International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Stabilization of Black Cotton Soil by Using Waste Material for Road Construction

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ABSTRACT

The stabilization of black cotton soil, which is known for its high swelling and shrinkage properties, is crucial for ensuring the durability and performance of road construction. This project investigates the use of waste materials such as granite powder, glass powder, lime, and rice husk to stabilize black cotton soil and enhance its engineering properties.

The study focuses on the mix proportions of these waste materials to improve parameters like strength, plasticity, and compaction characteristics of the soil. Granite powder and glass powder, being fine powder are tested for their ability to reduce the plasticity index and improve workability, while lime serves as a binding agent to enhance soil cohesion. Rice husk, an agricultural by-product, is explored for its potential in reducing soil expansion. Laboratory tests including Plastic limit, liquid limit, specific gravity, sieve analysis, standard proctor test and California Bearing Ratio are conducted to assess the effectiveness of the waste materials.

Keywords: Soil Stabilization, California Bearing ration, Plasticity etc.

1. Introduction

The Soil stabilization is the method of improvement of stability or bearing power of the soil by using controlled compaction, proportioning and the addition of suitable stabilizers. For any construction design, whether it's a structure, a road or an airport, the base soil acts as the foundation. also, soil is one of the pivotal construction raw accoutrements. The need to improve quality of soil using soil stabilization is becoming more important as good soil becoming scarcer and their location more difficult and costlier.

1.1 Importance of soil stabilization :

Stabilized soils provide a strong working platform, the foundation for all other parts of projects. After stabilization techniques, weak soils can be transformed by the formation of permanent pozzolanic reactions. Meaning that soils are not liable to leaching and have drastically reduced permeability resulting in reduced shrink potential and increased freeze thaw resistance. In addition, soils that have been stabilized have also under gone some modification. In other words, the soil has physically changed making compaction easier and reducing plasticity.

Easier compaction makes achieving maximum dry density easier. Plasticity index is an important geotechnical measure that involves the critical water contents of soils. Any time plasticity in soils is reduced, the soils are more friable and workable. [2] The soil stabilization process begins with soil samples that are analyzed to determine how much modification is required to permanently stabilize the soil. This testing is designed to establish proper design criteria for determining the appropriate mixture of additives to stabilize the soil and achieve its desired engineering properties. After the soil has been thoroughly mixed, compaction and grading prepare the stabilized soil for further construction.

1.2 Need of soil stabilization

Soil stabilization is necessary to improve engineering properties of soil, making it suitable for construction and other uses. After stabilizing of soil its strength, durability, and resistance to erosion are enhanced. This is crucial for creating stable foundations for buildings, roads, and other infrastructure. Stabilization increases the shear strength of the soil, allowing it to withstand greater loads. This is especially important for roads, building foundations, and embankments, where the soil needs to bear the weight of structures and traffic. Stabilization can minimize settlement problems, which can lead to structural damage.

2. METHODOLOGY

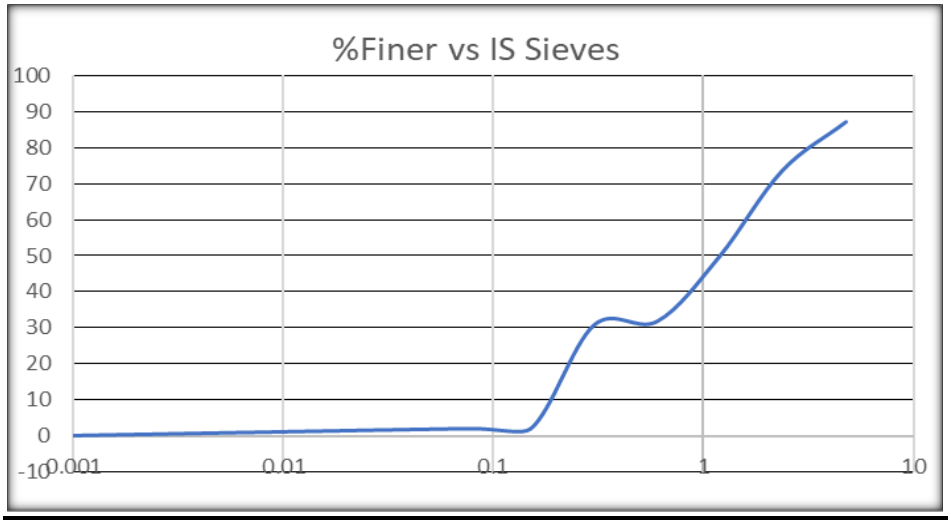
The black cotton soil is collected and its initial properties, such as plasticity, specific gravity, grain size distribution, CBR value are determined using laboratory procedures The waste materials are mixed with the soil in varying proportions to assess its stabilizing effects.

The Standard Proctor test and the California Bearing Ratio (CBR) test are carried out for varying proportions Finally, the results are analyzed to determine the most effective proportion of waste material for achieving the desired soil improvement & technical performance

2.1 Test conducted on black cotton soil before addition of waste materials –

To know the properties of a soil different tests are conducted. Test were conducted such as - Sieve Analysis, Specific Gravity, Plastic Test, Liquid Test, Standard Proctor Test, CBR test

a. Sieve analysis - Sieve analysis determines the particle size distribution of a soil sample and hence helps in easy identification of a soils mechanical properties. This mechanical properties determine whether a given soil can support the proposed engineering structure, it also helps to determine what modifications can be applied to the soil and best way to achieve maximum soil strength.



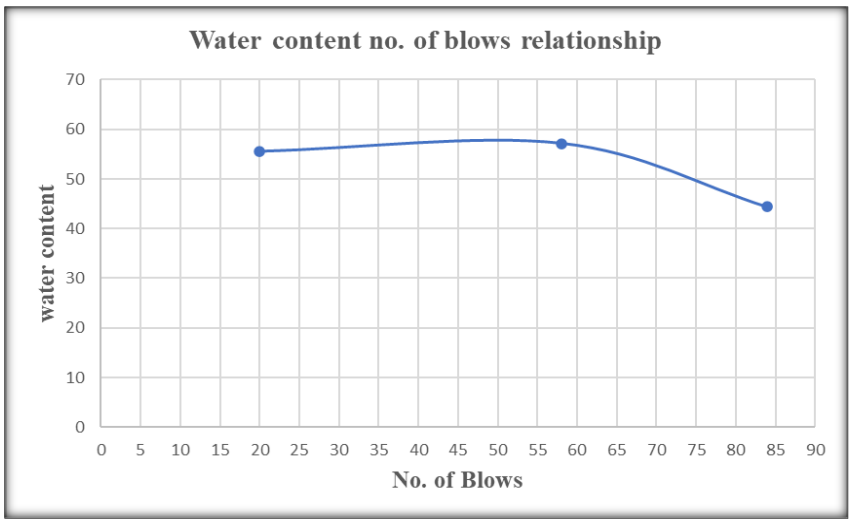
Sieve size

Conclusion – As Cu > 6 and Cc in between 1 and 3 the above black cotton soil is well graded sand

b. Specific Gravity -The Specific Gravity of soil solid is used to calculate the density of the soil and also used to determine the suitability of soil as fill material. The specific gravity of soil is important it determining its load bearing capacity.

Conclusion – The given soil sample is highly plastic and which is clayey type of soil.

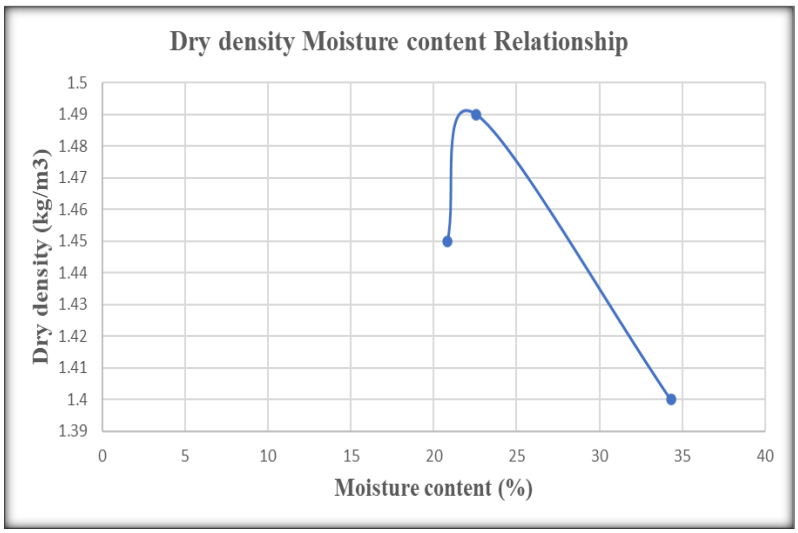
d. Liquid limit



Conclusion – The liquid limit of soil is 55.5% and the soil has high plasticity.

e. Standard proctor test -The Standard Proctor Test determines the optimum moisture content and maximum dry density for soil compaction. Black cotton soil is typically requires a high moisture content to reach optimal compaction, which can make it difficult to achieve a dense, stable subgrade.

Conclusion – The dry density of soil achieved is 1.495 gm/cc when the moisture content is 22.58% which is optimum moisture content



f. California Bearing Ratio (CBR) test – A California Bearing Ratio test is performed on soil to evaluate its strength and load-bearing capacity, which is essential for determining how suitable the soil is for the construction of roads, pavements. The CBR test measures the resistance of a soil sample to penetration by a standard piston under controlled conditions. For 2.5 mm penetration load is 1019.7 kg & standard value of load for construction is 1370 kg. after conducting test on black cotton soil the CBR value at 2.5 is 74.42 %, CBR value at 5 is 71.94 %.

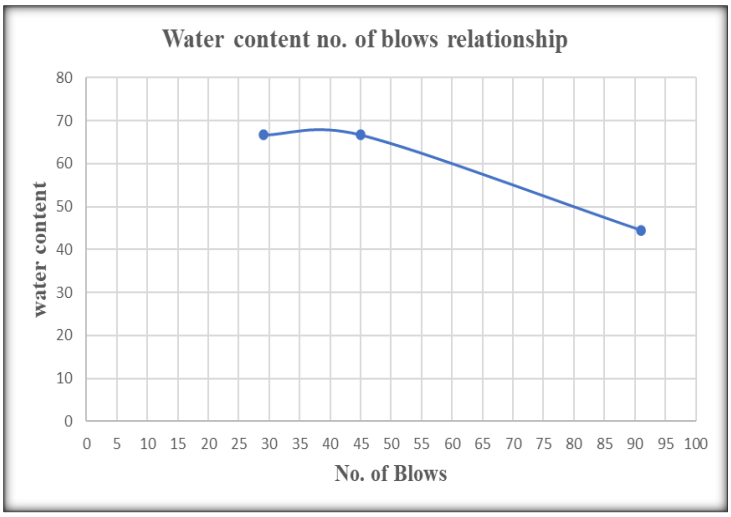
Conclusion – The CBR value of given soil sample is 71.94 % and hence is not suitable for road construction as per IRC:SP-72-2015 recommendations.

2.2 Proportion details

Proportion No.	Black cotton soil	Granite Powder	Lime	Rice husk	Glass Powder
1	60%	15%	10%	10%	05%
2	60%	10%	15%	10%	05%
3	70%	10%	-	15%	05%

Proportion No 1

a. Liquid limit



Conclusion – The liquid limit of soil is 66.6% and the soil has high plasticity.

b. Standard proctor test results

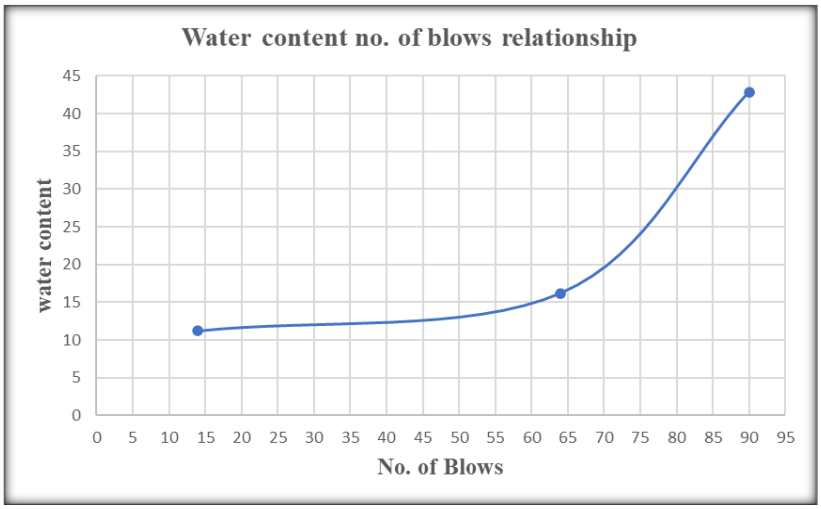
Sample	OMC (%)	MDD (gm/cc)
1	30.5	1.293
2	30	1.28
3	26	1.31

c. Average CBR Value of proportion 1

The average CBR value of three soil sample is 53.74 % and hence it is not suitable for road construction as per IRC:SP-72-2015 recommendations.

Proportion No. 2

a. Liquid limit



Conclusion – The liquid limit of soil is 38% and the soil has intermediate plasticity**.**

b. Standard proctor test results

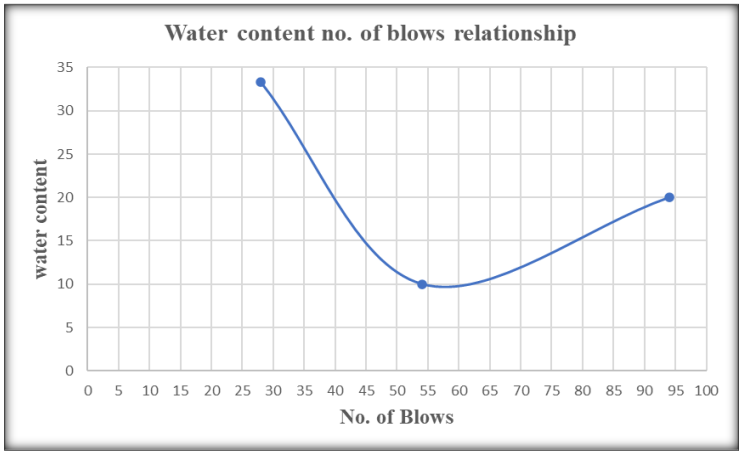
Sample	OMC (%)	MDD (gm/cc)
1	26.47	1.14
2	29	1.12
3	28	1.12

c. Average CBR Value of proportion 2

The average CBR value of three soil sample is 10.16 % and hence it is suitable for road construction as per IRC:SP-72-2015 recommendations.

Proportion No. 3

a. Liquid limit



Conclusion – The liquid limit of soil is 34% and the soil has low plasticity .

b. Standard proctor test results

Sample	OMC (%)	MDD (gm/cc)
1	31.57	1.18
2	30.58	1.18
3	31.6	1.14

c. Average CBR Value of proportion 3

The average CBR value of three soil sample is 39.7 % and hence it is not suitable for road construction as per IRC IRC:SP-72-2015 recommendations.

CONCLUSION

1. The addition of various waste materials showed a significant improvement in the properties of black cotton soil, such as increased strength, reduced plasticity, and enhanced compaction characteristics.

2. From the above study it can be concluded that addition of various waste material proves beneficial in improving soil stabilization.

3. After conducting the test on black cotton soil, proportion 2 (Black cotton soil 60% , Granite Powder 10% , Lime 15% , Rice husk 10% and Glass Powder 05%) is found to be more suitable for road construction compared to the other two proportions. Since the CBR value of proportion 2 is 11.34%, so it is suitable for road construction as per IRC IRC:SP-72-2015 recommendations.

4. One of the most significant improvements observed was the reduction in the plasticity index and the swelling potential of black cotton soil. By stabilizing the soil with the waste materials, its shrinkage and swelling behaviour were minimized, which is a critical issue with black cotton soil.

5. Utilizing waste materials like granite powder, glass powder, rice husk powder, and lime not only provided a cost-effective solution but also contributed to waste recycling, reducing the environmental burden associated with the disposal of these materials.

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