Behavior of Clayey Soil Stabilized with Rice Husk Ash & Lime

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ABSTRACT

In India the soil mostly present is Clay, in which the construction of sub grade is problematic. In recent times the demands for sub grade materials has increased due to increased constructional activities in the road sector and due to paucity of available nearby lands to allow excavate fill materials for making sub grade. In this situation, a means to overcome this problem is to utilize the different alternative generated waste materials, which cause not only environmental hazards and also the depositional problems. Keeping this in view stabilization of weak soil in situ may be done with suitable admixtures to save the construction cost considerably. The present investigation has therefore been carried out with agricultural waste materials like Rice Husk Ash (RHA) which was mixed with soil to study improvement of weak sub grade in terms of compaction and strength characteristics. Silica produced from rice husk ashes have investigated successfully as a pozzolanic material in soil stabilization. However, rice husk ash cannot be used solely since the materials lack in calcium element. As a result, rice husk ash shall be mixed with other cementitious materials such as lime and cement to have a solid chemical reaction in stabilization process. Lime is calcium oxide or calcium hydroxide. It is the name of the natural mineral (native lime) CaO occurs as a product of coal seam fires and in altered lime stone xenoliths in volcanic ejection. In this study RHA and Lime is mixed in different percentage like (RHA as 5%, 10%, and 15%) and (Lime as 3%, 6%, 9%) and laboratory test CBR is done with a curing period of 4, 7 and 14 days with different percentages of RHA & Lime and Lime+ RHA.

KEYWORDS: **California Bearing Ratio (CBR), clayey soil, Lime, Rice Husk Ash (RHA), Unconfined Compressive Strength (UCC).**

I. INTRODUCTION

Soil improvement could either be by modification or stabilization or both. Soil modification is the addition of a modifier (cement, lime etc.) to a soil to change its index properties, while soil stabilization is the treatment of soils to enable their strength and durability to be improved such that they become totally suitable for construction beyond their original classification. Over the times, cement and lime are the two main materials used for stabilizing soils. These materials have rapidly increased in price due to the sharp increase in the cost of energy since 1970s (Neville, 2000). The over dependence on the utilization of industrially manufactured soil improving additives (cement, lime etc), have kept the cost of construction of stabilized road financially high. This hitherto, has continued to deter the underdeveloped and poor nations of the world from providing accessible roads to their rural dwellers who constitute the higher percentage of their population and are mostly, agriculturally dependent. Thus the use of agricultural waste (such as rice husk ash) will considerably reduce the cost of construction and as well reducing the environmental hazards they causes. Therefore, replacing proportions of the Portland cement in soil stabilization with a secondary cementitious material like RHA will reduce the overall environmental impact of the stabilization process. Silica produced from rice husk ashes have investigated successfully as a pozzolanic material in soil stabilization. However, rice husk ash cannot be used solely since the materials lack in calcium element. As a result, rice husk ash shall be mixed with other cementitious materials such as lime and cement to have a solid chemical reaction in stabilization process.

Lime is a general term for calcium-containing inorganic materials in which carbonates, oxides and hydroxides predominate. Strictly speaking, lime is calcium oxide or calcium hydroxide. It is the name of the natural mineral (native lime) CaO occurs as a product of coal seam fires and in altered lime stone xenoliths in volcanic ejection. The word “lime” originates with its earliest use as building mortar and has a sense of “sticking and or adhering”. “Burning” converts them into the highly caustic material quicklime (calcium oxide, Cao) and through subsequent addition of water, into less caustic (but still strongly alkaline) slaked lime or hydrated lime (calcium hydroxide, $CA\ (OH)_2$ =74.10), the process of which is called slaking of lime.

Rice husk is an agricultural waste obtained from milling of rice. About 108 tonnes of rice husk is generated annually in the world. Meanwhile, the ash has been categorized under pozzolana, with about 67-70% silica and about 4.9% and 0.95%, Alumina and iron oxides, respectively (Oyetola and Abdullahi, 2006). The silica is substantially contained in amorphous form, which can react with the CaOH librated during the hardening of cement to further form cementations compounds.

Light compaction energy, the effect of Rice Husk Ash on the soil was investigated with respect to compaction characteristics, California Bearing Ratio (CBR) and unconfined compressive strength (UCS) tests. Results obtained, there was also a tremendous improvement in the CBR and UCS with increase in the RHA and lime at specified contents to their peak values at 6% lime and 10% RHA. The UCS values also improved with curing age and in the combination of lime + RHA, 6% lime+10% RHA showed good improvement in UCS and CBR value with increase in curing period.

Ario Muhammad, (2007) Silica produced from rice husk ashes has investigated successfully as a pozzolanic material in soil stabilization. However, rice husk ash cannot be used solely since the materials lack in calcium element. As a result, rice husk ash shall be mixed with other cementitious materials such as lime and cement to have a solid chemical reaction in stabilization process. For the stabilized soils, the admixture materials, i.e. lime, rice husk ash, were mixed in 12 % and 24 % of the dry weight of soil matrix respectively.

Biswas, (2007) The present investigation has therefore been carried out with agricultural waste materials like Rice Husk Ash (RHA) which was mixed with soil or lime-soil mixture to study improvement of weak sub grade in terms of compaction and strength characteristics. The laboratory test results show marked improvement of strength of soil on addition of admixtures in terms of California Bearing Ratio (CBR). In this study RHA is mixed with lime stabilized soil in which lime is 3%, 6% & 9%. Musa Alhassan, (2008) Soil sample collected from Maikunkele area of Minna, was stabilized with 2-12% rice husk ash (RHA) by weight of the dry soil. Performance of the soil-RHA was investigated with respect to compaction characteristics, California bearing ratio (CBR) and unconfined compressive strength (UCS) tests. The results obtained, indicates a general decrease in the maximum dry density (MDD) and increase in optimum moisture content (OMC) with increase in RHA content. There was also slight improvement in the CBR with increase in the RHA content. Chakraborty & Saibal, (2010) in recent times the need for suitable road materials has increased due to demand of construction activities in the road sector. Keeping this in view stabilization of weak soil in situ may be done with suitable admixtures. Investigation has therefore been carried out with agricultural waste materials like Rice Husk Ash (RHA) which was mixed with soil or lime-soil mixture to study improvement of weak sub grade in terms of compaction and strength characteristics. Abu Siddique (2011), the effects of lime stabilisation on plasticity, shrinkage, swelling, moisture-density relations and strength characteristics of an expansive soil have been investigated. The soil was stabilised with lime contents of 3%, 6%, 9%, 12% and 15%. With the increase in lime content, maximum dry density decreased while the optimum moisture content increased. California Bearing Raito (CBR) of the stabilised samples at all levels of compaction increased significantly with increasing lime content.

II. MATERIALS USED

A.Soil used

Soil sample is collected from a proposed for the construction of road alignment in guduvanchery area, Chennai. Standard tests were conducted to determine the physical properties of the soil and the results are given in Table 1.

Table 1: Physical properties of soil

SL. no	Test Conducted	Result	
1	Wet sieve analysis	% passing 75 microns sieve is 56%, so it is fine grained soil	
2	Liquid limit	36.5 %	
3	Plastic limit	12.62 %	
4	Plasticity index on A-line	11.61 %	
5	Shrinkage limit	21.68 %	
6	Specific gravity	2.23	
7	Free swell index	18.18 %	
8	Standard proctor	OMC 15.15 %	MDD 1.797 kg/cm^3
9	UCS (kg/sq cm)	0.624	
10	CBR	5.48 %	

B. CLASSIFICATION OF SOIL SAMPLE

Based upon the tests performed in laboratory for soil sample and according to the results obtained, the soil sample is classified as follows,

1. 56% of soil is passing through 75 microns sieve so it is fine grained soil.
2. According to A-line Chart , the soil can be classified as clay with Intermediate Compressibility –CI
3. According to free swell index value, the soil is classified as low compressible.

C. Rice Husk Ash (RHA)

Rice husk ash, basically a waste material, is produce by rice - mill industry while processing rice from paddy. Rice husk ash is a pozzolanic material that could be potentially used in soil stabilization, though it is moderately produced and readily available. About 20 – 22% rice husk is generated from paddy and about 25% of this total husk become ash when burn. It is non – plastic in nature. RHA has a good pozzolanic property. The chemical properties of RHA are shown in Table 2

Table 2: Chemical properties of rice husk ash

Chemical	Percentage (%)
Silica(SIO_2)	83.60
Aluminium(Al_20_3)	3.5
Iron($FE0_3$)	1.10
Calcium (CAO)	1.80
Magnesium(MGO)	1.28
Sodium(NA_2O)	0.17
Potassium(K_2O)	0.29

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D. Lime

Lime is a general term for calcium-containing inorganic materials in which carbonates, oxides and hydroxides predominate. Strictly speaking, lime is calcium oxide or calcium hydroxide. It is the name of the natural mineral (native lime) CaO occurs as a product of coal seam fires and in altered lime stone xenoliths in volcanic ejects. The word "lime" originates with its earliest use as building mortar and has a sense of "sticking and or adhering".

These materials are still used in large quantities as building and engineering materials (including limestone products, concrete and mortar) and as chemical feedstock's, and sugar refining, among other uses. Lime industries and the use of many of the resulting products date from prehistoric periods in both the old & new worlds.

The rocks and minerals from which these materials are derived, typically limestone or chalk, are composed primarily of calcium carbonate. They may be cut, crush or pulverized and chemically altered. "Burning" converts them into the highly caustic material quicklime (calcium oxide, Cao) and through subsequent addition of water, into less caustic (but still strongly alkaline) slaked lime or hydrated lime (calcium hydroxide, $CA\ (OH)_2$=74.10), the process of which is called slaking of lime.

III. Laboratory studies

The testing program conducted on the clayey soil samples included determination of the physical and chemical properties of soils at their natural state. On the other hand, the testing program conducted on the clayey soil samples mixed with different percentages of rice husk ash and lime materials, included unconfined compression test and CBR test.

A. Unconfined compression test UCS test is performed in accordance with IS:2720 part 10 (1973). The sample sizes were of 38 mm diameter and 76 mm length. At the optimum moisture content (OMC) and maximum dry unit weight, the tests were performed.

B. California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road sub grades and base courses. It was developed by the California Department of Transportation before World War II.

The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The CBR test is fully described in IS: 2720 part 16 (1987).

IV. RESULTS AND DISCUSSIONS

A.UCC TEST RESULTS

UCC test was conducted in laboratory on soil sample with addition of different percentages of lime and RHA and the results obtained are shown in table no 3 and the figures 1 & 2 shows the graphs for UCC. Figure 1 shows the UCS value for different percentages of lime and figure 2 shows the UCS value for different percentages of RHA.

Table 3: UCC Test Results on soil sample

Additives	UCS Value (Kg/Sq Cm)		
	4 days	7 days	14 days
3% LIME	2.338	5.32	6.464
6% LIME	4.558	6.26	8.62
9% LIME	1.662	3.698	4.504
5% RHA	2.248	3.29	4.068
10% RHA	3.344	4.552	6.14
15% RHA	1.788	2.75	3.148

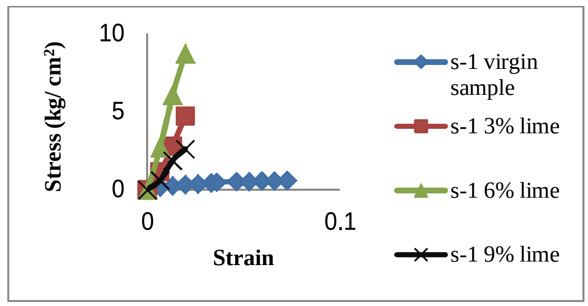

Figure 1: UCS value for lime

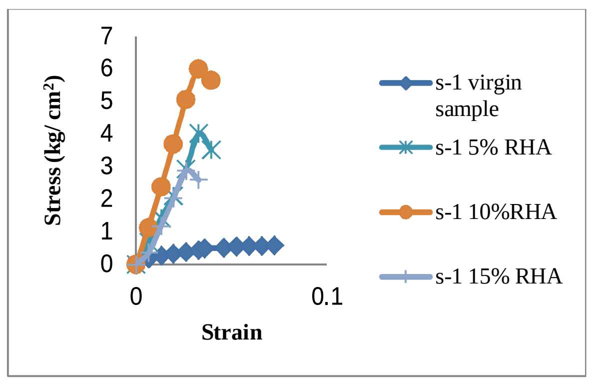

Figure 2: UCS value for RHA

B. DISCUSSION FOR SOILSAMPLE

Based on the ultimate UCS value as shown in Figure 3 & 4, the CBR test was performed for 6% of lime and 10% of RHA individually and combination of lime + RHA is done for 6% lime with different percentages of RHA i.e. (5%, 10%, and 15%).

C.CBR TEST RESULTS

CBR test was conducted in laboratory on soil sample with addition of different percentages of lime and RHA and the results obtained are shown in Table 4.

Table 4: CBR Test Results for Soil Sample

Additives	CBR Value For Curing Period			
	0 day	4 days	7 days	14 days
6% LIME	13.95	33.11	50.8	66.75
10% RHA	7.9	8.21	9.8	13.77
6% LIME + 5% RHA	14.56	26.7	27.54	39.73
6% LIME + 10% RHA	17.21	29.66	45.8	56.68
6% LIME+ 15 % RHA	7.9	20.13	21.33	27.8

Figure 3 shows the graph drawn for CBR value for 6% of lime and 10 % of RHA which can be compared with virgin sample. Percentage of lime and RHA are taken from ultimate UCS value.

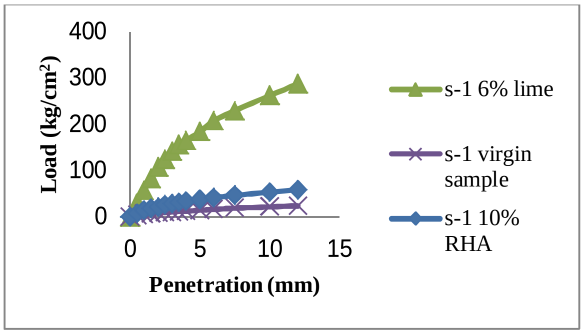

Figure 3: CBR value for lime and RHA

Figure 4 shows the graphs drawn for combination of lime +RHA in which ultimate UCS value of 6% lime is taken and mixed with RHA in different percentages i.e. (5, 10, and 15%). For which 6%lime + 10% RHA is giving the ultimate value.

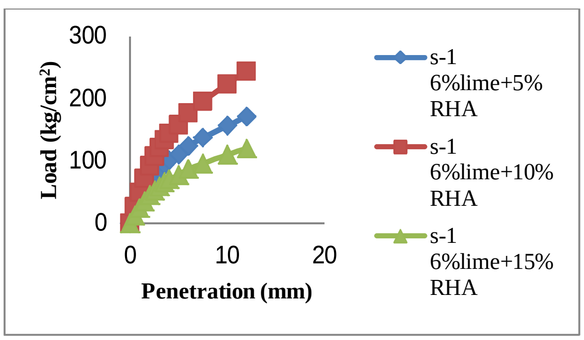

Figure 4: CBR value for lime+ and RHA

V. CONCLUSION

- Based on the UCS value comparison, 6% addition of lime showed the good improvement of 92.74% in UCS value for 14 days curing compared to virgin soil and for 10% of RHA with 89.93% for a same period of curing.
- CBR test was performed based on addition of 6% of lime for curing period of 14 days which showed an improvement of 91.79% and for the 10% RHA, CBR value was increased up to 60.20% at 14th day. CBR test is also conducted for the combination of lime+RHA in which lime is taken as 6% and the combination of RHA is done in different percentages i.e (5%, 10%, & 15%) in which maximum improvement of CBR is observed in the combination of 6%lime+10%RHA for which % of CBR improvement are 90.65% for 14th day of curing comparing with virgin sample.
- Addition of industrial waste (RHA) alone gave an average improvement of 60% when compared with virgin sample. When the additive lime is added to it the CBR value increased to great extent which had been mentioned above (91%). So based on the respective results, quality of soil is increasing from poor condition to excellent condition based on CBR test values. As per the Pavement Design, when the California Bearing Ratio increases, the sub grade thickness can be reduced. So the RHA and Lime can be used to improve the CBR ratio respectively.

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