

Stabilization of Expansive Soil using Rice Husk Ash and Lime



J.Jayashree, S.Yamini Roja

Abstract: *The high swelling and shrinking characteristics of expansive black cotton soils have posed several challenges for the construction works due to their low bearing capacity. Black cotton soils when exposed to changing moisture conditions exhibit high swelling and shrinking conditions. Hence, to overcome these problems, the soil needs to be stabilized. In this project, an experimental investigation is made to study the possibility of using Rice Husk Ash (RHA) and lime as a stabilizing material in the expansive black cotton soil by varying their concentrations. Laboratory tests were carried out to find the effect of RHA and lime in the index and engineering properties of the expansive soil. RHA is added and mixed with the soil at varying proportions of 10%, 15% and 20% and keeping lime concentration constant at 5% by weight of dry soil. The specific gravity test and grain size distribution tests are initially carried out for the virgin soil sample. The index properties such as liquid limit, plastic limit and shrinkage limit and strength properties using Standard Proctor compaction test, California Bearing Ratio test, Unconfined Compressive Strength tests of soil with and without these admixtures are found out. The various test results are compared and the optimum proportion of 5% Lime and 15% of Rice Husk Ash gave the maximum strength and improved index properties of the soil.*

Index Terms: *California Bearing Ratio, Rice Husk Ash, Unconfined Compressive Strength test, Optimum moisture Content*

I. INTRODUCTION

In any construction projects, the foundation of a structure is a very important factor for any land based structure as it has to support the entire load exerted by the structure on the soil. The soil around the structure plays a very crucial role in order to make the foundation strong. The foundation on expansive soils such as black cotton soil has always posed a tough task for the engineers since the structure resting on those soils crack without any warning. Black cotton soils are generally expansive soils which possess high swelling and shrinkage characteristics when exposed to moisture content. This behavior is due to the presence of a mineral called montmorillonite. This cyclic swelling and shrinking of soils are subjected to moisture variations and these cause severe

failures of structures laid on them. These soils are hence not suitable for construction activities due to low strength, high compressibility and volumetric changes. In order to overcome these problems, improvement of soil can be done either by modification of soil or by method of soil stabilization. As a solution to the problems caused in these soils, many innovative techniques must be selected after comparing the various possible techniques in order to improve the stability characteristics of soil.

Soil stabilization is generally the modification of the soil properties to improve the behaviour of the soil. The main purpose of the soil stabilization is to improve the bearing capacity of the soil and its resistance to weathering process & soil permeability. The durable life of any construction project mainly depends on the underlying soils on which the structure is built. Unstable soils create considerable problems for structures. Therefore soil stabilization techniques are essential to ensure the stability of soil in order to successfully uphold the load of the superstructure especially in case of expansive soil. The chemical stabilization of clays using lime is one of the most universal methods which can be used to upgrade the poor soils to form a feasible platform for construction projects.

RHA is an agricultural waste obtained from milling of rice. Tonnes of Rice-Husk are generated every year in the agricultural industry. The ash has been categorized under pozzolana. It contains about 60-70% silica, 49% Alumina and 0.95% Iron Oxides. Therefore, replacing the use of cement and other materials in stabilization of soil with a secondary cementitious material like Rice Husk Ash have proved effective as a pozzolanic fabric in soil stabilization. The use of these wastes will significantly reduce the construction cost and the environmental hazards caused by them. Hence, replacing the Portland cement with certain proportions of these RHA in stabilization of soil as a secondary cementitious material will decrease the environmental impact of the soil stabilization process. Silica from rice husk ashes was found to be successful as a pozzolanic material in stabilization of soil. However, rice husk ash couldnt be used exclusively since the materials are lack of calcium element and hence they can be mixed with some other cementitious materials like lime or cement to have a chemical reaction in soil stabilization process. Lime is chemically known as Calcium oxide and are also commonly known as quicklime. It is a commonly used chemical compound which are a white, caustic and alkaline crystal solid at room temperature.

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It is consistently used as a soil modification agent in order to improve the performance of sub grade soils for reducing the occurrence of volume change in expansive soils.

Efficient mixing of lime and soil must be ensured for improvements throughout the entire soil mass. Lime also reduces the amount of fines present in a soil mass by causing flocculation and agglomeration of clay particles. Generally, all lime treated fine-grained soils show enhanced workability, reduced plasticity and reduced volume change characteristics.

II. OBJECTIVES OF STUDY

The main objectives of the experimental investigation are:

- i. To determine the index and engineering properties of the black cotton soil with various proportions of Rice Husk Ash and Lime.
- ii. To study and compare the results for the determination of optimum content of Rice Husk Ash and lime.

III. MATERIALS USED

The different materials used in order to conduct the experimental investigation are:

A. Soil

The soil sample used for the conducting various experiments in the project was collected at a depth 1.5 m below the ground surface of the site located in Vilankurichi-Ganapathy of Coimbatore District.

The soil properties are listed in Table 1 after conducting laboratory tests.

B. Lime

The lime used for the experiments were purchased locally from the market for conducting the experiments on the black cotton soil.

C. Rice Husk Ash

The Rice Husk Ash used for conducting experiments on the black cotton soil were purchased locally from the rice mill situated in Kangayam.

The various properties of the black cotton soil sample without the addition of admixtures like Rice Hush Ash and Lime obtained from laboratory tests are tabulated below:

I. Properties of Black Cotton Soil

Sl.no	Property	Values
1	Percentage of Gravel	0.6
2	Percentage of Sand	19.6
3	Percentage of Silt	53.8
4	Percentage of Clay	26
5	Specific Gravity	2.61
6	Liquid Limit	52%
7	Plastic Limit	25%
8	Plasticity Index	27%
9	Shrinkage Limit	11.73%
10	Optimum Moisture Content	14%
11	Maximum Dry Density	2.03g/cm ³
12	Unconfined Compressive Strength	49.5KN/m ²

13	California Bearing Ratio (Unsoaked)	4.457%
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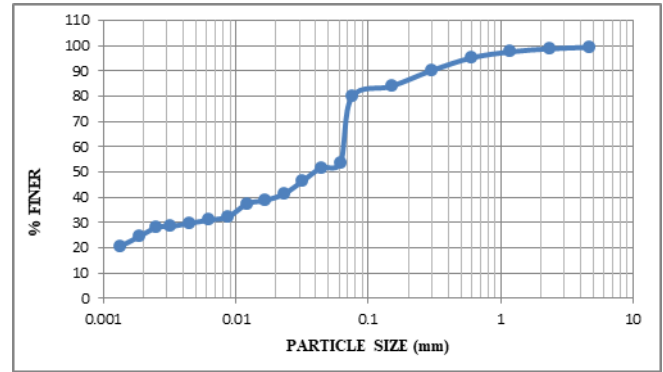


Fig.1: Particle size distribution

IV. EXPERIMENTAL METHODS

In order to determine the Index and engineering properties of the black cotton soil sample such as liquid limit, plastic limit, plasticity index, shrinkage limit, optimum moisture content, maximum dry density, unconfined compressive strength and California Bearing Ratio value various laboratory experiments were conducted such as:

1. Atterberg's Limit test
2. Standard Proctor Compaction test
3. Unconfined Compressive strength test
4. California Bearing Ratio tests

These tests were conducted for both control soil sample as well as for soil sample mixed with 0%, 10%, 15% and 20% percentages of RHA and concentration of Lime kept at constant 5% with the soil sample. The specific gravity of the soil sample is obtained using Pycnometer test and the grain size distribution of the soil was done using dry sieve analysis, wet sieve analysis and hydrometer analysis.

V. RESULTS AND DISCUSSIONS

A. Atterberg's Limit Test

Atterberg's Limits tests were conducted in laboratory at 0%, 10%, 15% and 20% percentages of RHA and Lime at constant 5% and the results obtained are as below:

II. Variation of Index properties of Black Cotton soil with RHA and Lime

Lim e %	RH A %	w _L %	w _P %	I _P %	w _S %
0	0	52	25	27	11.73
5	0	38	29	9	12.8
5	10	58	NP	-	28.9
5	15	66.4	NP	-	34.3
5	20	70.6	NP	-	48.3

It was observed that with addition of 5% lime and 0% RHA, the liquid limit reduced to 38% which further increased to 58% when 10% RHA was added. Addition of RHA and Lime made the soil non-plastic which led to decrease in plasticity. The shrinkage limit increased with increase in percentages of lime and RHA.

B. Standard Proctor Compaction Test

With various percentages of Rice Husk Ash (0%, 10%, 15% and 20%) and Lime at a constant percentage of 5%, and also for control soil sample, Standard Proctor Compaction test was conducted as per IS 2720 and the results obtained are tabulated below:

III. Variation of OMC and MDD

Lime %	RHA %	OMC %	MDD(g/cm ³)
0	0	14	2.03
5	0	22	1.795
5	10	26	1.747
5	15	30	1.678
5	20	38	1.632

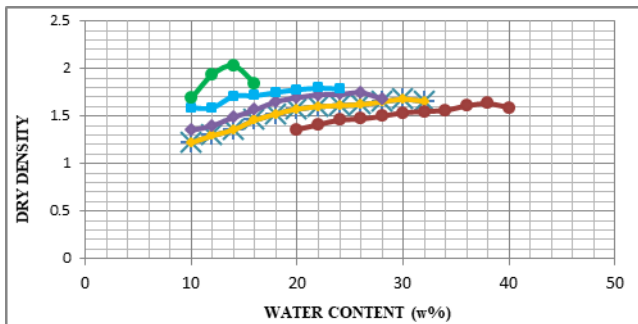


Fig 2. OMC and MDD for various proportions of RHA and Lime

From the tests results, it was found that Optimum Moisture Content of soil is increased with increase in percentages of Rice Husk Ash(RHA) content from a value of 14% to 38% at 5% lime+ 20% RHA content. The Maximum Dry Density of the soil decreased with increase in RHA content for the soil from 2.03g/cm³ to 1.632g/cm³

C. Unconfined Compressive Strength Test

The Unconfined Compressive Strength tests were conducted in laboratory on control soil sample and for soil mixed with 0%, 10%, 15% and 20% percentages of RHA and 5% of Lime and the results obtained are tabulated below:

IV. Variation of UCS value for various percentages of RHA and Lime

Lime %	RHA %	UCC in kN/m ²
0	0	49.5
5	0	50.05
5	10	50.91
5	15	52.9
5	20	46.7

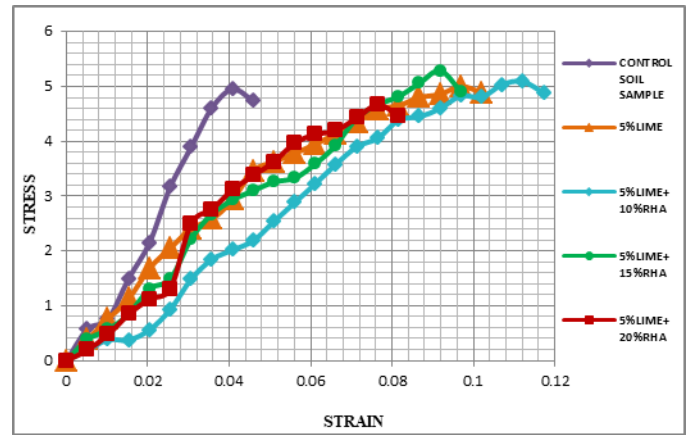


Fig 3. UCS values for various proportions of RHA and Lime

It was found that the Unconfined Compressive Strength (UCS) of soil sample increased gradually with increase in percentages of RHA. The UCS values increased from 4.805kg/cm² to 5.138 kg/cm² for control sample and 15%RHA+ 5% lime respectively and then decreased to 4.54 kg/cm² with further addition of RHA content.

D. California Bearing Ratio test

California Bearing Ratio tests were conducted in laboratory for control soil sample as well as for 0%, 10%, 15% and 20% percentages of RHA and 5% of Lime proportions and the test results obtained are tabulated below:

V. Variation of CBR values for various percentages of RHA and Lime

Lime %	RHA %	CBR %
0	0	4.457
5	0	4.564
5	10	6.139
5	15	7.50
5	20	3.457

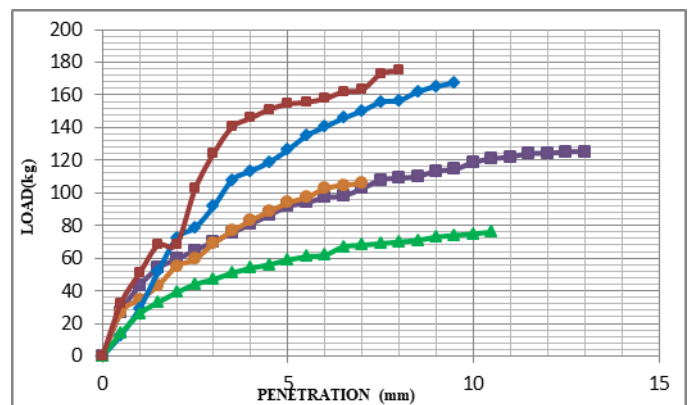


Fig 4. CBR values for various proportions of RHA and Lime

From the test results, it was found that the California Bearing Ratio increased with increase in percentages of RHA. The values increased from 4.457% to 7.5% for control soil sample and 15% RHA respectively and then decreased steeply to 3.46% with further addition of RHA(20%).

VI. CONCLUSION

In this project, after conducting various laboratory experiments on the black cotton soil by keeping proportion of lime as constant and varying the proportion of Rice Husk Ash, it was found that the various properties of the soil sample improved with addition of these admixtures. From the experimental investigation conducted, the following conclusions were drawn as given below:

1) It was found that the Optimum Moisture Content (OMC) of the soil increased from 14% to 38% with increasing percentage of RHA with addition of 20% RHA to the soil. The maximum OMC was attained for 20% RHA+5% Lime proportion.

2) The Maximum Dry Density of the soil decreased from 2.03g/cm^3 to 1.632g/cm^3 with increase in RHA content.

3) The Unconfined Compressive Strength of the soil increased from 49.5kN/m^2 of plain soil to 52.9kN/m^2 for 15% RHA content and then reduced to 46.7kN/m^2 for 20% RHA content. The maximum UCS value was obtained corresponding to 15% RHA and 5% lime proportion.

4) It was also found that the CBR value of the soil increased greatly from 4.457% to 7.5% with addition of 5% lime and 15% RHA as admixtures. The value later decreased steeply to 3.46% with further addition of RHA and lime. The maximum CBR value was obtained for 5% lime+15% RHA proportion.

5) The liquid limit and shrinkage limit of the soil increased with increase in RHA content. Liquid limit increased from 52% to 70.6% and shrinkage limit of the soil increased from 11.73% to 48.3% with addition on Rice Husk Ash and lime.

6) The plastic limit and plasticity index of the soil is reduced with addition of admixtures. Addition of RHA and lime made the soil non-plastic.

7) From the test results it can be concluded that the improved soil properties were obtained corresponding to 5% Lime and 15% Rice Husk Ash proportion. Hence, this proportion can be used as the optimum value for obtaining improved soil properties.

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