

**STUDY OF STABILIZATION OF BLACK COTTON SOIL  
USING ADMIXTURES**Assist.Prof.Aarohi.V.Langalia<sup>1</sup>, Assist. Prof. Mayuri wala<sup>2</sup>Civil Engg dept. BITS college, Vadodara  
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**ABSTRACT:** Black cotton soil is the most expansive soil having less bearing capacity and high swell index. Its stabilization is required to mainly improve the stated properties. It is found that Black cotton soil mainly stabilized using Fly ash, Lime and Cement. Agricultural wastes are also used to stabilize Black cotton soil, but they cannot be used as a single stabilizing component. Combination of Bagasse ash with other additives proves to be very effective and cheaper method of stabilization. Stabilization of soils is an effective method for improvement of soil properties and the pavement system performance. Plasticity Index is one of the important properties of soil to determine the behavior of soil in presence of water. The poorest soil among all is Black Cotton Soil (BC Soil). Laboratory test was conducted on black cotton soil treated with up to 16% Cement Kiln Dust (CKD) by dry weight of soil to assess its suitability for use as road pavement material.

**KEY WORDS:** Black cotton soil, Soil stabilization, Bagasse ash, Plasticity Index, Compressive Strength

**I. INTRODUCTION**

In India expansive soils cover about  $0.8 \times 10^6$  km<sup>2</sup> area approximately 20% of surface area. In many situations, expansive soils cannot be used directly as road service layers, foundation layers and as a construction material; hence the properties of those soils should be changed.

Expansive soil is a type of clayey soil having montmorillonite mineral, which expands when comes in contact with water and shrinks when the water evaporates. It expands during the rainy season due to intake of water and shrinks during summer season. A lot of damages occur on structures founded on this type of soil. The damages normally appear as cracks in, buildings, canal beds and linings, pavements, lifting of water supply pipeline and sewerage lines etc.

The black cotton soils possess low strength and undergo excessive volume changes, making their use in the constructions very difficult. The properties of the black cotton soils may be altered in many ways viz. mechanical, thermal, chemical and other means. Modification of black cotton soils by chemical admixtures is a common stabilization method for such soils (Bell, 1993). Among various admixtures available lime, fly ash and cement are most widely and commonly used for the stabilization of the black cotton soils. Fly ash contains siliceous and aluminous materials (pozzolans) and also certain amount of lime. When mixed with black cotton soils, it reacts chemically and forms cementitious compounds. The presence of free lime and inert particles in fly ash suggests that it can be used for stabilization of expansive soils (Indraratna et.al., 1991). Cement kiln dust (CKD) is an industrial waste from cement production.

The quantities and characteristics of CKD generated depend upon a number of operational factors and characteristics of the inputs to the manufacturing process. Although the relative constituent's concentrations in

CKD can vary significantly; CKD has certain physical characteristics that are relatively consistent. When managed on site in a waste pile, CKD can retain these characteristics within the pile while developing an externally weathered crust, due to absorption of moisture and subsequent cementation of dust particles on the surface of the pile (Liman, 2009). The ability of the CKD to absorb water stems from its chemically dehydrated nature, which results from the

Thermal treatments it receives in the system. The action of absorbing water (rehydrating) releases a significant amount of heat from non-weathered crust, a phenomenon that can be exploited in the Stabilization of poor engineering material.

The Black Cotton soils are inorganic clays of medium to high compressibility and form a major soil group in India. The black cotton soils possess low strength and undergo excessive volume changes, making their use in the constructions very difficult. The properties of the black cotton soils may be altered in many ways viz. mechanical, thermal, chemical and other means.

**Table 1: Basic Engineering properties of Black cotton soil have been listed below:**

<b>Properties</b>	<b>Black Cotton Soil</b>
Colour	Grayish Black
Specific Gravity	2.46
GRAIN SIZE DISTRIBUTION	
Fine sand fraction (%)	2.4
Silt size (%)	22.5
Clay size (%)	75.0
ATTERBERG,S LIMIT	
Liquid Limit (%)	62.13
Plastic Limit (%)	29.44
Plasticity Index (%)	32.69
Shrinkage Limit (%)	15.58
IS classification	MH-OH
COMPACTION CHARACTERISTICS	
Maximum Dry Density(kN/m <sup>3</sup> )	15.16
Optimum Moisture Content (%)	21.96
Unconfined Compressive Strength(KN/m <sup>2</sup> )	84.92
CALIFORNIA BEARING RATIO	
Soaked	2.11
Unsoaked	1.40

Dynamic properties of soil needed for the nonlinear analysis of the earthquake response of the ground have usually been measured in the laboratory using cyclic triaxial test. The cyclic triaxial test consists of imposing either a cyclic axial deviator stress of fixed magnitude (load control) or cyclic axial deformation (stroke control) on a cylindrical soil specimen enclosed in a triaxial pressure cell. The resulting axial strain and axial stress are measured and used to calculate either stress-dependent or stroke-dependent modulus or damping.

The study shows that under undrained conditions, cyclic shear stress causes transient disturbance and give rise to increase in excess pore water pressure leading to loss of shear strength in saturated soil deposits, there will be excessive strains with continued loss of shear strength resulting in liquefaction. Studies show a decrease in liquefaction resistance and others show an increase in liquefaction resistance with increase in fines content in soil deposit. It was found that Liquefaction strength of soil deposit decreases with increase in clay fines content up to limiting fines content beyond which it increases. Non-plastic & low plastic sand clay mixtures fail by initial liquefaction and medium plastic sand-clay mixtures fail by cyclic mobility.

The Bharuch City situated in South Gujarat area of India having top layer of black cotton soil. Fig. 1 - Map of soil deposits in Gujarat State shows that the majority of South Gujarat area having black cottons soil as top layer. This soil being expansive required special attention for foundation construction as well as pavement design.

Geotechnical properties of Bharuch Region Black cotton soil have been freshly calculated by carrying out various experiments in the laboratory briefed as follows.

**Table 2: Bharuch Region Black cotton soil Properties.**

<b>PROPERTIES</b>	<b>BLACK COTTON SOIL</b>
Colour	Grayish black
Specific gravity	2.74
Water content (%)	3.91

ATTERBERG'S LIMIT	63.795
Liquid Limit (%)	25.48
Plastic Limit (%)	38.315
Plasticity index (%)	14.05
Shrinkage Limit (%)	
Free swell index (%)	<b>33.33</b>
Maximum dry density( $\text{kN/m}^3$ )	17.34
CBR (%)	<b>2.05</b>
Unconfined Compressive Strength( $\text{KN/m}^2$ )	<b>82.92</b>
Optimum moisture content (%)	14.4

## II. METHODS OF STABILIZATION

Methods of stabilization may be grouped under two main types:

- (a) Modification or improvement of a soil property of the existing soil without using any admixture and
- (b) Modification of the properties with the help of admixture.

The examples of the first type are compaction and drainage, which improve the inherent shear strength of soil. The examples of the second type are stabilization with admixtures like cement, lime, bitumen, fly ash and chemicals. However these are costly options.

### **(a) Modification or improvement of a soil property of the existing soil without using any admixture.**

Modification or improvement of soil without using any admixture is called mechanical soil stabilization. Mixing two or more soils to obtain desired gradation or placing a non-chemical, non-granular material in or on soil to provide added strength can be categorized under mechanical stabilization. Mechanical soil stabilization also refers to either compaction or the introduction of fibrous and other non-biodegradable reinforcement to the soil.

The use of compressible inclusion such as expanded polystyrene (EPS) geofoam is a simple, versatile and innovative technique to mechanically stabilize expansive soils and reduce subsequent swelling pressures on the foundations. The experimental results indicate that the swelling pressure reduce substantially with the increase in thickness of EPS geofoam layer. Also this reduction in swelling pressures due to EPS geofoam is more pronounced for soils with higher swell potential.

### **(b) Modification of the properties with the help of admixture.**

The black cotton soil samples when mixed with DFA (Dandeli Fly Ash) on dry weight basis in varying percentages, improve the plasticity parameters such as liquid limit, plastic limit and shrinkage limit. (i.e. the liquid and plastic limits decrease while the shrinkage limit increases with the addition of fly ash).

The stability of soil using fly ash (FA) and rice husk powder (RHP) has also been experimented. The Unconfined compressive strength (UCS) of natural soil (which is 198 KPa) is increased to 253 KPa after the addition of FA and RHP at 15% for the period of 28 days curing. However, the combination of fly ash and rice husk shows progressive strength development with longer curing period.

Improvement in the performance of the soil is also observed when chemical admixture RBI grade 81 and sodium silicate is added. Strength of soil treated with RBI Grade 81 increases with age. Soil can be stabilized by the adding of small percentages, by weight, of sodium silicate for enhancing many of the engineering properties of the soil. Unconfined Compressive strength, CBR (soaked) values increase with increase in RBI 81 addition in soft soils. Similarly, UCS and CBR values reduce with increasing dose of sodium silicate in soil which is limitation of sodium silicate as a stabilizer. Free swell index decreases as the addition of RBI 81 increases and it goes on increasing with addition of sodium silicate.

Bagasse is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice. For each 10 tons of sugarcane crushed, a sugar factory produces nearly 3 tons of wet bagasse which is a byproduct of the cane sugar industry. Bagasse ash (i.e. the residue after extraction of the sugar juice) are obtained after this wet bagasse was openly incinerated with in a temperature range of 500<sup>0</sup>C-700<sup>0</sup>C. Research works have been carried out on the improvement of geotechnical characteristics of soils using this bagasse ash. It was found that adding bagasse ash, rice husk and groundnut shell ash to stabilization the black cotton soil. By using these stabilizers the results of these tests showed improvement in CBR value with the increase in percentage of waste. The stabilization of black cotton soil using cement and bagasse ash showed an increase in optimum moisture content (OMC) for cement with increase in bagasse ash content. It also obtained decrease in maximum dry density (MDD) with low cement content

### III. DISCUSSION

It is observed from the literature survey that stabilization of Black cotton soil is very prominently done by using Fly ash. Combination of various chemicals and admixtures with fly ash has shown a considerable stabilization of Black cotton soil. The Black cotton soil is prominent in south Gujarat region. It is also well known that sugar cane wastes are easily available due to sugar factories situated in Sayan near Bharuch region. Use of Bagasse ash could be an economical and feasible solution to stabilize the black cotton soil due to its ample availability at free of cost. Further investigation should be carried out for stabilization of black cotton soil using bagasse ash & GGBS.

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