IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 1, June 2023

Experimental Study on Stabilization of Black Cotton Soil using Plastic Waste and Coconut Shell

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Abstract: *Black cotton soils are known for their suitability in agriculture; however, they exhibit lower bearing capacity compared to other soil types, making them less ideal for constructing high-rise buildings and highways. These soils possess high swelling properties during the rainy season and experience significant shrinkage during the summer season. To address these challenges, soil stabilization techniques have been developed over the years to mitigate the swelling and shrinkage tendencies of black cotton soil. Stabilization methods involve the use of various materials such as waste material, Coconut shell & Plastic waste, fly ash, lime, cement, and admixtures, which enhance the physical characteristics of the soil, including increased bearing capacity and shear resistance. This paper presents a study focused on improving the stability of black cotton soil through soil stabilization using Coconut shell & Plastic waste only. Different proportions of Coconut shell & Plastic waste i.e., fusing Coconut shell & Plastic waste with Black cotton soil in 4%, 8%, 12% with the total soil the study involved laboratory tests to evaluate the strength properties of black cotton soil with varying compositions of Coconut shell & Plastic waste.*

Keywords: Black cotton soil (BCS), Stabilization, Coconut shell & Plastic waste, increasing stability, increasing Unconfined Compression Strength

I. INTRODUCTION

Black cotton soil covers around 20% of India's land area and is mainly found in regions like Gujarat, Maharashtra, Madhya Pradesh, South Uttar Pradesh, Karnataka, Andhra Pradesh, and Tamil Nadu. These soils undergo significant consolidation settling and exhibit high compressibility when saturated. However, their pronounced swelling behavior presents structural challenges. During the rainy season, water fills the cracks and crevices, reducing the soil's bearing capacity. Conversely, the soil contracts in the dry season, leading to uneven settlement of buildings, cracks in walls and floors, and other related issues.To address these concerns, soil stabilization techniques are employed to improve the soil's strength and load-bearing capacity. These techniques involve controlled compaction, appropriate proportioning, and the addition of suitable admixtures or stabilizers. Stabilization plays a crucial role in enhancing the soil's strength, durability, and design life for various engineering projects. Since soil characteristics vary depending on location and physical properties, it is vital to perform laboratory tests using actual soil samples before implementing stabilization techniques in the field.The primary objective is to enhance the favourable properties of black cotton soil, ensuring adequate strength and load-bearing capacity to prevent structural failure. Long-term physical and chemical modifications can improve shear strength, unconfined compressive strength, and reduce soil permeability. Cost-effectiveness is a crucial consideration in soil stabilization.

Soil stabilization techniques have evolved over time to meet the specific engineering requirements of projects. Stabilized materials can be utilized as improved subgrades, capping layers, or sub-bases for road and airfield pavements. This process involves modifying one or more soil properties through mechanical or chemical means to create an improved soil material with desired engineering properties. The goal of stabilization is to increase strength, durability, prevent erosion, and minimize dust generation.

II. LITERATURE REVIEW

YulianFirmana Arifin , and Gazali Rahman, et al (2019) (1), This paper study the Stabilization of Soft Soil With Cement And palm kernel shell Ash Admixture , Records from the literature show that cement is an effective stabilizer in the improvement of the strength requirement for coarse-grained soils is between 3- 11% and for low plasticity of clay or silt soils of 7-12%.

Athira T, Ashish Johnson, et al (2017), Expansive Soil Stabilization using Coconut Shell Powder and Lime, This paper presents the improvement of compressive strength of expansive soil when stabilized with different dosages of coconut shell powder (0%, 3%, 6%, 9% and 12%) and lime (3%, 6% and 9%).

T. Ako1 and I. T. Yusuf2, et al (2016), Utilization of Palm Kernel Shell Ash as a Stabilizer of Lateritic Soil for Road Construction, The chemical compositions of the PKSA were also determined. PKSA was added to the soil in 2, 4, 6, 8 and 10% proportions by dry weight of the soil.

Armin Roohbakhshan, Behzad Kalantari, et al (2013), Stabilization of Clayey Soil With Lime and Waste Stone Power ,Three different material were used in this research ; Clayey soil ,Lime and Waste Stone Powder

Ayushi D. Panchal et al, Stabilization of Black Cotton Soil Using Waste Material quarry Dust, This paper presents the different test for black cotton soil with addition of quarry dust (i.e. 05%, 10%, 15%) such as Atterberg's Limit, Compaction Test, California Bearing Ratio Test and unconfined compressive strength Test and the satisfactory results were obtained up to the addition of 10% of quarry dust and beyond 10% amount of quarry dust, results are not effective.

Avinash Bhardwaj et al, Stabilization of Clayey Soil Using Waste Foundry Sand and Molasses, clayey soil has been reported in the past. On adding optimum percentage of molasses(10%) alone in clayey soil, the 28 days UCS value of clayey soil increased by 20%when compared with 28 days UCS value of composite.

P. Imran Khan et al, The adding the certain amount of stone dust in the black cotton soil the value of plastic limit percentage changes from 0% to 8% it will decrease and in the liquid limit it will increase. The tremendously raise in California Bearing ratio the penetration of plunger at 12.5mm the value of 3% will increase compare to the 0% and 8%.

III. OBJECTIVE

1. To Study the effect of various mix proportion of coconut shell powder and plastic waste on index properties of soil.
2. To Study the effect of various mix proportion of coconut shell powder and plastic waste on Engineering properties of soil.
3. To compare the index properties of treated and untreated soil.
4. To compare the engineering properties of treated and untreated soil.

IV. MATERIAL

I. Plastic Waste:

Plastic is a term that encompasses a broad range of synthetic or semi-synthetic materials widely utilized in various applications. These materials are extensively used and can be easily recycled due to their complex chemical composition. By incorporating plastic waste bottles into geotechnical construction, the challenges associated with their disposal can be mitigated, as their properties often resemble those of natural materials. In this chapter, we discuss the utilization of plastic waste bottles and how they contribute to soil stabilization.

II. Black Cotton Soil:

Black cotton soil, which is commonly found in India, is a distinctive type of soil renowned for its specific characteristics. It is identified by its dark hue and high clay content. This type of soil occupies a considerable portion of India's land area, particularly in regions like Gujarat, Maharashtra, Madhya Pradesh, South Uttar Pradesh, Karnataka, Andhra Pradesh, and Tamil Nadu. In comparison to other soil types, black cotton soil exhibits relatively low bearing capacity. Consequently, it may not offer sufficient support for heavy structures such as high-rise buildings or highways unless appropriate stabilization techniques are employed. To conduct suitable tests, we procured approximately 60 kilograms of black cotton soil from Taljai Temple Road, Maharashtra. The selection of this specific location was made in consultation with our guide, and it was chosen for its proximity to our college.

III. Coconut Shell

The disposal of solid waste, including coconut shells, generated from agricultural activities poses a significant challenge. Coconut shells account for a substantial portion, more than 60%, of domestic waste volume. Improper disposal of coconut shells can have adverse effects on local environments. To address this issue, the utilization of coconut shells as a composite material in concrete production has gained attention. The motivation behind incorporating coconut shells into concrete production stems from the need to tackle solid waste disposal problems. Coconut shells are by-products of coconut oil production and are recognized for their hardness and high carbon content, making them suitable for the production of activated carbon. However, they can also serve as potential materials or replacement materials in the construction industry.

Coconut shells exhibit promising properties, such as high strength and modulus, making them viable candidates for the development of new composite materials in concrete mix designs. By utilizing coconut shells in concrete production, it is possible to enhance the sustainability and efficiency of construction practices while addressing the challenge of solid waste disposal

V. EXPERIMENTAL PROCEDURE

The initial step of the study involved determining the primary properties of black cotton soil. Subsequently, the soil was subjected to stabilization using of coconut shell &plastic waste. Different proportions of of coconut shell &plastic waste, namely 4%, 8%, and 12% by dry weight of soil, were incorporated. Mix samples were prepared based on these proportions, and a series of laboratory tests were conducted, including liquid limit, plastic limit, Additionally, the Unconfined Compressive Strength(UCS) and Standard Proctor test values were determined for both the natural soil and the samples with the mixed proportions.

Black Cotton Soil

- Black Cotton Soil +4% of coconut shell &plastic waste
- Black Cotton Soil + 8% of coconut shell &plastic waste
- Black Cotton Soil + 12 %of coconut shell &plastic waste

5.1 Standard Proctor Test

Obtain approximately 3 kg of soil. Pass the soil through a No. 4 sieve to remove any large particles. Weigh the soil mass and the compaction mould without the collar (Wm). Place the soil in a mixer and gradually add water until the desired moisture content (w) is achieved. Apply lubricant to the collar of the compaction mould.

Remove the soil from the mixer and fill the compaction mould in either 3 layers (Standard Proctor) or 5 layers (Modified Proctor). Compact each layer with 25 blows using a compaction hammer, manually or mechanically, at a consistent rate. The soil should fill the mould and extend slightly into the collar, but not more than approximately 1 centimetre.

Carefully remove the collar and trim any excess soil extending above the mould using a straight-edge tool. Weigh the mould with the compacted soil (W). Gently extrude the soil from the mould using a metallic extruder, ensuring that the extruder and mould are aligned. Measure the water content of the soil sample from the top, middle, and bottom sections. Return the soil to the mixer and add water to achieve a higher water content, w, for further testing if necessary. This test procedure is also performed for various soil samples that contain different percentages of Coconut shell & Plastic waste. The sample of black cotton soil + 4% of coconut shell &plastic waste, black cotton Soil + 8 % of coconut shell &plastic waste, black cotton Soil + 12% of coconut shell &plastic waste respectively

5.2 Liquid Limit Test

A soil sample weighing 50 grams was collected and subjected to oven drying for a duration of 24 hours. After the drying process, the sample was allowed to cool down to room temperature for approximately 30 minutes. Subsequently, the sample was placed in a cup with a closure set at a distance of around 10 mm. Following this, the soil sample was compacted by delivering 20 blows using the standard procedure.

5.3 Plastic Limit Test

The plastic limit of soil refers to the moisture content at which the soil exhibits plastic behavior. It is the water content at which the soil starts to crumble when rolled into threads with a diameter of 3.2mm

5.4 UCS Test (Unconfined Compression Test)

Unconfirmed Compressive Strength (UCS) stands for the maximum axial compressive stress that a specimen can bear under zero confining stress. Due to the fact that stress is applied along the longitudinal axis, the Unconfined Compression Test is also known as Uniaxial Compression Test

VI. RESULT & DISCUSSION

Sr. no.	Name of test	0% of coconut shell & plastic waste	4% of coconut shell & plastic waste	8% of coconut shell & plastic waste	12% of coconut shell & plastic waste	Unit
1	Modified proctor test					
	a)Maximum dry density (MDD)	1.67	1.78	1.8	1.71	g/cc
	b) Optimum moisture content (OMC)	15.7	13.2	12.3	13.4	%
2	Atterberg limit					
	a)Liquid limit	71.5	67.5	63	61	%
	b)Plastic limit	32.5	28.03	27.67	26.75	%
	c)Plasticity index	39	39.03	35.33	34.24	%
5	Unconfined Compression Strength	10.90	11.11	11.87	11.03	Kg/cm^2

VII. CONCLUSION

From the experimental study, it concluded that the Unconfined compressive strength of black cotton soil with8% of coconut shell &plastic waste increases. After increasing the percentage the Unconfined compressive strength decreases. The liquid limit and plastic limit of black cotton soil decreases with increasing the percentage. The maximum dry density of soil after stabilizing the soil is 1.8 g/cc with optimum moisture content of 12.3%.

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