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A STUDY OF CHANGE IN ENGINEERING PROPERTIES OF EXPANSIVE SOIL ON TREATED WITH CALCIUM CHLORIDE SOLUTION

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ABSTRACT*: *Primary step while constructing a structure is to evaluate the bearing capacity of the soil strata over which the foundation of the structure will be laid on. As the much larger part of south India and some parts of Madhya Pradesh and southern region of Rajasthan has expansive soil. While this soil is great for the farmer as it is rich in nutrients but, it causes problems to the Civil engineers. The expansive soil shows its characteristic swelling and shrinking behavior along with seasonal variation as the water available to be absorbed by the soil varies with seasons. This volumetric change in the soil strata causes excessive damage to the structure. To overcome this an engineer have to enhance the engineering properties of the soil. On the field, various methods are being used viz. Addition of calcareous materials like lime, marble dust, etc. But, many of these methods are cumbersome due to they are more laborious and not quite effective while using at larger projects. An easy method can also be applied which is more effective and less laborious that is the addition of property enhancing material in solution form. So that the mixing will be effective and so the results will be more worthy. The present study is a critical evaluation of the addition of calcium chloride solution in black cotton soil. Concentration of the $CaCl_2$ solution adopted is 1%, 2%, 3% and 4%. Results show that the solution of 3% $CaCl_2$ concentration found to be the optimum dose. Swelling pressure reduced by 67% and the Unconfined Compressive strength increased by 30%.

KEYWORDS: Expansive Soil, Calcium Chloride, Unconfined Compressive Strength, Swelling Pressure

I. INTRODUCTION

Expansive soil or black cotton soil (BCS) is a high to medium plastic soil which shows characteristic low bearing capacity, permeability and high volumetric change due to moisture absorption which is dependent upon the season. BCS contains Montmorillonite mineral as the basic unit, which is responsible for its high volumetric changes. This excessive change in volume of the soil strata causes heavy damage to the structure, which is a hassle to construction agencies. A larger part of southern India and some part of Gujrat Madhya Pradesh and southern Rajasthan are covered with the strata of BCS.

In the field, various additive like sand lime waste stone slurry and natural fibers are used to enhance the engineering properties of BCS .but many of these methods are troublesome for larger projects as they require more skills and quite costly.

A most effective method for stabilization is to apply an additive material in the form of the solution as found by many researchers [1],[2],[3],[4],[5].This paper analyses the efficacy of calcium chloride solution to improve the engineering property of expansive soil.

For the test conduction, 5 batches of expansive soil each of 20 kg was prepared. One batch was separated for tests to be done on expansive soil and other 4 soil batches were mixed with different concentration of calcium chloride solution viz. 1%, 2%...4%. The water in the solution to be mixed to the batches was in between the liquid limit and plastic limit so that the diffusion of the calcium chloride solution in the soil matrix be effective. The mixes were left for 2 days for the diffusion period. Than separate tests were conducted on each of 5 batches according to respective IS codes.

II. LITERATURE REVIEW

A. *Sangita Lajurkar et al (2016)*:

This paper deals with the efficacy of the calcium chloride solution. This paper suggests that the diffusion of chemical solution in expansive soil is possible and it develops the positive effect in respect of improving the strength characteristics and also a different percentage of calcium chloride has a different effect on the volumetric strain and UCS. The optimum dose was found at 2 %.

B. *Ramya H.N. (2018):*

This study was conducted to determine the effect of sodium chloride solution on the properties of Black Cotton Soil. Solution concentration was chosen to be 0.5N, 1N, 2Nand 4N. It is found that variation in the values of optimum moisture content was not well pronounced with the increase in the concentration of the salt solution. However, the values of maximum dry density at higher concentration are found to be increased and also the strength of the expansive soil, transforming the soil from CH to CI zone.

C. *Dr. K.V. Manoj Krishna (2012):*

Paper describes the strength behavior of Black Cotton Soil treated with calcium chloride with a curing period of 30 days. The optimum dose was found 3% concentration solution. Addition of 3% Calcium Chloride showed a higher factor of safety with higher curing periods for an embankment slope of 1:2:5. Strength of the soil increased 17 times with a curing period of 30 days.

D. *Desai and Oza (1997):*

On the addition of calcium chloride solution in expansive soil causes not only cation exchange but also by intercalation whereby $cacl_2$ enters into the interstellar spaces of clay mineral structure thus bringing about significant modification of clay.

III. MATERIAL

Laboratory tests were conducted on remolded soil to study the effect of calcium chloride diffused in the BCS unit matrix.

A. *Soil:*

Black cotton soil collected from Borekhera Area on Baran-Kota highway .basic properties are –

Table I: Properties of Black Cotton Soil

Sr. No.	Property	value
1	Specific Gravity	2.53
2	Liquid Limit	49.51%
3	Plastic Limit	25.92%
4	Plasticity Index	23.59%
5	Maximum Dry Density	1.63 gm/cc
6	Optimum Moisture Content	21.88%
7	Unconfined Compressive Strength	1.56 kg/cm^2
8	Sand	12.46%
9	Silt & Clay	87.54%
10	Soil classification	CI
11	Differential free swell	58.82%
12	California Bearing Ratio	1.58%

B. *Calcium Chloride:*

In the present study dehydrate calcium chloride industrially produced supplied by LOBA CHEMIE PVT. LTD., which as molecular weight 147.02 and freely soluble in water.

IV RESULT

A. Atterberg's Limits:

Atterberg's limit tests were conducted according to IS 2720: Part 5: 1985. As the concentration of $CaCl_2$ Solution increases the liquid limit, plasticity limit decreases. This effect is due to a change in the thickness of the double diffused layer [1], [2], [3], [4]

Table II: Atterberg's Limit Tests Result

Calcium Chloride Solution Concentration	Liquid Limit %	Plastic Limit %	Plasticity Index %
0%	49.51	25.92	23.59
1%	44.68	23.8	20.88
2%	35.51	22.72	12.79
3%	31.48	22.72	8.76
4%	29.31	22.85	6.46

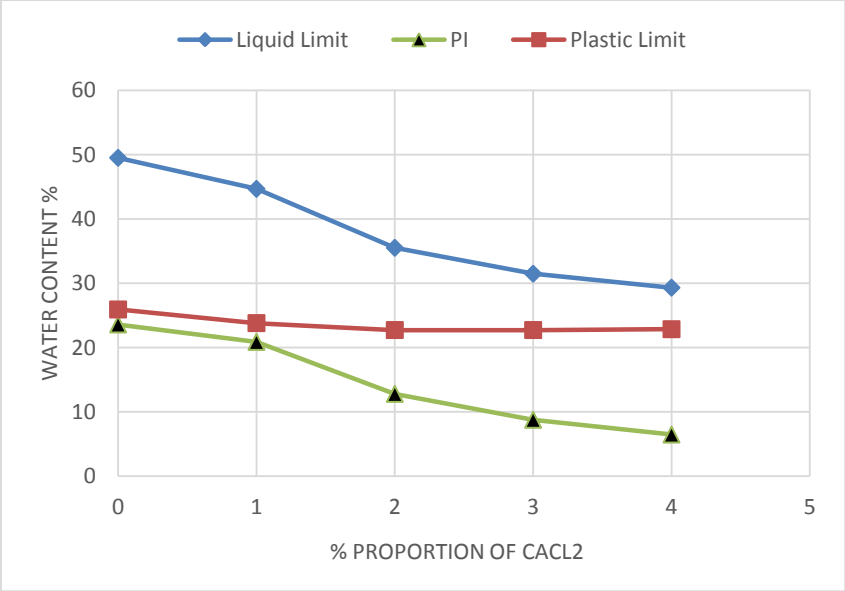

Fig. I: Atterberg's Limit Tests Result

B. *Free Swell Index*:

Test Conducted according to IS 2720 part XL: 1977. On adding Calcium Chloride up to 4% free swell index decreased by 43% in comparison to virgin soil. Similar results found by Sangita Ljurkar and others [1].

Table III: Free Swell Index Results

The concentration of CaCl2 Solution %	Free Swell Index %	% Decrease
0	58.82352941	
1	52.94117647	9.99
2	47.05882353	20.01
3	44.44444444	33.9
4	33.33333333	43.33

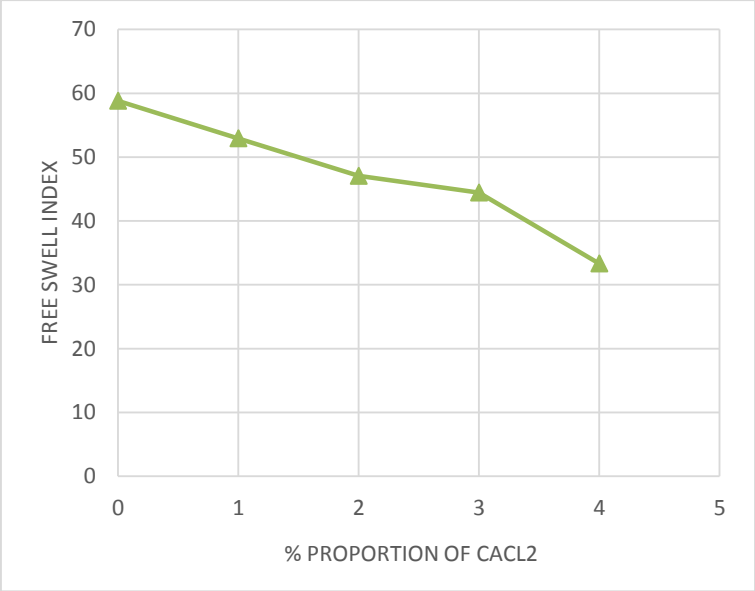

Fig. II: Free Swell Index Results

C. *Compaction Properties*:

Tests were conducted according to IS 2720: Part VII: 1980. On addition of 1%, $CaCl_2$ solution to expansive soil causes an increase in OMC as well as MDD. On further addition of $CaCl_2$ solution with increasing salt concentration, the results tend to a reversal panorama for OMC while, MDD tending to increase. This trend found up to 3% $CaCl_2$ concentration solution. On addition of 4% $CaCl_2$ solution, the OMC decreased while the MDD also decreased.
By adding Calcium chloride solution to pore fluid the thickness of the diffused double layer decreases. So that packing of particle become denser on applying the same compaction energy and hence dry density increases [2].

Table IV: Standard Proctor Tests Result

Calcium Chloride Solution Concentration	Maximum Dry Density g/cc	Optimum Moisture Content %
0%	1.59	22.67
1%	1.64	21.25
2%	1.7	18.82
3%	1.73	17.94
4%	1.71	16.67

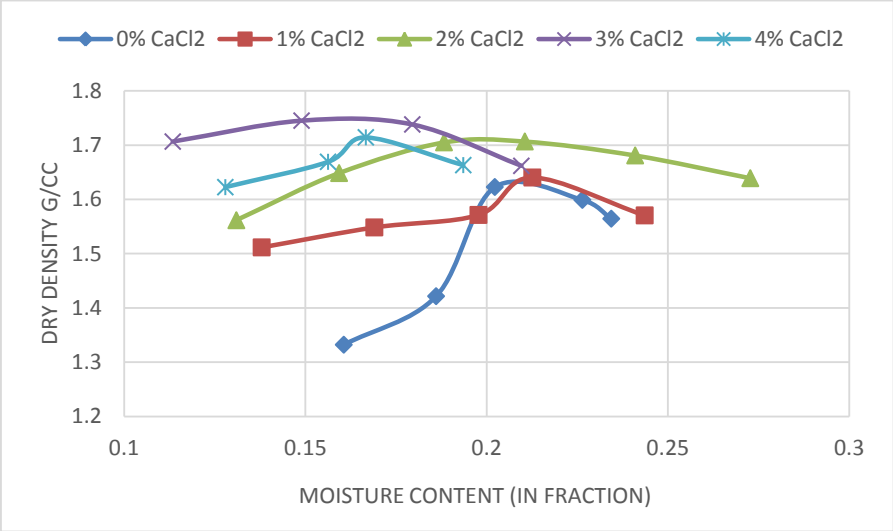

Fig. III: Standard Proctor Tests Result

D. Unconfined Compressive Strength

Tests were conducted according to IS 2720 part III: 1980. Addition of Calcium chloride solution up to 3% concentration the Unconfined Compressive Strength (UCS) increases and on further addition of 4% concentration the UCS decreases. Similar results were found by Ramesh et al (2005) [5], [3].

Table V: Unconfined Compressive Strength Test Results

Calcium Chloride Solution Concentration	UCS Kg/Cm2	Shear Strength Kg/Cm2	Increment %
0%	1.56	0.78	
1%	1.73	0.865	10.89
2%	1.85	0.925	18.58
3%	2.02	1.01	29.48
4%	1.85	0.925	18.58

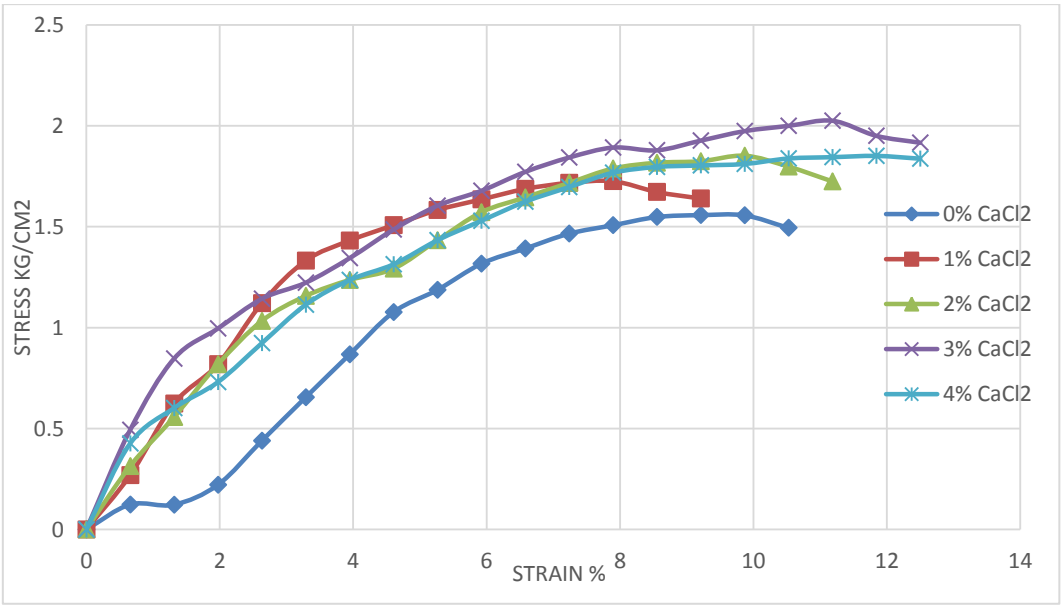

Fig. IV: Unconfined Compressive Strength Test Results

E. Swelling Pressure

Tests were conducted as specified by IS 2720 part XLI: 1977. Addition of Calcium Chloride Solution incurs the incremental trend in swelling pressure. Swelling pressure decreased by 63% in comparison to virgin soil.

Table VI: Swelling Pressure Test Result

Calcium Chloride Solution Concentration	Swelling Pressure Kg/Cm2	Decrement %
0%	1.2	
1%	0.93	22.5
2%	0.77	35.83
3%	0.54	55
4%	0.44	63.33

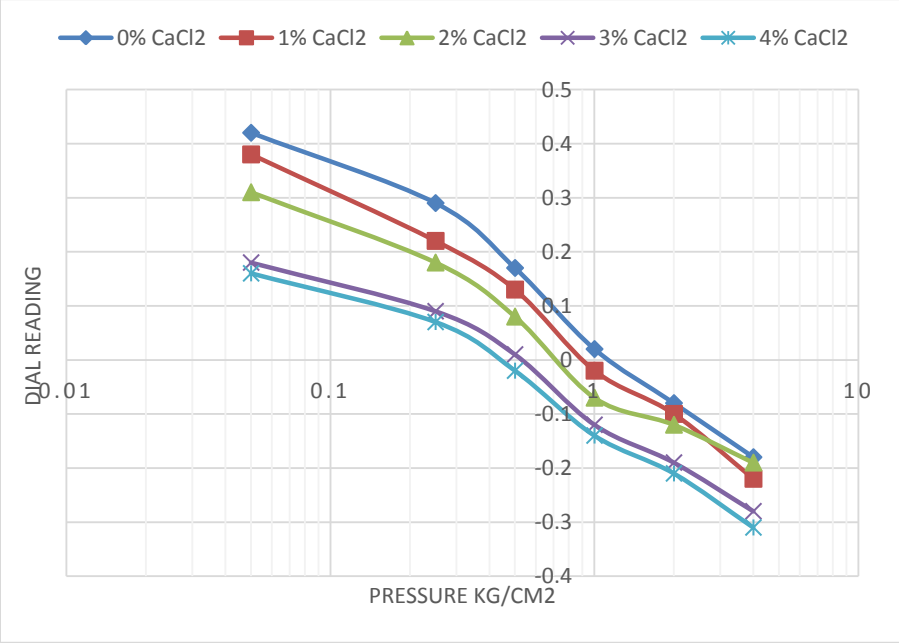

Fig.V: Swelling Pressure Test Result

IV. CONCLUSION

Following conclusions are drawn from the above discussion

1. Addition of calcium chloride solution with increasing concentration incurs decremental trend in both liquid limit and plasticity index.
2. the free swell index decreased by 43% in comparison to expansive soil on the addition of up to 4% concentration of calcium chloride solution.
3. On the addition of a 3 % solution of calcium chloride, causes an increase in the dry density and lowering of optimum moisture content.
4. On addition of 3% solution of Calcium chloride, the unconfined compressive strength increased by 30% in comparison to expansive soil.
5. Swelling pressure decreased 63% on addition of up to 4% Calcium chloride solution.

On the basis of the above results found we can conclude that 3% concentration solution of calcium chloride is an optimum dose.

REFERENCES

1. Sangita Lajurkar et al (2016), "Effect of Calcium Chloride Solution on engineering properties of Black cotton Soil", IJIRSET ISSN 2319-8753, ISSN 2347-6710.
2. Ramya H. N. et al (2018), "Effect of Sodium Chloride on geotechnical properties of black cotton soil", Journal of Materials Science & Nano Technology, Vol.6 issue 3 ISSN 2348-9812.
3. K.V. Manoj Krishna et al (2012), "Strength and FOS Performance of Black Cotton Soil Treated With Calcium Chloride", IOSRJMCE vol. 2, issue 6 pp 21-25, ISSN 2278-1684.
4. Sivapullaiah, P .V and Manju (2006), Ferric chloride treatment to control alkali-induced heave in the weathered red earth. Geotech. Geol. Engg. 23(5), 601–614

5. Sivapullaiah, P.V., Hari Prasad Reddy, P. (2010), Potassium chloride treatment to control alkali-induced heave in black cotton soil, Geotechnical and Geological Engineering, 28(1), 27-36
6. Desai I. D. et al (1977), "Influence of Anhydrous Calcium Chloride on the Shear Strength of Expansive soil", Proc., 1st National Symposium on Expansive soil, HBTI-Kanpur, India, pp. 4.1-4.5,1977.