

SUDDA SOIL – A STABILISING MATERIAL FOR BLACK COTTON SOIL

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Abstract: The black cotton soil, are widely distributed in many parts of the world and are well-known for their problematic engineering behaviour. These soils exhibit excessive swelling when wet and significant shrinkage when dry, leading to severe damage to foundations, pavements, and other civil infrastructure. Their low bearing capacity, poor shear strength, and high plasticity make them unsuitable for construction unless properly stabilized. In this context, soil stabilization becomes a crucial technique to improve the performance of such soils. This project investigates the potential of using Sudda soil, a naturally occurring material, as a stabilizing agent for black cotton soil. Sudda soil is locally available and has shown promising results in traditional construction practices due to its binding and strengthening characteristics. The main objective of this study is to analyse how the addition of Sudda soil affects the geotechnical properties of black cotton soil and whether it can serve as a sustainable and cost-effective alternative to conventional stabilizers like lime or cement. A series of laboratory tests were conducted on both untreated and treated soil samples. These tests include determination of Atterberg limits (liquid limit, plastic limit), standard Proctor compaction. Various proportions of Sudda soil were mixed with black cotton soil to identify the optimum content that provides maximum strength and stability. The experimental results shows a significant improvement in soil properties, such as reduced plasticity, increased maximum dry density, improved bearing capacity. This study contributes to sustainable construction practices, especially in rural and semi-urban areas where access to industrial stabilizers is limited.

Keywords: Black Cotton Soil (BCS), Sudda Soil (SS), Stabilization

I. INTRODUCTION

Soil stabilization is a process of changing soil properties and improves its strength and stability. There are many methods for stabilization which includes compaction, dewatering and addition of chemicals and admixture to the soil for stabilization. As in all engineering design problems, the economics of the problem in light of the benefits derived from the stabilization process determine whether it is warranted or not. Even though some means of stabilization like mechanical, chemical stabilization involve Physico-chemical changes the property of soil and affects soil gradation, solidity and other strength characteristics.

In this method, soil is basically mixed and combined with cement and water to add strength and durability. This is one of the most commonly used method of soil stabilization due to wide availability of cement and it's relatively low cost. On addition of water to cement, cementitious arterial like calcium silicate and calcium aluminates, hydrates to produce hydrated calcium aluminates and silicate gels. The mechanism of stabilization in granular soil is a result of the development of bond between hydrated cement and compacted soil particles. The disadvantage of this is it requires high degree of quality control and because of volumetric changes that takes place during hydration of cement results in early shrinkage cracks in soil cement layers that may affect overall performance of the pavement structure.

The various factors affecting the strength property of soil cement mix are cement content, nature of soil, water content, mixing, compaction, curing etc.

II. LITERATURE REVIEW

Bhattacharya (2017),The study began with a detailed characterization of the untreated black cotton soil, which exhibited a high free swell index, high liquid limit, and low shear strength, confirming its expansive and weak engineering nature. Sudda soil was selected due to its high calcium carbonate content and alkaline nature, properties known to induce chemical stabilization in clayey soils. Various proportions of Sudda soil were blended with black cotton soil, and a comprehensive laboratory testing program was carried out. The testing regime included free swell index (FSI), swelling pressure, Atterberg limits, standard Proctor compaction tests, and unconfined compressive strength (UCS) tests, enabling a holistic evaluation of both volumetric and strength-related behaviour.

Gopal & Verma (2020),Soils affected by acidity and chemical aggressiveness present a distinct set of geotechnical and durability challenges compared to expansive or soft soils. Acidic soils, commonly encountered in industrial zones, mining regions, coastal belts, and areas exposed to chemical effluents, often exhibit reduced strength, high corrosivity, and adverse reactions with buried concrete and steel infrastructure. Conventional treatment methods involve chemical neutralizers or replacement of soil, which are costly and

environmentally intrusive. In this context, Gopal and Verma (2020) investigated the potential of Sudda soil as a natural alkaline amendment for neutralizing acidic and corrosive soils while simultaneously improving their engineering properties.

Iyer & Banerjee (2023), The results clearly demonstrated that Sudda soil-treated soils retained significantly higher structural integrity after repeated environmental cycles. Unlike untreated soils, which showed progressive disintegration, cracking, and loss of strength, treated samples maintained their shape and cohesion. Shrink-swell behaviour was markedly reduced, indicating improved volumetric stability. This reduction was attributed to the formation of cemented bonds that restricted moisture-induced expansion and contraction of clay minerals.

Kumar & Das (2018), Understanding the fundamental material characteristics of a stabilizing agent is essential before its large-scale application in geotechnical engineering. While several studies have demonstrated the mechanical benefits of Sudda soil stabilization, Kumar and Das (2018) provided a critical scientific foundation by investigating the geochemical and mineralogical properties of Sudda soil. Their work aimed to establish the intrinsic characteristics responsible for its stabilizing behaviour, thereby enabling a mechanistic understanding rather than empirical observation alone.

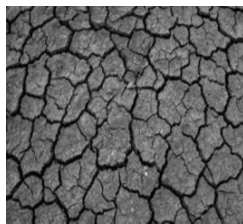
III. OBJECTIVES

1. To evaluate the geotechnical properties untreated BCS and BCS treated with SS at different proportions.
2. To investigate the effect of SS on Engineering and Geotechnical properties of BCS.
3. To promote sustainable and cost-effective soil with improved properties of BCS treated with SS.

IV. MATERIALS AND METHODOLOGY

1. Black cotton soil: Obtained from Kadur, Chikkamagaluru, Karnataka.
2. Sudda soil obtained for Nandagudi, Hoskote Taluk, Karnataka.

Fig 4.1 Black cotton soil Fig 4.2 Sudda Soil



METHODOLOGY

1. Material Collection and Preparation
2. Preparation of Soil-Stabilizer Mixtures
3. Determination of Index Properties, Compaction characteristics and Strength (UCS) of BCS alone and different proportions of SS
4. Data Analysis and Interpretation:

V. EXPERIMENTAL RESULTS & DISCUSSION

1. Atterberg Limit

Table 5.1 Variation of Atterberg's limit of BC soil with varying Percentage of SS

Mixtures	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
BCS	78	36.68	41.32
SS	42	26.19	15.81
BCS 95% + 5%SS	30.6	25.3	5.3
BCS 85% + 15%SS	34.86	31.7	3.16
BCS 75% + 25%SS	38.42	28.53	9.89
BCS 65% + 35%SS	33.76	32.7	0.06
BCS 55% + 45%SS	43.1	29.66	13.44

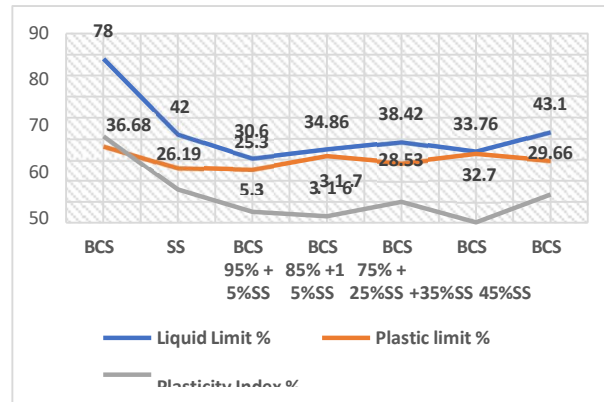


Fig. 5.1: Variation of LL, PL, and PI of Black cotton soil treated with various percentages of SS

2. Compaction Test

Table 5.2 Compaction properties for BC soil with varying percentage of SS

Mixtures	MDD (g/cc)	OMC (%)
BCS	1.74	22
SS	1.76	22
BCS 95%+ 5%SS	1.4	25
BCS 85% + 15%SS	1.45	26.9
BCS 75% + 25%SS	1.9	20
BCS 65% + 35%SS	1.4	15
BCS 55% + 45%SS	1.42	19

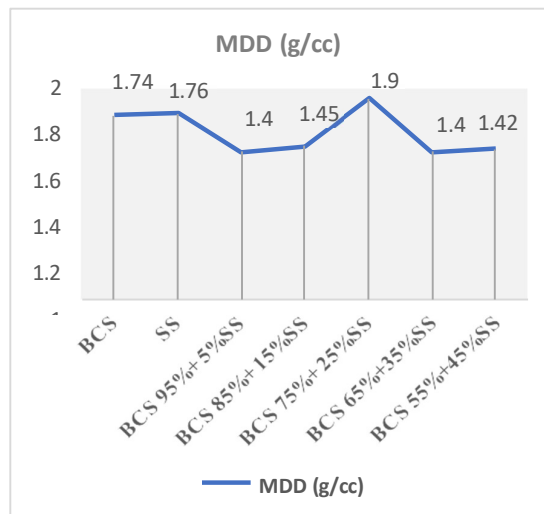


Fig no.5.2.1 Variation of MDD with varying percentage of SS

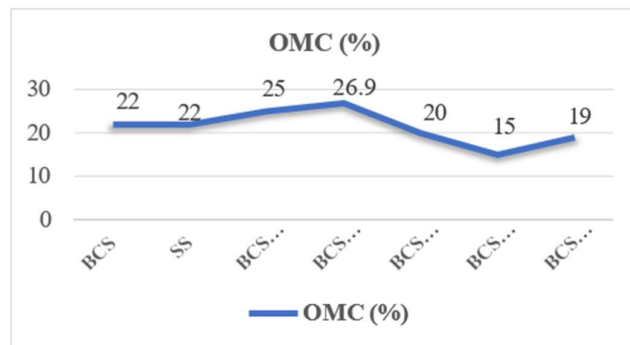


Fig.no.5.2.2 Variation of OMC with varying percentage of SS

Table 5.3 UCS variations for BCS+SS for different curing periods

Mixtures	Curing no of Days	UCS kN/m ²
BCS	0	136.87
SS	0	121.94
95% BCS + 5% SS	0	194.86
85% BCS + 15% SS	7	383.76
75% BCS + 25% SS	14	663.33
65% BCS + 35% SS	21	580.55
55% BCS + 45% SS	28	515.25

VI. CONCLUSIONS

1. Improvement in Geotechnical Properties:
2. There was a notable overall improvement in the geotechnical properties of the black cotton soil when treated with Sudda soil.
3. Reduced Plasticity: The tests showed a reduction in plasticity, which is a critical improvement for expansive soils like black cotton soil.
4. The untreated Black Cotton Soil (BCS) had a Plasticity Index (PI) of 41.32% resulted in the lowest Plasticity Index of 0.06% with BCS 65% + SS 35%
5. Compaction Characteristics: The Maximum Dry Density (MDD) was increased from 1.74g/cc to
6. 1.9g/cc with BCS 75% + SS 25% and optimum moisture content (OMC) was decreased from 22% to 15% with BCS 65% + SS 35%
7. Increased Strength: The Unconfined Compressive Strength (UCS) of treated BCS with untreated BCS BCS 75% + SS 25% was found to be increased by 3 times compared to BCS alone..
8. Sustainable and Cost-Effective Alternative: Sudda soil, being a naturally occurring and locally available material, serves as a sustainable and cost-effective alternative to conventional industrial stabilizers like lime or cement, which is particularly beneficial in rural and semi-urban areas.

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