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# AN EXPERIMENTAL INVESTIGATION ON SOIL STABILIZATION OF EXPANSIVE SOIL BY USING INORGANIC CHEMICALS

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## ABSTRACT
Expansive soils in India are a boon to farmers but problematic to civil engineers, particularly to geotechnical engineers. Foundation structures experience large scale damage due to change in properties of soil. The design of foundations and pavements founded on swelling soils always involve a certain degree of risk and damage. Usually high degree of risk is associated even with the lowest cost of the design alternative. Thus it is necessary to explore various foundation alternatives in expansive soils. The foundation alternatives include: Strip foundation, Pad foundation, Pad and beam foundation, Pile and beam foundation, Pier and beam foundation, Reinforced Strip or Stiffened foundation, Skirted footing and Skirted stone column etc. These methods have several limitations. Also there are simple techniques such as Pre-wetting, Environmental control with limited applicability. Most feasible methods rely on improving the soil properties. There are several techniques available to improve the soil properties. In this investigation, an attempt has been made to study the effect of the chemicals like Sodium Carbonate (Na2C03), Calcium Carbonate (CaC03), on the geotechnical properties of an expansive soil. Maximum improvement found in CBR value when 1.00% of the chemical used in case of Sodium Carbonate (Na2C03) and Calcium Carbonate (CaC03) and after all calculations it is found that Calcium Carbonate (CaC03) is more effective in improving the CBR values of the admixed soil when compared to Sodium carbonate.

**KEYWORDS**: Soil Stabilization, Chemicals, Sodium Carbonate (Na2C03), Calcium Carbonate (CaC03), Expansive Soil, pH Value etc.

## I. INTRODUCTION

Proper remedial measures are to be adopted to modify the soil or to reduce its detrimental effects if expansive soils are indentified in a project. The remedial measures can be different for planning and designing stages and post construction stages. Many stabilization techniques are in practice for improving the expansive soils in which the characteristics of the soils are altered or the problematic soils are removed and replaced which can be used alone or in conjunction with specific design alternatives. Additives such as lime, cement, calcium chloride, rice husk, fly ahs etc. are also used to alter the characteristics of the expansive soils. The characteristics that are of concern to the design engineers are permeability, compressibility and durability. The effect of the additives and the optimum amount of additives to be used are dependent mainly on the mineralogical composition of the soils. This study focuses about the various stabilization techniques that are in practice for improving the expansive soil for reducing its swelling potential and the limitations of the method of stabilization there on.

Black cotton soils occupy up to about 72 million hectares in India between 80 45’ to 260 N latitude and 680 to 830 45’ to E longitude. This soil is approximately spread over 257 million hectares of earth’s surface and is having major share. Venkatarathnam (1987) Expansive soils are predominantly clayey soils or very fine silts showing marked tendency to volumetric changes i.e., swelling and shrinking cycles on variation in moisture conditions. This precarious property of swell and shrink has created numerous problems due to highly unpredictable upward movement of structures founded on them, resulting in severe cracking either in the buildings or pavements. This is a universal phenomenon. This crucial trend affects the serviceability performance of the pavements or the structures founded on these kinds of soils. The doming (Centre heave) and dishing (edge heave) curvatures in foundations would result, due to soil movement.

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Swelling in clays can be sub-categorized into two distinctive types, namely:

- Elastic rebound in the compressed soil mass due to reduction in compressive force.
- Imbibing of water resulting in expansion of water-sensitive clays.

Swelling clays are the clays that exhibit latter type of swelling, where the clay minerals with largely inflating lattice are present. One of the fundamental characteristics of clayey soil is that they display little cohesion and strength when wet, but they become hard when devoid of water. However, all of them do not swell due to wetting action. Decrease in ultimate bearing capacity at saturation, and large differential settlement due to this occurs. Thus, clayey soils exhibit foundation problems

Grouped into three categories, following are the methods of recognizing expansive soils:

- Mineralogical identification
- Indirect methods, such as soil suction, activity and index properties
- Direct measurement.

Impractical and uneconomical in practice, methods of mineralogical identification still hold importance in exploring basic properties of clay minerals. Direct measurement, out of the remaining two categories, offers the most useful data. By their shattered or fissured condition, or obvious structural damage to existing buildings caused by such soils, potentially expansive soils are usually identified in the field. To classify expansive soil, potential swell, or potential expansion, or the degree of expansion is a favoured term used; from this, geotechnical engineers establish how good or bad the expansive soils are.

## II. LITERATURE REVIEW

**Zumrawi Magdi M. E. (2015)** shown **t**he performance of pavement is very responsive to the characteristics of the soil Subgrade. For that reason, weak Subgrade is enhanced by adopting the most efficient stabilization technique. Based on the literature review, stabilization with fly ash activated with cement was found to be an effective option for improvement of soil properties. In this regard an experimental program was undertaken to study the effect caused by the combined action of fly ash and cement stabilization on the geotechnical characteristics of expansive Subgrade soils. Expansive soil treated with varying percentages of fly ash, 0, 5, 10, 15, and 20 percent combined with 5% cement content were studied. Consistency limits, compaction, California Bearing Ratio, swell potential and swell pressure tests were conducted on treated and untreated soils. The experimental results show that addition of cement-fly ash admixture to the soil has great influence on its properties. It was found that the optimum dosage of fly ash is 15% mixed with 5% cement revealed in significant improvement in strength and durability and reduction in swelling and plasticity properties of the soil. Based on the results, it is recommended that cement-fly ash admixture be considered a viable option for the stabilization of expansive sub grades.

**Minde et. al. (2017)** have shown, In India, Black cotton soil covers over one-fifth of the entire land area. These are mostly found in and around the Deccan plateau. Black cotton soil is an expansive soil which proves problematic for the engineering work. Black cotton soil has low bearing capacity, high compressibility and swelling and shrinkage properties. To overcome on these engineering problems soil stabilization is the best solution. In our research we used the concept of chemical stabilization. We used fly ash and rice husk straw ash in different proportion with black cotton soil. The present paper briefly describes the experimental investigation carried out by adding fly ash and rice husk straw ash to black cotton soil for improving its engineering properties.

**Pandey and Rabbani (2017)** have presented a study on stabilisation of pavement Subgrade soil using lime and cement. India is a place of geographical diversity having different soil in different areas. So to improve those areas having poor bearing capacity stabilisation technique is used. Both mechanical and chemical stabilisation methods are used for the improvement of soil strength. In mechanical method, some machines are used for digging the soil and some other type of soil mixed with poor soil in required quantity. After properly mixing of the soil, spread it by machine and compacted with machine up to required strength. In chemical methods soil mixed with chemical compounds like lime, cement, fly ash and terazyme. Though cement is capable of stabilising a wide range of soil types, it is most effective in sandy soil, sand with silt soil, and clay soil having plasticity range low to medium. Lime is primarily use for clay soil having high plasticity.

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**Venkara Muthyalu et. al. (2012)** studied about Expansive soils, such as black cotton soils, are basically susceptible to detrimental volumetric changes, with changes in moisture. This behaviour of soil is attributed to the presence of mineral montmorillionite, which has an expanding lattice. Understanding the behaviour of expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers. Extensive research is going on to find the solutions to black cotton soils. There have been many methods available to controlling the expansive nature of the soils. Treating the expansive soil with electrolytes is one of the techniques to improve the behaviour of the expansive ground. Hence, in the present work, experimentation is carried-out to investigate the influence of electrolytes i.e., potassium chloride, calcium chloride and ferric chloride on the properties of expansive soil.

## III. METHODOLOGY

In this investigation, an attempt has been made to study the effect of the chemicals like Sodium Carbonate (Na2C03), Calcium Carbonate (CaC03), on the geotechnical properties of an expansive soil. The properties of soil used the chemical composition of chemicals, the procedure adopted for mixing and the tests conducted are presented in this Chapter. The mixing has been done in the laboratory. The properties considered in this study are plasticity, pH, and swelling. The soil sample kept ready is mixed with chemical solution of varying percentages. Chemical solution is prepared by dissolving chemical powder in distilled water. The percentages of chemical are varied from 0.00, 0.25, 0.50, 0.75, 1.00 And 1.25 percent by weight of the soil. The soil and the chemical are mixed thoroughly and **used** for the tests. The California bearing ratio test is penetration test meant for the evaluation of sub grade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

## IV. RESULTS

The California Bearing Ratio (CBR) is defined as the rate of force per unit area required to penetrate a soil mass with a standard circular plunger of **50mm** diameter at the rate of **1.25** mm/min to that required for the corresponding penetration of a standard material. The CBR value is determined corresponding to both **2.50** mm and **5.00 mm** penetrations, and the greater value is used for the design of flexible pavement.

Generally CBR for 2.50 **mm** penetration is high. However, if the CBR for **5.00** mm penetration is greater than that for **2.50** mm penetration the test is repeated. If the results are unchanged, the value for **5.00 mm** penetration is used for defining CBR value.

***Table 4.1: CBR Values of Soil Admixed With Different Percentages of Sodium and Calcium Carbonates at 2.50 mm Penetration***

| % of Chemical | California Bearing Ratio (Kn/m3) | | (%) Increase / Decrease in California Bearing Ratio | |
|---|---|---|---|---|
| | Sodium Carbonate | Calcium Carbonate | Sodium Carbonate | Calcium Carbonate |
| 0.00 | 5.930 | 5.930 | - | - |
| 0.25 | 6.610 | 10.420 | 11.467 | 75.717 |
| 0.50 | 7.254 | 12.750 | 22.327 | 115.008 |
| 0.75 | 7.745 | 13.215 | 30.607 | 122.850 |
| 1.00 | 8.205 | 13.674 | 38.364 | 130.590 |
| 1.25 | 7.745 | 12.765 | 30.607 | 115.261 |

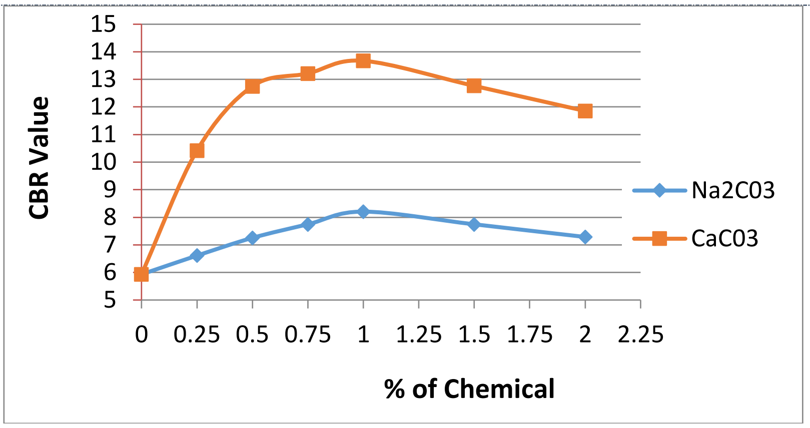


***Figure 4.1 CBR Values of Soil Admixed With Different Percentages of Sodium and Calcium Carbonates at 2.50 mm Penetration***

***Table 4.2 California Bearing Ratio Values of Soil Admixed With Different Percentages of Sodium And Calcium Carbonates At 5.00 Mm Penetration***

| **% of Chemical** | **California Bearing Ratio (Kn/m3)** | | **(%) Increase / Decrease in California Bearing Ratio** | |
|---|---|---|---|---|
| | **Sodium Carbonate** | **Calcium Carbonate** | **Sodium Carbonate** | **Calcium Carbonate** |
| 0.00 | 5.170 | 5.170 | - | - |
| 0.25 | 5.775 | 9.420 | 11.702 | 82.205 |
| 0.50 | 6.075 | 10.936 | 17.505 | 111.528 |
| 0.75 | 6.384 | 11.858 | 23.482 | 129.362 |
| 1.00 | 6.689 | 12.468 | 29.381 | 141.161 |
| 1.25 | 6.380 | 11.559 | 23.404 | 123.578 |

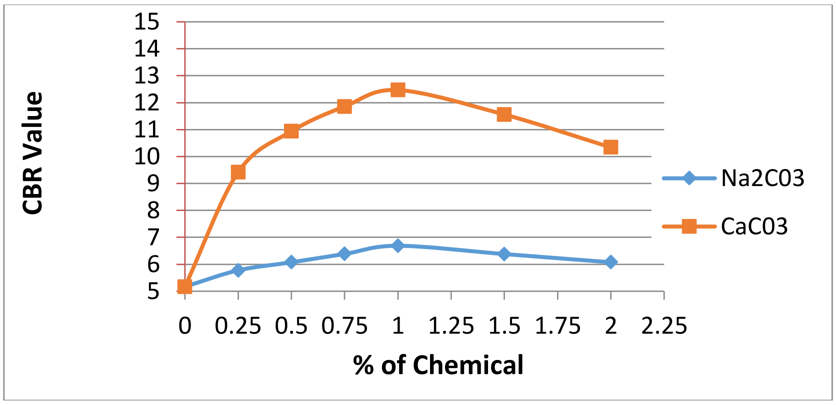


**Figure 4.2 California Bearing Ratio Values Of Soil Admixed With Different Percentages Of Sodium And Calcium Carbonates At 5.00 *Mm* Penetration**

## V. CONCLUSION

(1) The CBR values of the admixed soil corresponding to 2.50mm as well as 5.00mm penetrations are higher that of the untreated soil.
(2) The maximum improvement in CBR value corresponding to 2.50mm penetration is found to be 38.46% and 130.60%, a when the soil is admixed with Sodium Carbonate (Na2C03) and Calcium Carbonate (CaCO3) respectively.
(3) The maximum improvement in CBR value corresponding to 5.00mm penetration is 29.40% and 141.20%, when the soil admixed with Sodium Carbonate (Na2C03), Calcium Carbonate (CaCO3), respectively.

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(4) The maximum improvement in CBR value occurs at 1.00% of the chemical in case of Sodium Carbonate (Na2C03) and Calcium Carbonate (CaC03).
(5) The Calcium Carbonate (CaC03) is more effective in improving the CBR values of the admixed soil when compared to Sodium carbonate..

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