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EFFECT OF CALCIUM CHLORIDE ON CONSISTENCY LIMITS OF BLACK COTTON SOIL

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ABSTRACT

As a part of the study, calcium chloride and fly ash were tested on a Black Cotton soil that has expansive properties in order to improve its engineering properties. The laboratory experiments were conducted by mixing calcium chloride solutions of 1%, 2% and 3% with black cotton soil in a ratio of 1:3, 2:3 and 3:3. By comparing the results obtained with calcium chloride percentages with fly ash percentages of 20% and 30%, we were able to compare the results obtained. In this study, calcium chloride and fly ash were evaluated for their consistency limits and their differential free swell. We performed an unconfined compressive strength test at a cure time of 7, 14, and 28 days in order to compare the results of the test with those obtained at a cure time of 0 days in order to find out which conditions lead to the best results. There was a decrease in the consistency limits and a reduction in the swelling index of the soil samples after being subjected to wet and dry cycles. As a result of wet and dry cycles, the calcium chloride mixed soil samples showed higher strength and a lower swelling index than the unmixed soil samples.

Keywords: BCS, $CaCl_2$, LL, PL, FSI.

I. INTRODUCTION

The black cotton soils are swelling soils or shrink-swell soils, which tend to shrink and swell with moisture changes. Globally, expansive soils are predominant. The variation of water content lead to cracking of the structures which built on them. Annually, billions of dollars are spent on their repair due to expansive soils. As a result of these expansive behaviors, property and lives are lost. In some places, these soils are called regur soils. Expansive soils have been subject to enormous research over the past 30 years. Physical mechanical and chemical stabilization methods are available for soil stabilization. In India, black cotton soil is stabilized using chemical admixtures. The most commonly used chemicals are fly ash stabilization, lime stabilization, and cement stabilization. Black cotton soils are vastly spread in the regions of middle India Andhra Pradesh, Madhya Pradesh, Gujarat, and Maharashtra and in some places of Orissa, expansive soils are available in the regions of Narmada, Tapi, Krishna, and Godavari. Black cotton soil is abundant in northwestern India. Black cotton soils are residual soils created by weathering or chemical decomposition of rocks, left on site after formation. Montomorollonite content in black cotton soils causes the soil to expand and contract. Presently at India nearly 25% of the soils are covered by the expansive soils. Since these soils are able to retain large amounts of moisture, they are suitable for crops like wheat, oilseeds, citrus fruits, cereals, sugarcane and vegetables. Agriculturally, black cotton soils are very profitable but problematic constructively.

In this study, we aim to contribute to the understanding of the effect of adding calcium chloride and fly ash to Black Cotton soil in order to improve its characteristics.

II. LITERATURE REVIEW

Ramdas. T.L., et al. (2012), studied the stabilization of expansive soil using calcium chloride. Different proportions of calcium chloride were used to determine soil strength and durability. They investigated the consistency limits, unconfined compressive strength, and swelling behavior of the soil after adding 0.5, 1,2, and 2.5% calcium chloride. Calcium chloride increases the soil's unconfined compressive strength and decreases its swelling behavior. Additionally, they observed decreasing liquid limits and increasing plastic limits. In both 14 and 28 day curing periods, UCS strength improved. According to the results of the study, soil should be treated with 1% CaCl2 by dry weight.

Sivapullaiah P.V, et al. (2010) it is observed that mineralogy plays an important role in the behavior of fine-grained soils. Adding acids to pore water causes sudden changes in the geotechnical properties of the soil and also changes in its mineral structure. The soil's properties deteriorate when the mineralogy of the original

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structure is altered. The behavior of soil during and after contamination can be challenging to determine. According to the research, the type of chemical that was contaminated with the soil and the type of soil were related to the duration of contact with the soil in terms of assessing its properties.

Ling-Chu Lin, et.al (2000), liquid limit, plastic limit, swelling index, and permeability tests were conducted on soils, to determine how wet and dry cycling affects the plastic and swell behavior of expansive soil, and to determine whether expansive clay liners added to water with a pH value of 6.5, tap water with a pH value of 6, or a pH value of 6.3. The 0.01255-M CaCl2 solvent has a pH value of 6.3, whereas the 0.01255-M CaCl2 solution has a pH value of 6.7. So the swelling characteristics of expansive soil added with water enhance at each wetting and drying cycle, the swelling behavior of expansive soil added with water and CaCl2 reduced for every cycle of wet and dry. Wet-dry cycling in Deionized water and tap water had very small effect on swelling of the bentonite which can be negligible.

III. MATERIALS

3.1 Black Cotton Soil

The soil sample for this study was collected from a construction site in Jabalpur. The soil was dried and grinded to 4.75mm sieve to carry out laboratory experiments. The Properties of Black cotton soil is shown in Table 1.

Table 1- Properties of Black Cotton Soil

SL. No.	Properties	Values
1	Specific Gravity	2.57
2	Liquid Limit	75%
3	Plastic Limit	27%
4	OMC	25.10%
5	MDD	1.56g/cc
6	UCS	26.58 N/cm^2
7	Natural Moisture	9.2%
8	Free Swell Index	75

3.2 Calcium Chloride

Calcium Chloride was bought from Jabalpur Market. It has molecular weight 110.47grams. It is in white crystalline powder form.

3.3 Fly Ash

Fly Ash was obtained from Sanjay Gandhi Thermal Power Station, Birsighpur, Pali, Madhya Pradesh.

IV. METHODOLOGY

This study was conducted as part of the following research process, which is described below. Calcium Chloride in different proportions in alternate wet and dry cycles was compared with industrial wastes such as fly ash in different proportions in alternate wet and dry cycles. To evaluate the effect of soil/calcium ratio and soil/fly ash ratio on swelling index, consistency limits and three different types of calcium chloride and two different fly ash ratios were used. The calcium ratios were 1%, 2% and 3% and two different proportions of fly ash were used in the present study. The soil and fly ash were thoroughly mixed before the experiments were carried out. Based on the method described in the IS code, all tests were carried out in compliance with the standards.

This study involved mixing soil specimens that were produced from black cotton with water, calcium chloride solution compositions, and fly ash compositions at different proportions. In the laboratory environment (at a controlled temperature of 21± 5°C), the black cotton soil was allowed to air dry for a period of time. The soil was then dried until it no longer lost moisture in the laboratory environment. Each black cotton soil specimen was then rewetted with the same concentration of liquid as used initially. The soil specimens were tested for up to five wet–dry cycles. In each cycle the behavior of the soil was observed.

The following experiments were conducted in the laboratory:

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- Free Swell Index
- Liquid Limit
- Plastic Limit

V. RESULTS AND DISCUSSIONS

The experimental study involves Free Swell Index, Liquid Limit, Plastic Limit and Unconfined Compression Strength tests on soil sample with 1%, 2% and 3% of Calcium Chloride and 20% and 30% of Fly Ash as stabilizer. The results are also compared for different number of alternate wet and dry cycles.

Liquid Limit

According to the code of IS 2720: PART 5:1985, the liquid limit experiment was conducted. A soil sample of 300 grams was taken and was thoroughly mixed with water. The paste was mixed thoroughly using knife plate for 10 minutes. In order to determine the liquid limit, the Casagrande apparatus was used. A soil sample is placed in a cup after thoroughly mixing the soil. A groove is formed at the center of the soil sample. By using of the crank-operated cam, the cup is lifted height of 10 cm and then dropped. The water content, to the soil, mixes to end the length of 12.7 mm along the bottom of the groove after 25 blows is defined as the liquid limit. It is very difficult to make the water content in the soil to get the required 12.7 mm closure of the groove in the soil pat at 25 blows. At least three tests for the same soil were conducted at different water contents, and the number of blows required to achieve closure varied between 15 and 35. A semi-logarithmic graph of the water content versus the number of blows was drawn and the water content at 25 blows was determined. The graph formed between water content and number of blows is almost straight. This line known as flow line. The water content at 25 number of blows gives the liquid limit of the soil. The slope of the flow line is defined as the flow index.

Table 2- Liquid limit in % at different cycles

	BCS	BCS+ 1% CaCl2	BCS+ 2%$CaCl_2$	BCS+ 3%$CaCl_2$	BCS+ 20%FA	BCS+ 30%FA
0CYCLE	76.621	72.25	67.325	66.325	65.857	57.4855
1CYCLE	75.0455	69.416	66.548	65.602	65.4765	58.6175
2CYCLE	75.01	67.035	64.325	63.347	67.4885	58.985
3CYCLE	75.58	65.988	60.365	59.26	66.908	57.985
4CYCLE	75.89	65.12	61.258	57.698	65.958	59.875
5CYCLE	76.52	64.858	58.365	56.36	66.0202	59.685

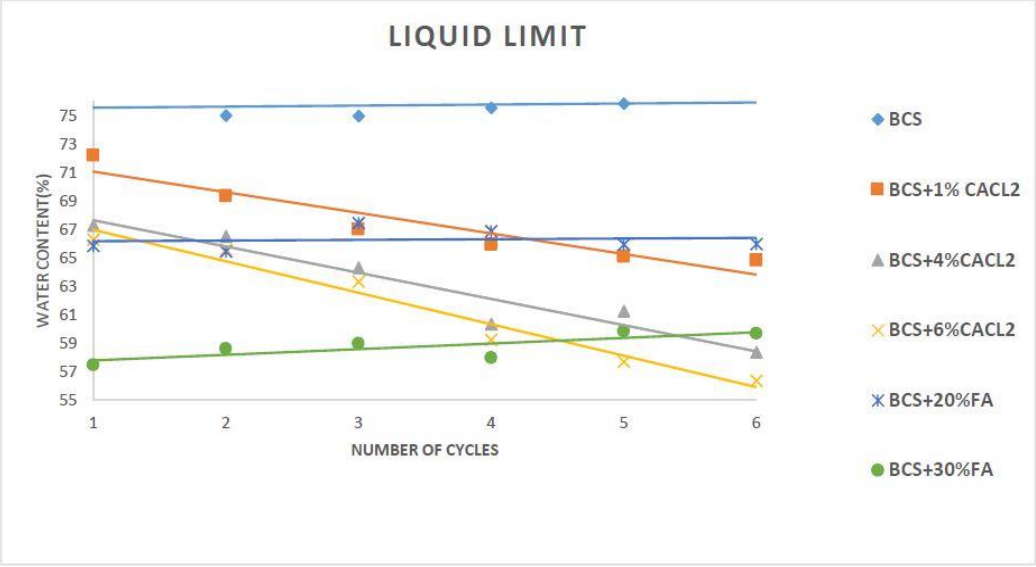

Figure 1: Graph between liquid limit and number of cycles

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Plastic Limit

In soil, the plastic limit is defined as the water content at which soil crumbles into 3.2mm threads. The plastic limit is the lowest water content at the plastic stage. The plastic limit test is easy to determine and is determined by continuous rolling of soil mass by hand on a ground glass plate. According to ASTM, we followed the plastic limit procedure.

Table 3 - Plastic limit in % of the at different cycles

	BCS	BCS+1%$CaCl_2$	BCS+2%$CaCl_2$	BCS+3%$CaCl_2$	BCS+20%FA	BCS+30%FA
0 CYCLES	27	32	38	39	23	21
1 CYCLES	28	34	39	40	24	21
2CYCLES	27	35	40	41	24	22
3CYCLES	28	36	40	42	26	23
4CYCLES	28	37	41	43	26	23
5 CYCLES	29	37	42	43	27	24

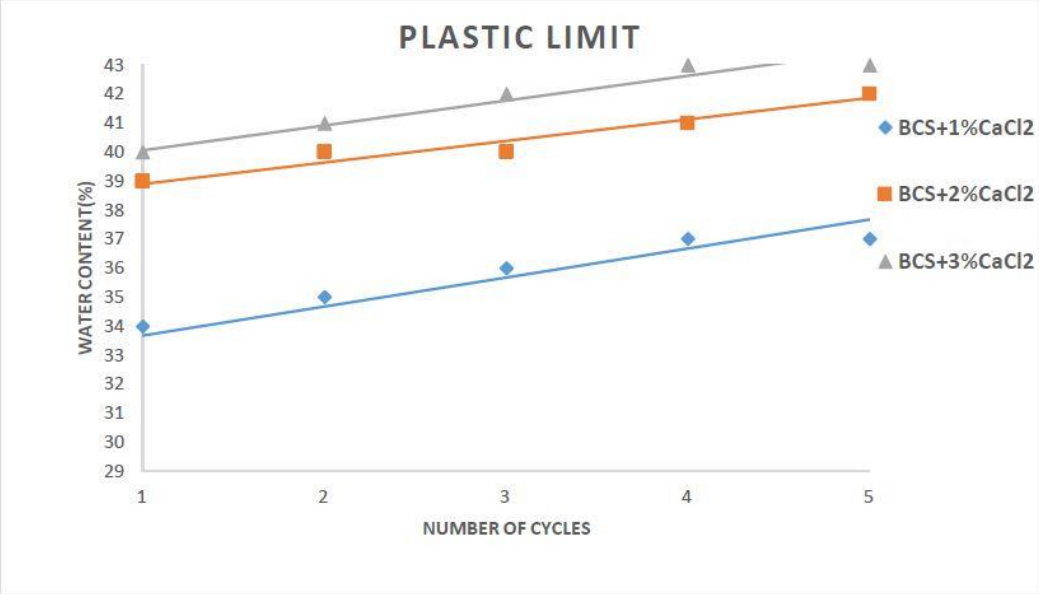

Figure 2: Graph between plastic limit and number of cycles

Free Swell Index

The free swell test has been followed the code of IS 2720:PART XL:1977. To determine the expansiveness and non-expansiveness of soil, the free swell index has been developed in the field. Also determine the expansive percentage of the soil. Bureau of indian standard suggest that the free swell index test should be used for fine grained soil, which is defined as

$$\text{Free swell index} = (Vd-Vk)/(Vk))*100$$

Vd is the equilibrium sediment volume of 10gm of oven dried sample passed through 425microns and placed in distilled water to expand up to its capacity. Vk is the equilibrium sediment volume of 10 gm of oven dried sample passed through 425 microns and placed in kerosene which would not expand at all. With the above formula, it is easy to determine the free swelling index of the soil.

In the present experimental program free swell index has been found for different proportions of calcium chloride. It has been observed that soil with calcium chloride has less expansion compared with soil and fly ash mixes.

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Table 4- Free swelling of the soil at different cycles

	BCS	BCS+1%$CaCl_2$	BCS+2%$CaCl_2$	BCS+3%$CaCl_2$	BCS+20%FA	BCS+30%FA
0 cycles	77.27273	72.72727	66.365	65.45455	61.534	57.69231
1 cycles	77.98165	69.72477	61.368	60.55046	61.923	58.294
2 cycles	76.52174	66.95652	57.598	56.52174	62.124	58.289
3 cycles	75	65	55.368	54.1667	62.952	58.721
4 cycles	75	63.3333	53.34	51.66667	63.124	59.724

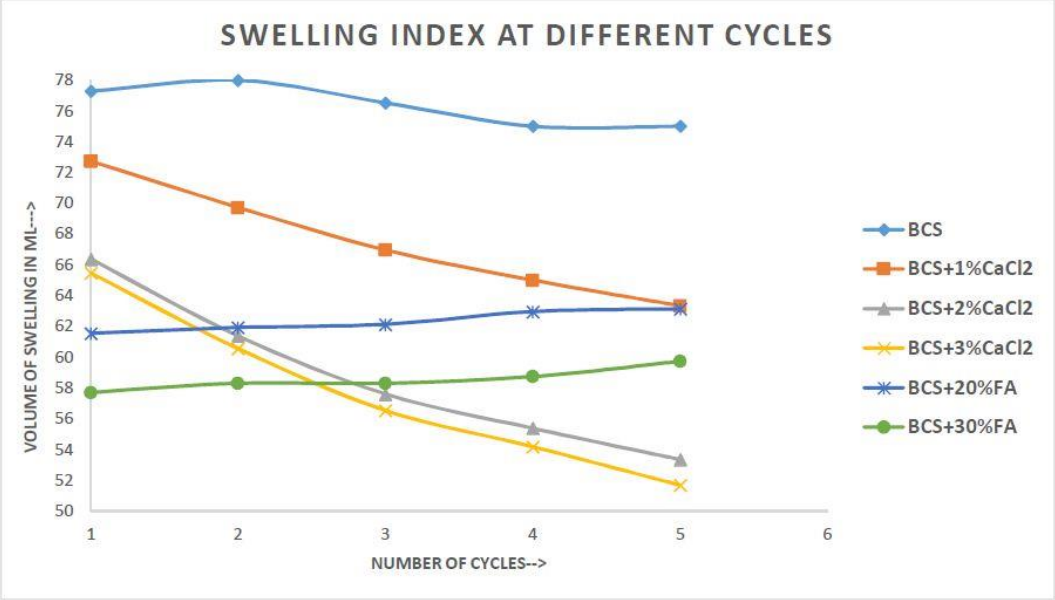

Figure 3: Swelling index at different cycles

VI. CONCLUSION

Based on experimental study and analysis, the following conclusions were made:

- Liquid limit of the soil decreases with a change in calcium chloride percentage. Thus, with an increase in calcium chloride content, the cation exchange of the soil increases.
- Liquid limit also decreases with the number of wet and dry cycles so we can conclude full cation exchange capacity does not takes place instantly after adding to the soil.
- Based on the fact that the plastic limit of the soil increases with a change in calcium chloride percentage, it can be concluded that swelling characteristics also decrease as the plasticity index of the soil decreases.
- Calcium chloride content and alternate wet/dry cycles reduce the Black Cotton soil Free Swell Index.

VII. REFERENCES

[1] Abdelmalek Bouazza, Stephan Jefferis, Thaveesak Vangpaisal" Investigation of the effects and degree of calcium exchange on the Atterberg limits and swelling of geosynthetic clay liners when subjected to wet–dry cycles" Geotextiles and Geomembranes 25 (2007) 170–185.

[2] Ramadas.T.L, Darga Kumar.N And Yesuratnam.G, "A study on strength and swelling characteristics of three expansive soils treated with cacl2" Academic Research Journals (India), pp. 77-86.

[3] Reddy.B.V.V, Ram.S.M, Mutttharam.M "The impact of cyclic wetting and drying on the swelling behavior of the expansive soils" engineering geology 60(2001) 223-233.

[4] S.D.V. Mohan, H.N.Ramesh " volume change behavior of alkalis treated expansive and non-expansive soils contaminated with acids" Proceedings of Indian Geotechnical Conference December 22-24, 2013, Roorkee.

[5] Ramesh H.N., Venkataraja, Mohan S.D." Index and compaction properties of alkalies treated red earth contaminated with acids" igc 2009, guntur, india.