhn and Slossen [7] estimated that damage to all sorts of structures erected on swollen soils costs the United States $7 billion annually. According to Sabaa, M.R. [8], soils containing montmorillonite exhibit nearly high swelling and shrinkage properties, but soils containing kaolinite or illite exhibit a considerable initial volume reduction upon drying and relatively minimal swelling upon rewetting.

Saxena [9] noted that the pressure required to condense a swollen soil back to its original volume and/or the pressure required to maintain the starting volume of a swollen soil at a constant value can be used to determine the swelling pressure of clay minerals. According to Sivapullaiah et al. [10], the key factors influencing soil swelling are the percentage of coarse-grained soil, the type and quantity of clay minerals, the initial dry, density, and the primary water content. Additionally, Komine and Ogata [11] observed that the pore water ion concentration and the precise surface of the clay particles expressly affect the clay's swelling characteristics.

When plastic soils are partially saturated and exposed to moisture during rainy seasons, leaks in water pipes, or a rise in the water table through the porous soil layer, the soil will swell. Swell potential is a measurement of a soil's capacity and potential swelling when its environment is about to change [12]. The percentage increase in volume of a partially saturated soil sample when subjected to wetness is known as the free swell. Numerous attempts have been made to anticipate the type of swell potential; this is dependent on the free swell index [12].

Investigational research to examine the impact of stone column installation arrangement were presented by Sankar.K. and Shroff.A.V. [13], who demonstrated that a triangular layout appears to be the most ideal and sensible. A.P. Ambily and S.R. Gandhi [14] investigated the behaviour of columns made of clay and strengthened with stones. The stone column spacing was changed during the load test. According to the test results, the load-settlement for s/ds of 2 and 3 significantly improves over s/d 4.

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III. MATERIALS

A. *Exapansive Soil*

The natural clayey soil used in this study was obtained from the Sangli District of the state of Maharashtra, India. Table 1 list down the properties of the clay sample.

Table 1. Properties of Clay Sample

Property	Value
Liquid Limit	160%
Plastic Limit	62%
Plasticity Index	98&
Specific Gravity	2.24
Maximum Dry Unit Weight	15.1 kN/m^3
Optimum Moisture Content	29.8%
Classification	CH

B. *Sand*

Three zones were used to categorise the sand used in this investigation (0.6mm, 1.18 mm and 2.36mm).

IV. PREPARATION OF TEST SPECIMEN

Some of the experiments are carried out on naturally clayey soil, while others are carried out on clayey soil by filling sand columns with three different sand sizes (2.36mm, 1.18mm, and 0.6mm) and examining the effects of sand columns on free swell and swelling pressure.

V. RESULT AND DISCUSSIONS

A. *Free Swell Test*

The previous tests were conducted on clayey soil treated by a sand column, but this test was conducted on natural soil. Three different sand sizes (2.36 mm, 1.18 mm, and 0.6 mm) and three different sand column diameters are used (20,15,10 mm). Table 2 and Figure 2 illustrate the results of the impact of modifying the diameter of the sand column on free swell.

B. *Swelling Pressure Test*

After being submerged in water, samples were kept from expanding by gradually increasing the applied strains on their tops to ensure that no swelling would occur. Reaching the equilibrium state requires some time. The highest stress necessary to avoid sample swelling is noted. As may be seen in the following table 4 and fig. 4, this stress is characterized as swelling pressure in accordance with ASTM D 4546. For the three sizes of sand particles utilised, swelling pressure will decrease as sand column diameter increases.

C. *Percentage Improvement of Swelling Pressure*

By using results in table 4, the impact of percentage improvement in swelling pressure from the two formulas given below are calculated:

% Improvement in swelling pressure= $(w_2-w_1)/w_2 * 100$

Where, w_1= Swell pressure with treated soil

w_2 = Swell pressure without treated soil

Area Ratio = A_1/A_2

Where, A_1 = Area of soil with sand column with different diameters.

A_2 = Area of soil without sand column.

Sand with a diameter of 2mm and a size of 2.36mm produced the best results, followed by 1.18 mm and then 0.6 mm, respectively.

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D. Percentage Improvement of Free Swell

% of swelling potential improvement = $\Delta H/(H°)$
$= (I2-I1)/I2$

Where:
I1= (Free Swell) / (Sample height origin)
I2 = (Free swell in normal clay) / (Sample height origin)

The results shown in table 6 and fig. 6. The sand size 2.36mm with a 2mm sand column diameter produces the best results, followed by 1.18 mm and then 0.6 mm, respectively.

VI. CONCLUSION

The study's conclusions can be inferred from the experimentation and analysis that were done as-

1. By reducing the free swell and swelling pressure, the expansive soil can be treated with a sand column.
2. For the three sizes of sand employed, free swell will decrease as sand column diameter increases.
3. For the three sizes of sand employed, swelling pressure will decrease as sand column diameter increases.

Table 2. Effects of changing the diameter of sand column on free swell

Diameter of sand column	Free Swell, mm			Free swell in normal clay, mm	Sample Height Sand size origin, mm
	Sand Size 0.6mm	Sand size 1.18mm	Sand size 2.36mm		
1cm	5.1	5.35	3.83	6	12
1.5 cm	4.2	3.18	2.48	6	12
2 cm	2.4	2.21	1.88	6	12

Table 3. Effects of changing the diameter of sand column on swelling pressure

Diameter of sand column	Swell pressure, kN/m^2			Swell Pressure in normal clay, kN/m^2
	Sand Size 0.6mm	Sand size 1.18mm	Sand size 2.36mm	
1cm	23.32	19.06	8.317	24.66
1.5 sm	19.45	15.25	6.88	24.66
2 cm	16.34	10	6.1	24.66

Table 4. Percentages of improvement swelling pressure with different diameters of sand column and sand sizes

Diameter of sand column	% of improvement in Swelling pressure			Area ratio (A_1/A_2)
	Sand Size 0.6mm	Sand size 1.18mm	Sand size 2.36mm	
1cm	5.43	22.7	66.3	0.02367
1.5 sm	21.12	38.158	72.1	0.0625
2 cm	33.73	59.45	75.26	0.1322

Table 5. Percentages of improvement swelling potential with different diameters of sand column and sand sizes

Diameter of sand column	% of improvement in Free Swelling			Area ratio (A_1/A_2)
	Sand Size 0.6mm	Sand size 1.18mm	Sand size 2.36mm	
1cm	10	10.83	36.167	0.02367
1.5 sm	25	47	58.67	0.0625
2 cm	55	63.167	68.67	0.1322

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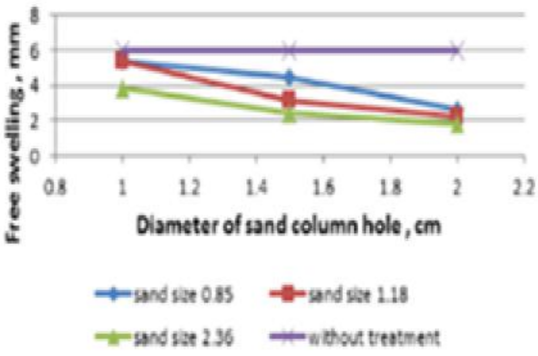

Figure 2. Effects of changing diameter of sand column on free swell

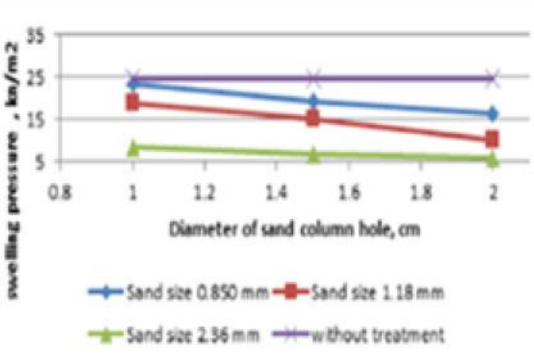

Figure 3. Effects of changing diameter of sand column on swelling Pressure

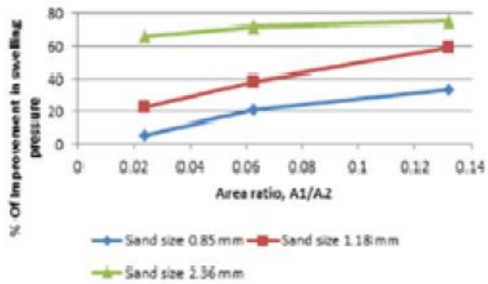

Figure 4. Percentages of improvement swelling pressure with different diameters of sand column and sand sizes

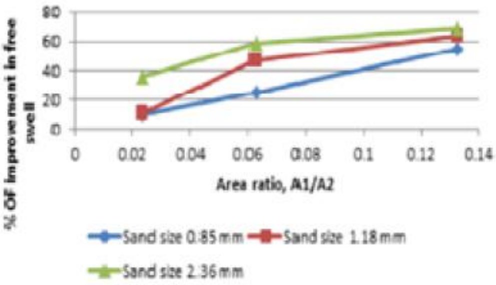

Figure 5. Percentages of improvement swelling potential with different diameters of sand column and sand sizes

4. More so than small particles, large sand particles have an impact on percentages of improved swelling potential.

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