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Use of calcium chloride for soil stabilization and dust suppression of unpaved roads

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ABSTRACT

In this study, Index properties of a soil sample, taken from campus, were determined to comment on the nature of the soil, and then its strength is determined in terms of CBR value. The strength of this soil sample was compared with that of soil samples prepared with adding 2% and 4% of $CaCl_2$ in the form of a flake. From the results of the study, samples of soil with 0 to 4% calcium chloride have reached optimum strength. Findings showed that soil containing Calcium chloride 0 to 4% showed the highest amount of strength of soil.

Keywords: *California Bearing Ratio, Optimum Moisture Content, Maximum Dry Density, Calcium Chloride.*

1. INTRODUCTION

Unacceptable levels of dust are generated on the unsealed road networks in most countries. In the past, dust has mostly been considered as a safety hazard and nuisance. However, research on unsealed roads has revealed that the loss of fines associated with road dust contributes to increased gravel loss and the need for more frequent maintenance. By controlling this dust, the rate of gravel loss and maintenance expenditure can be significantly reduced. Effective dust control can be achieved either with chemical dust suppressants or by upgrading the road to a sealed surface. Calcium chloride can be used as a dust suppressant and base stabiliser

2. LITERATURE REVIEW

A. G Radhakrishnan, Dr M Anjan Kumar and Dr GVR Prasada Raju (2014) have discussed that expansive soil shows recurrent volume changes with the change in moisture content, causing serious problems to the civil engineering structures such as road pavements resting on them. Several attempts are being made all over the world to control the swell-shrink behavior of expansive soils. Flexible Pavements constructed on these soil shows signs of damage continuously during the service life of the pavement causes an increase in the maintenance costs. Numerous methods are available in the stabilization of expansive subgrade soil. Many researchers have made an attempt with the chemical stabilization technique, it has gained prominence due to its easy applicability and adaptability. Flyash is freely available waste product which has little cementing property can be used for altering the characteristics of expansive soil. The main objective of this work is to study the swelling properties of the expansive subgrade soil treated with chemicals like Magnesium Chloride (MgCl2), Aluminum Chloride (AlCl3) and also by adding flyash in varying percentages. The swelling properties of the collected expansive soil samples were determined based on the parameters like Free Swell Index, Swell Potential and Swell Pressure. The results obtained from the experimental study indicate that the measured Free Swell, Swell Potential and Swelling Pressure are reduced substantially with the increasing percent of chemicals and flyash and remain stable after reaching certain concentration. This paper discusses the results of the testing.

B. Durotoye T.O and Akinmusuru J.O (2016) investigated the effect of sodium chloride on some geotechnical properties of expansive soil for highway pavement (subgrade) works. In this study, engineering properties including; Natural water content, Atterberg limits, specific gravity, compaction, free swell index, unconfined compressive strength, soaked and unsoaked California bearing ratio were determined in the laboratory and their behavior on stabilizing with various percentages of sodium chloride (0, 0.5, 1.0, 1.5. 2.0 and 2.5) investigated. From the study, plastic limit, liquid limit, plasticity index, linear shrinkage, specific gravity, free swell index and optimum water content values of the stabilized soil reduced, while the maximum dry density, California bearing ratio and unconfined compressive strength values increased. The highest reduction percentages of 60.42 % (131 to 51.85 %), 42.86

% (50.00 to 28.57 %), 71.26 % (81.00 to 23.28 %), 66.64 % (15.11 to 5.04 %), 83.43 % (115.00 to 19.05 %), and 28.57 % (28.00 to 20.00 %) in liquid limit, plastic limit, plasticity index, linear shrinkage, free swell index and optimum water content respectively; and maximum percentage increase of 11.38 % (1.67 to 1.86 g/m3 ,on maximum dry density), 31.78 % (29.20 to 38.48 %, on unsoaked CBR), 257.67 % (4.3 to 15.38 %, on soaked CBR), and 26.98 % (67.86 to 86.17 kN/m2 on unconfined compressive strength) were obtained on treatment of the soil with 1.5 % sodium chloride by weight. Treatment of the soil with sodium chloride has thus reduced its swelling potential and increased the strength

C. Mallika and B. Ganesh (2017) have discussed that expansive soil popularly known as black cotton soils are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Understanding the behaviour of expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers. Proper characterization and selection of suitable foundation is essential in case of problematic soils. Extensive research is going on to find the solutions to black cotton soils. There have been many methods available to control the expansive nature of the soils. Treating the expansive soil with electrolytes are one of the technique to improve the behaviour of the expansive ground. Hence, in the present work, experimentation is carried-out to investigate the influence of electrolytes like calcium chloride and ferric chloride on the properties of expansive soil. A methodical process, involving experimentation in the laboratory under controlled conditions is done. With addition of electrolytes to the expansive soil, improvement in its physical and engineering properties is observed. It is observed that the maximum improvement in properties of expansive soil is obtained for Ferric Chloride treatment compared to other electrolytes tried in this investigation.

3. OBJECTIVE

This study was conducted to achieve the following objectives:

• To study the strength developments of soil sample with calcium chloride.

• To add the calcium chloride with various percentage 2% and 4 %, in the form of flake in soil sample.

• To determine the effect of various percentage of calcium chloride as dust suppressant and base stabiliser towards CBR value of soil sample.

• To study the effect of calcium chloride on optimum moisture content, maximum dry density and California bearing ratio of soil sample.

4. MATERIALS USED AND TESTS CONDUCTED

4.1 Materials

• Natural Soil sample Location: Behind CME block, L.N.C.T Bhopal

• Modified Soil sample-1: soil sample mixed with 2% $CaCl_2$

• Modified Soil sample-2: soil sample mixed with 4% $CaCl_2$

Calcium chloride Formula

Calcium chloride is an important calcium salt that has many household and industrial applications.

Formula and structure: The chemical formula of calcium chloride is CaCl2, and its molar mass is 110.983 g/mol. It is an ionic compound consisting of the calcium cation (Ca2+) and two chlorine anions (Cl-). The bivalent calcium metal forms an ionic bond with two chlorine atoms.

4.2 Preparation of Samples

Following steps are carried out while mixing the CaCl2 to the soil-

• All the soil samples are compacted at their respective maximum dry density (MDD) and optimum moisture content (OMC), corresponding to the standard proctor compaction test

As per lab manual prepared by Leo Cautte from hopec enterprises, St. Paul, U.S. State of Minnesota.

• 2 to 4 % of flake should be added to the soil by weight of the soil

[FLAKE – comes in 20-25 kg bags, with a 77% to 80% calcium chloride content and water of crystallization.]

• The different values adopted in the present study for the percentage of calcium chloride are 0, 2, and 4.

• In the preparation of samples, if calcium chloride is not used then, the air-dried soil was mixed with an amount of water that depends on the OMC of the soil.

• If calcium chloride was used, the adopted content of calcium chloride was first mixed into the air-dried soil in small increments by hand, making sure that all the calcium chloride was mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

5. TESTS CONDUCTED

The experimental work consists of the following steps:

1) Water content of soil

2) Specific gravity of soil

3) Determination of soil index properties (Atterberg Limits)

i) Liquid limit by Casagrande's apparatus

ii) Plastic limit

4) Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test

5) Determination of the soil strength by California bearing ratio (CBR) Test

6) Preparation of soil samples mixed with calcium chloride.

7) Determination of the strength of soil samples mixed with calcium chloride by California bearing ratio (CBR) Test.

5.1 Representation of Index Properties of Soil

Table 1 Representation of index properties of soil

Property	Value	Remark
Water Content	5.48%	…….……
Specific Gravity	2.51	the soil is coarse-grained soil
Liquid Limit	29%	……..
Plastic Limit	24.52 %	……
Plasticity Index	4.48	the soil is low plastic

5.2 Comparison of OMC, MDD and CBR% of Soil without Cacl2, Soil With 2 % $Cacl_2$ and Soil with 4% $Cacl_2$

Table 4.18 Comparison of OMC, MDD and CBR% of soil without $CaCl_2$, soil with 2% $CaCl_2$, and soil with 4% $CaCl_2$

Property	Soil without $CaCl_2$	Soil with 2 % $CaCl_2$	% increase /decrease	Soil with 4% $CaCl_2$	% increase /decrease
Optimum Moisture Content (%)	11.2	14.5	29.46% increase	15	33.92 % increase
Maximum Dry Density (gm./cc)	1.61	1.605	0.31 % decrease	1.58	1.86 % decrease
CBR % (Unsoaked condition) for 2.5 mm penetration	4.5	5.32	18.22% increase	7.4	64.44% increase
CBR % (soaked condition) for 2.5 mm penetration	2.34	2.7	15.38% increase	3.79	61.96% increase
CBR % (Unsoaked condition) for 5 mm penetration	4.33	5.35	23.55% increase	7.58	75.05% increase
CBR % (soaked condition) for 5 mm penetration	2.22	2.7	21.62% increase	3.85	73.42% increase

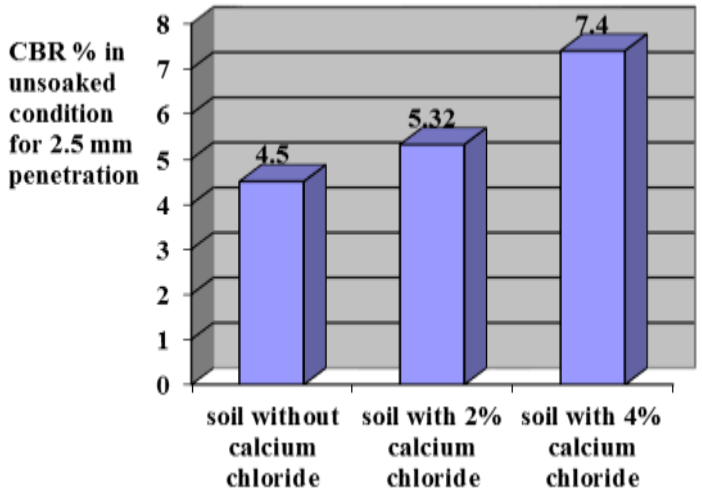

Figure 4.7 Comparative Graph of CBR Values in Unsoaked Condition for 2.5 mm Penetration

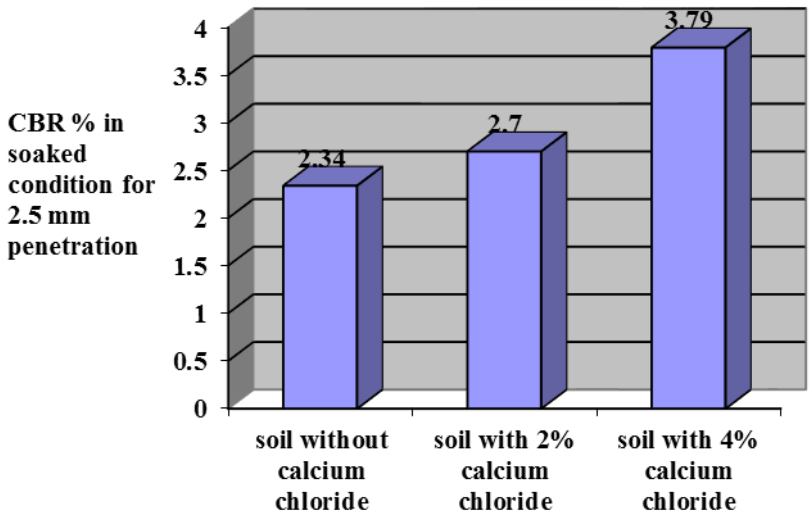

Figure 4.8 Comparative Graph of CBR Values in Soaked Condition for 2.5 mm Penetration

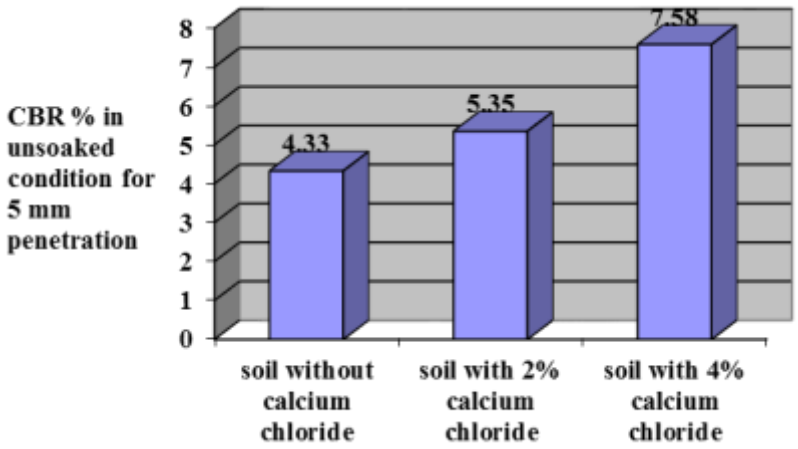

Figure 4.9 Comparative Graph of CBR Values in Unsoaked Condition for 5 mm Penetration

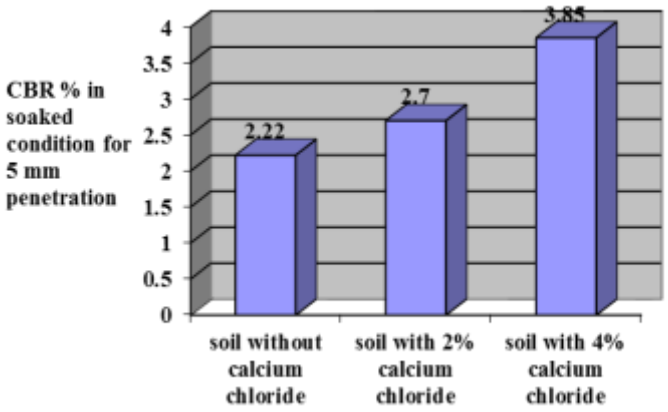

Figure 4.10 Comparative Graph of CBR Values in Soaked Condition for 5 mm Penetration

6. CONCLUSION

Following are the salient conclusions of the study:

• In this exploratory examination, we have used calcium chloride as base stabiliser and dust suppressant for soil of unpaved roads. From different tests on soil we have closed after outcomes.

• For stabilisation CaCl2 is preferred over other chemical additives due to its deliquescent and hygroscopic properties.

• Index properties of soil were determined and an idea about the type of soil was obtained. In our case the soil in the campus was coarse-grained and low plastic.

• The fundamental point is to find the optimum moisture content (OMC) required to achieve the best compaction. The rule is that optimum moisture content of soil is that moisture content at which the maximum dry density is achieved. The optimum moisture contents of the soil without CaCl2, soil with 2% CaCl2 and soil with 4 % CaCl2 in this examination were seen to be 11.2%, 14.5% and 15% respectively.

• It was observed that optimum moisture contents increased by 29.46% and 33.92% on the addition of 2% and 4% CaCl2 to the soil.

• It was observed that maximum dry density decreased by 0.31% and 1.86 % on the addition of 2% and 4% cacl2 to the soil.

• It was observed that CBR% of soil in unsoaked condition for 2.5 mm penetration increased by 18.22% and 64.44% on the addition of 2% and 4% cacl2 to the soil.

• It was observed that CBR% of soil in soaked condition for 2.5 mm penetration increased by 15.38% and 61.96% on the addition of 2% and 4% cacl2 to the soil.

• It was observed that CBR% of soil in unsoaked condition for 5 mm penetration increased by 23.55% and 75.05% on the addition of 2% and 4% cacl2 to the soil

• It was observed that CBR% of soil in soaked condition for 5 mm penetration increased by 21.62% and 73.42% on the addition of 2% and 4% cacl2 to the soil.

• After overall examination, it can be observed that addition of 2% to 4% calcium chloride can enhance the strength of soil 15% to 75%.

• Calcium chloride has an additional advantage of suppressing dust on the unpaved roads, which not only solves the problem of vision and respiration but also takes care of reduction in strength due to loss of fines.

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