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[Nayak * *et al.*, 6(12): December, 2017]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

AN EXPERIMENTAL STUDY ON MODIFICATION OF GEOTECHNICAL PROPERTIES OF EXPANSIVE SOIL THROUGH INORGANIC CHEMICALS

Jitendra Nayak[*1] & Tapas Singh[2]

[*1]M.tech Scholar Civil Engineering Department TIT (Excellence) Bhopal (M.P.) INDIA
[2]Asst. Prof. Civil Engineering Department TIT (Excellence) Bhopal (M.P.) INDIA

DOI: 10.5281/zenodo.1084119

ABSTRACT

Construction of foundation and other civil engineering structures on weak or soft soil involves risk due to the susceptibility of high compressive and poor shear strength. In the constructions of foundation on soft soils, the subsoil needs to have adequate bearing capacity and shear strength to prevent unnecessary differential settlements and shear failure of the substructure. If the bearing capacity and shear strength is insufficient, it can be increased by replacing good soil in place of bad soil, which involves high financial aspects or improve the properties of existing soil by ground improvement techniques. 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. 1.25% amount of Sodium Carbonate (Na2C03) and Calcium Carbonate (CaC03) is found effective in reducing the plasticity characteristics to a certain extent in the tested range when mixed with soil. The pH values of soil admixed with Sodium Carbonate (Na2C03) and Calcium Carbonate (CaC03) is also higher than that of the untreated soil.

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

I. INTRODUCTION

Expansive soil is one among the problematic soils that has a high potential for shrinking or swelling due to change of moisture content. Expansive soils can be found on almost all the continents on the Earth. Destructive results caused by this type of soils have been reported in many countries. In India, large tracts are covered by expansive soils known as black cotton soils. The major area of their occurrence is the south Vindhyachal range covering almost the entire Deccan Plateau. These soils cover an area of about 200,000 square miles and thus form about 20% of the total area of India. The primary problem that arises with regard to expansive soils is that deformations are significantly greater than the elastic deformations and they cannot be predicted by the classical elastic or plastic theory. Movement is usually in an uneven pattern and of such a magnitude to cause extensive damage to the structures resting on them.

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.

Clay mineral is the key element which divulges the swelling characteristics to any ordinary non-swelling/non-shrinking soil. Montmorillionite, out of several types of clay minerals has the maximum amount of swelling

potential. In-situ formation of chief clay minerals occurs under alkaline conditions, or sub-aqueous decomposition of blast rocks can be seen the origin of such soil – expansive soil. These type of soil can also be formed due to weathering under alkaline environments, and under adequate supply of magnesium or ferric or ferrous oxides. Given there's a good availability of alumina and silica, the formation of Montmorillionite is favoured.

II. LETERATURE REVIEW

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.

Radhakrishnan et. al. (2014) have studied about expansive soils and shows recurrent volume changes with the changes 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 behaviour 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. Fly ash 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), Aluminium Chloride (AlCl3) and also by adding fly ash 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 fly ash and remain stable after reaching certain concentration.

Subramanyam et. al. (2015) have discussed about expansive soils which are mostly found in the arid and semi-arid regions and occupy major area of the world. About 22% of the land mass in India mostly entire Deccan plateau. These kinds of highly swelling soil are usually termed as Black Cotton Soils. The delta region in Andhra Pradesh formed between 60 and 68 million years ago at the end of the Cretaceous period. In this region the main classes of soil are black, brown soil. The volcanic, clay-like soil of the region owes its black colour to the high iron content of the basalt from which it formed. As the Delta region is mainly dominated by Black Cotton Soil, it is one of the types of expansive soil, which has a high prospective for shrinkage and swelling under varying moisture environment. These deposits, due to their dominating physical and chemical constituents, are subject to change in volume with seasonal variations. Because of the inherent property of swelling, these soils are a latent peril to the natural balance and it results in incomparable disfigurement world-wide every year. Usage of expansive soils in sub grades in its natural form is not viable and chemical stabilization is one of the many alternative tried. One of the many a established methods is stabilizing with chemicals like KCl, CaCl2, FeCl3. Expansive soils untreated and treated with chemicals have been tested for various Engineering properties and also analyzed in Scanning Electron Microscope to understand the mineralogical changes manifested at different resolutions.

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

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

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 plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit, and is a dimensionless number. Both the liquid and plastic limits are moisture contents.

Plasticity Index = Liquid Limit - Plastic Limit (PI =LL- PL)
The soil pH reflects whether a soil is *acidic, neutral, basic or alkaline*. The acidity, neutrality or alkalinity of a soil is measured in terms of hydrogen ion activity of the soil water system. The negative logarithm of the H ion activity is called pH and thus pH of a soil is a measure of only the intensity of activity and not the amount of the acid present. The pH range normally found in soils varies from 3 to 9.

Mathematically pH is represented as, **$\log 1/H = -\log H^+$**

IV. RESULTS

The plasticity characteristics have been originally designed for the purpose of classification of soils, they are, in the recent past, are increasingly used to correlate with their physical and mechanical properties. The changes in the plasticity characteristics of the soil in the presence of various carbonates may indicate their possible changes in their mechanical behaviour.

Table 4.1 Plasticity Index Of Soil Admixed With Sodium and Calcium Carbonates

% of Chemical	Plasticity Index (%)		Increase / Decrease in Plasticity Index (%)	
	Sodium Carbonate	Calcium Carbonate	Sodium Carbonate	Calcium Carbonate
0	37	37	-	-
0.25	42	42	13.514	13.514
0.50	42	43	13.514	16.216
0.75	37	39	0.000	5.405
1.00	34	35	-8.108	-5.405
1.25	32	34	-13.514	-8.108

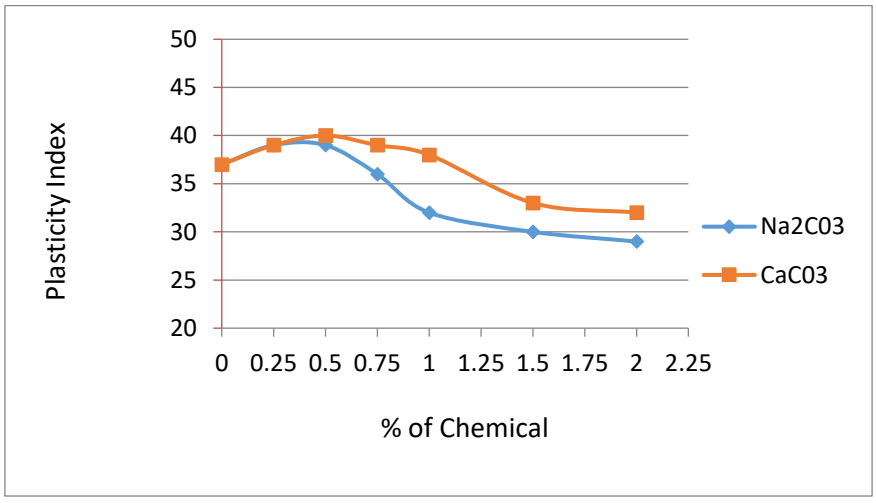

Figure 4.2 Plasticity Index of Soil Admixed With Sodium and Calcium Carbonates

The per cent increase or decrease in plasticity index values computed is also tabulated in Table 4.3. The value of plasticity index for the untreated soil is 37.00%. It is observed from the Table 4.3 that the plasticity index values of soil admixed with Calcium Carbonate (CaC03) is higher for 0.25%, 0.50% and 0.75% and lower for 1.00% and 1.25%. In case of Sodium Carbonate (Na2C03) the values are higher for 0.25% and 0.50%, equal at 0.75% and lower for 1.00% and 1.25%.

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The maximum increase in plasticity index values are 13.51%, which occurs at 0.50% of the chemical in case of Sodium Carbonate (Na2C03) and Calcium Carbonate (CaCO3) The maximum decrease in plasticity index values is 13.51 and 8.11% which occurs at 1.25% of the chemical when the soil is admixed with Sodium Carbonate (Na2C03), Calcium Carbonate (CaCO3), respectively. In other words, it indicates that the soil behaviour is slightly non-plastic; it is also *easy to* pulverize the soil lumps at this percentage. From the above findings, it can be concluded that 1.25% of any carbonate [Sodium Carbonate (Na2C03) or Calcium Carbonate] is effective in reducing the plasticity characteristics such as liquid limit, plastic limit, and plasticity index in the tested range.

Table 4.2 pH Values of Soil Admixed With Sodium and Calcium Carbonates

% of Chemical	pH Values		(%) Increase / Decrease in pH Values	
	Sodium Carbonate	Calcium Carbonate	Sodium Carbonate	Calcium Carbonate
0	9.54	9.54	-	-
0.25	10.02	9.60	5.031	0.629
0.50	10.15	9.75	6.394	2.201
0.75	10.25	9.85	7.442	3.249
1.00	10.38	9.81	8.805	2.830
1.25	10.65	9.91	11.635	3.878

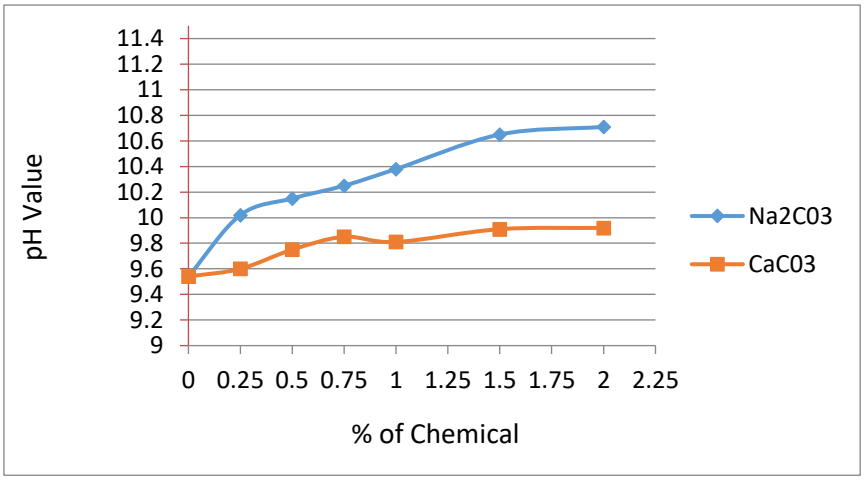

Figure 4.2 pH Values of Soil Admixed with Sodium and Calcium Carbonates

The per cent increase in pH for various percentages of chemicals Sodium Carbonate (NazC03), Calcium Carbonate (CaCO3), are also shown in Table 4.4. From this Table, it is found that the pH value of soil admixed with Sodium Carbonate (Na2C03), Calcium Carbonate (CaC03), chemicals are higher than that of the untreated soil. The maximum improvement in pH values are 11.74% which occurs at 1.25% of chemical in case of Sodium Carbonate (Na2C03) whereas in the case of Calcium Carbonate (CaC03) the maximum increase in pH value is 2.94% only which occurs at 0.50% of the chemical. The increase in pH with the addition of carbonates to the untreated soil is partly due to alkaline reaction of chemicals Sodium Carbonate (Na2C03), Calcium Carbonate (CaC03), when dissolved in water.

V. CONCLUSION

1) 1.25 percent of any carbonate [Sodium Carbonate (Na2C03) and Calcium Carbonate (CaC03)] is effective in reducing the plasticity characteristics to a certain extent in the tested range.
2) The pH values of soil admixed with Sodium Carbonate (Na2C03) and Calcium Carbonate (CaC03) is higher than that of the untreated soil.
3) 1.25 percent of any carbonate is effective in reducing the swelling characteristics **(DFSI)** Swelling Pressure and Swelling Potential to some extent in the tested range.

ISSN: 2277-9655
Impact Factor: 4.116
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CITE AN ARTICLE

Nayak, J., & Singh, T. (n.d.). Soil Stabilization, Chemicals, Sodium Carbonate (Na2C03), Calcium Carbonate (CaC03), Expansive Soil, pH Value etc. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(12), 7-11.