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EXPERIMENTAL STUDY ON STABILISED GRAVEL FOR ROAD SUB BASE

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ABSTRACT

The present investigation has been carried out with easily available materials like lime and rice husk ash mixed individually and in combinations with different proportions. The different percentages of lime with respect to weight of dry soil were 2%, 4%, 6%, 8% 10% and for rice husk ash (RHA) were 2%, 4%, 6%, 8% and 10%. In each case the stabilized soil was compacted at optimum moisture content (OMC), 2% above and 5% above optimum moisture content (OMC+2, OMC+5). In each case California Bearing Ratio (CBR) tests and in case of compaction at OMC Unconfined Compressive Strength (UCS) tests were performed. The effect of curing on UCS samplesup to 180 days with the intervals of 30 days was also studied. It was found that CBR of original soil improved from 4.25% to a maximum value 28.25% when mixed with combination of 6% lime and 9% rice husk ash (RHA) under unsoaked conditions and from 3.5% to 29.82% when mixed with a combination of 6% lime and 9 % rice husk ash (RHA) with respect to dry weight of soil under soaked condition at optimum moisture content. The unconfined compressive strength (UCS) of original soil improved by 253% when mixed with 6% lime and 6% rice husk ash (RHA), however the maximum value of UCS is attained by a value of 285% when mix proportion of 4% lime and 9% rice husk ash. Based on the laboratory test results correlations have been developed between California Bearing Ratio (CBR) for different placement of moisture contents and also respective values of Unconfined Compressive Strength (UCS) considering each of them as function of different soil parameters. The study incorporates an exhaustive and systematic experimental programmer. This helps in searching the most cost effective design mix of rice husk ash and lime admixtures with near surface alluvial soil,

extensively used for construction of sub- grade. It is concluded from this study that desired CBR and UCS values may be obtained on mixing a limited quantity of lime with soil when rice husk ash is also used as an auxiliary stabilizer making the mix cost effective

I. INTRODUCTION

India has a road network of more than 33lakhs km which is the second largest road connecting system in a country in the world. At 0.66 km of roads per square kmof land, the quantitative density of India‟s road network is similar to that of the United States (0.65). About 65% of fright and 80% of passenger traffic area carried bythe roads. In spite of having the biggest railway network, the road transport has remained a preferred choice in our country. This is because of its flexibility, accessibility to remote areas and adaptability to changes for achieving the desired objective of connectivity. The overall development of any country depends on a goodand well- connected road network. Roads are one of the strongest measures of economic activity and the development of any nation. Accumulation of various waste materials is now becoming a major concern to the environmentalist. So the safe disposal of these waste materials is very vital issue and challenging task for the engineers and technologists. This problem can be greatly mitigated by the bulk utilization of such waste materials mainly in the field of Civil Engineering.

Out of many stabilizing materials lime improves the soil much with its little addition by pozzolanic reaction. Lime reduces the plasticity index of soil making it more friable and easy for handling and pulverized. There are generally an increase in Optimum Moisture Content and decrease in Maximum Dry Density but the strength and durability increases. Hydrated (slaked) lime is very useful in treating heavy, plastic clayey soils. Lime may be used alone or in combination with cement, fly ash,or other pozzolanic materials like rice husk ash etc. Lime has been mainly used for stabilizing the road bases and sub grades.

Rice husk is an agricultural waste material obtained from milling of the rice. About 770 million tons of rice husks are produced annually in Asia. In India it is approximately 120 million tons per annum. In developed countries, where the mills are typically large, disposal of the husks is a big problem for the environment and also burning them in an open place is not desirable, so the majority of the husk is currentlyused for land filling. This waste material, if suitable, can be used for the economic utilization in construction of road system. Therefore a systematic detailedinvestigation should be undertaken to make possible use of rice husk ash (RHA) to improve the quality of weak subgrade soil so that it can be used with desired improvement for cost effective construction of good quality of subgrade.

II. REVIEW OF LITERATURE

Roy (2014) conducted the study of soil stabilization by using the rice husk ash (RHA) and cement. The experimental study established the suitability of locally available materials like rice husk ash (RHA) is used in the construction industry. The effectiveuses of rice husk ash (RHA) also minimize the waste disposal as well as environmental hazards. In this study three different percentage of rice husk ash (RHA) such as 10%, 15% and 20% are used and mixed with soil. In each case 6%cement was mixed with it to get the adequate cementation property of the mix. To study the effect of admixture the CBR and UCS tests were carried out of the above Mix proportions. From the experimental results it was found that the unsoaked CBRvalue improved by 106% at 10% RHA and 6% cement and after that it is slightly tobe decreased. The similar trend was in UCS results which improved 90.6% of the same mix proportions. The improvements of CBR and UCS value as reported by herare shown in the Fig. 2.1 and Fig. 2.2. Hence the maximum improvement in strength of soil occurs when it is mixed with 10% RHA and 6% cement as an optimum amount.

Yadav et.al (2014), studied the effect of lime and RHA on the Index property of Black cotton Soil. In the experimental investigation they used black cotton soil blended with 5% lime and treated by mixing of RHA in 5%, 10%, 15%, 20%. A seriesof laboratory test such as Grain Size, Specific gravity, liquid limit, plastic limit, Shrinkage limit and Differential free swelling were conducted to study the effect of RHA used as admixture to the black cotton soil. The laboratory test result indicated a marked change in index property of black cotton soil. The plastic limit increased from 22.7% to 29.5% and Shrinkage limit increases from 8.61% to 13.76%, but Specific gravity decreased from 2.56 to 2.40 and DFS decreased from 54.3% to 7.10. Based on this investigation they concluded that the swelling behavior of lime stabilized black cotton soil decreased with addition of RHA.

III. OBJECTIVES

The main objectives of the present study are as follows:-

- To examine the applicability, effectiveness and suitability of mixing lime and some locally available agricultural waste materials such as Rice Husk Ash(RHA) in isolation and in different combinations as ground improving materials for use in soft cohesive sub-grade of a flexible pavement.

- To find out the best possible design mix proportion of the chosen soil and admixtures used which gives maximum strength of stabilized soil compared tothat of the original soil.

IV. METHODOLOGY

All the tests of soil before and after stabilization with different RHA and lime contents were carried out as per the procedures recommended in the relevant IS codes. For laboratory tests, specimens of soil with and without admixtures were prepared by thorough mixing the required quantity of soil and stabilizers in pre-selected proportions in dry state and then required quantity of water was added and mixed thoroughly to get a homogeneous and uniform mixture of soil and admixtures. The California Bearing Ratio tests were performed under both soaked and unsoaked conditions, with different water content such as OMC, OMC+2 and OMC+5. The 2%, 4%, 6%, 8% and 10% proportions were used in cases of lime and 2%, 4%, 6%, 8 %, 10% for RHA. Laboratory tests were conducted following the procedure recommended in different IS codes. The different IS codes followed for different tests are referred in below Table 1.

Table 1: IS Codes for different tests

Name of tests	Relevant IS code
Specific Gravity	IS : 2720, Part-3, 1987
Grain Size Analysis	IS : 2720, Part-4,1985
Classification and Identification of Soil	IS : 1498,1970
Atterberg Limits	IS : 2720, Part -5,1985

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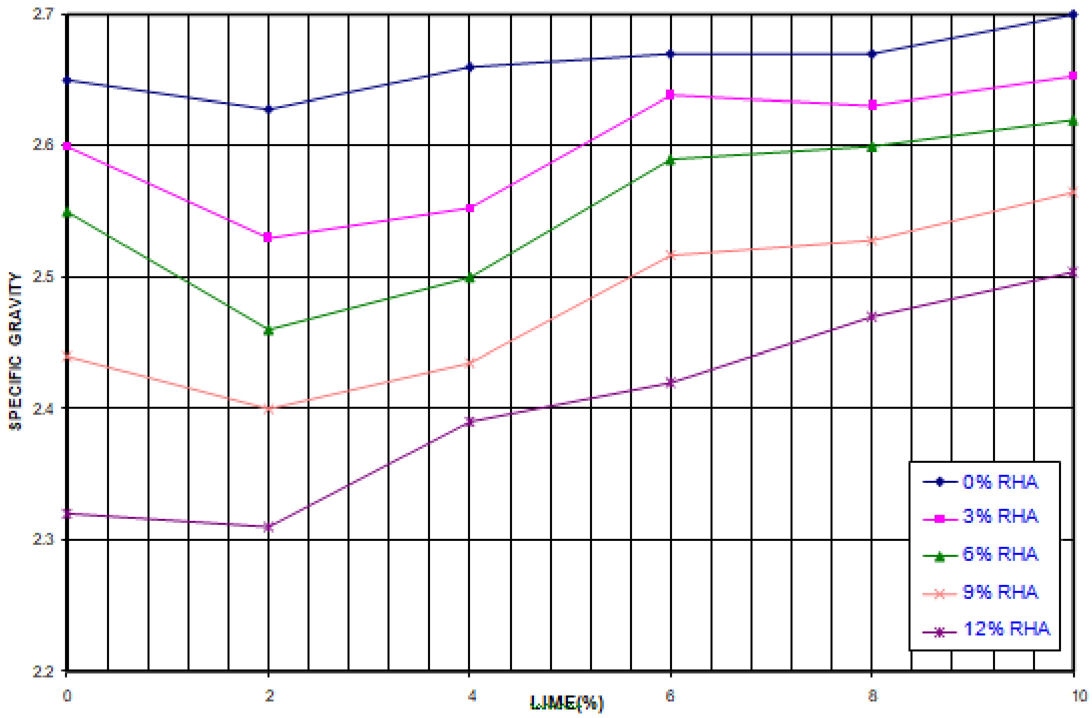
Light Compaction Test	IS 2720, Part-6, 1980.
Laboratory CBR	IS :2720, Part-16,1979

V. RESULTS

A. Specific gravity

The variations of specific gravity of soil, lime and rice husk ash combinations with different percentages of admixtures are given in details in Graph 1. It appears from the plot that specific gravity decreases with increasing additionof lime upto 2% irrespective of RHA content. But with addition of lime more than 2%, it again increases asymptotically to a constant value. But increase in RHA contentit decreases for any lime content, however with high lime percentages although it follows similar patterns but rate of variation falls. Increase of specific gravity with addition of lime beyond 2% indicates effect of chemical action of lime being predominant above this percentage.



Graph 1: Variation of Specific Gravity with Lime content for differentRHA contents

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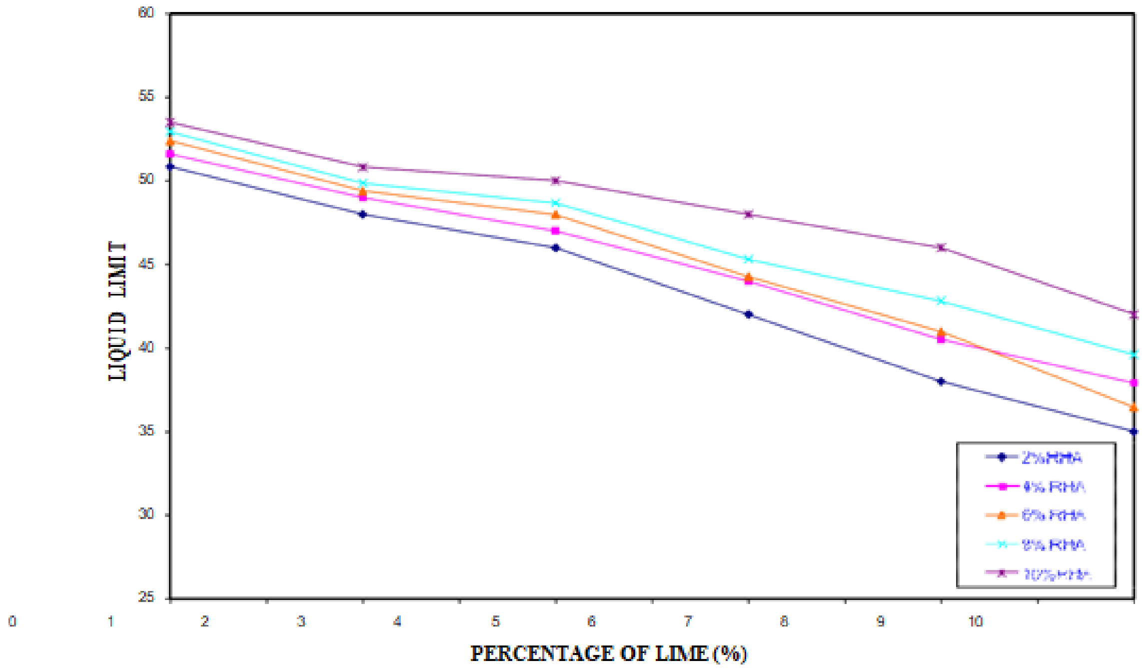
B. Atterberg limits

When only lime is added liquid limit decreases with increasing lime percentage and plastic limit increases decreasing plasticity index. This also agrees with the result of grain size analysis. When only RHA is added liquid limit and plastic limit both increase but not appreciably and plasticity index almost remains in the range of that of original soil although effect of plasticity index is much pronounced when RHA content is as high as 10%. When lime and RHA are added in combination their combined effect decreases the plasticity index indicating an expectation of better strength which is justified later.



Graph 2: Variation of Liquid Limit with Lime content for different RHA contents

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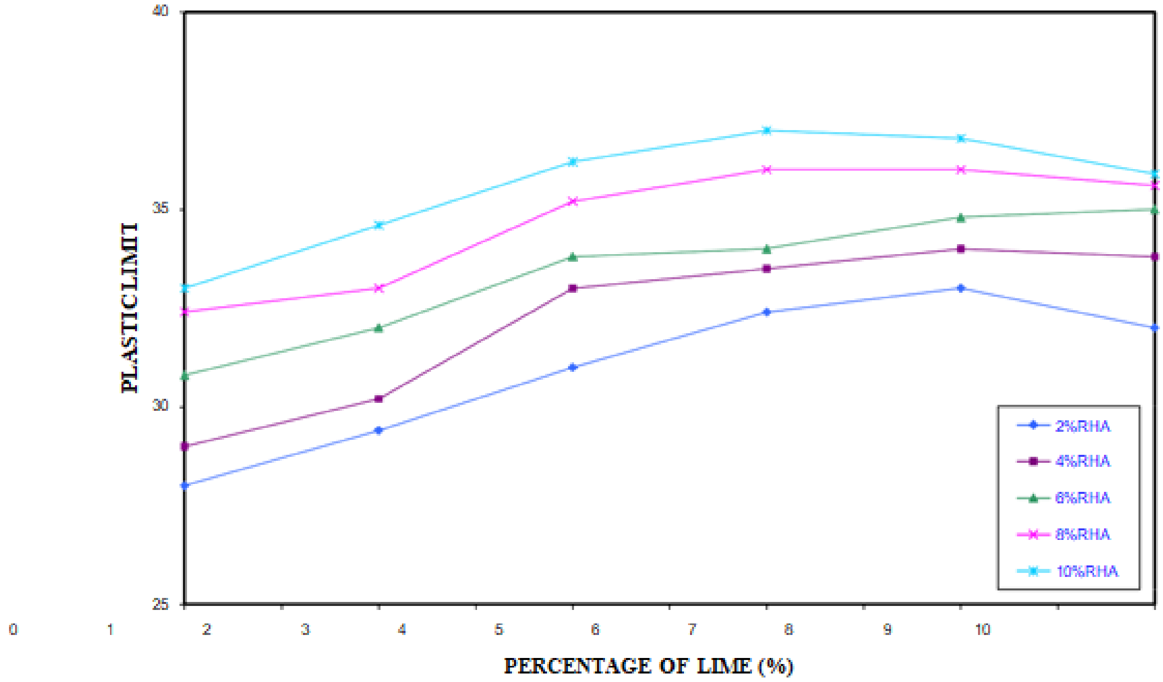
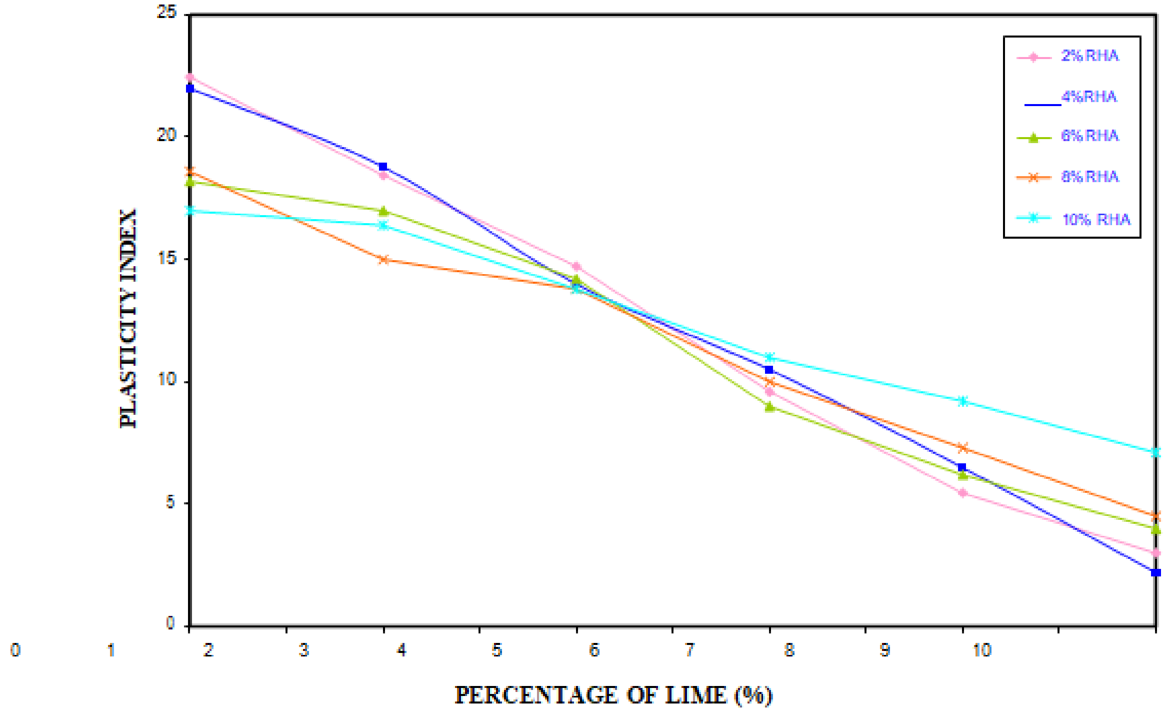


Graph 3: Variation of Plastic Limit with Lime content for different RHA contents



Graph 4: Variation of Plasticity Index with Lime content for different RHA contents

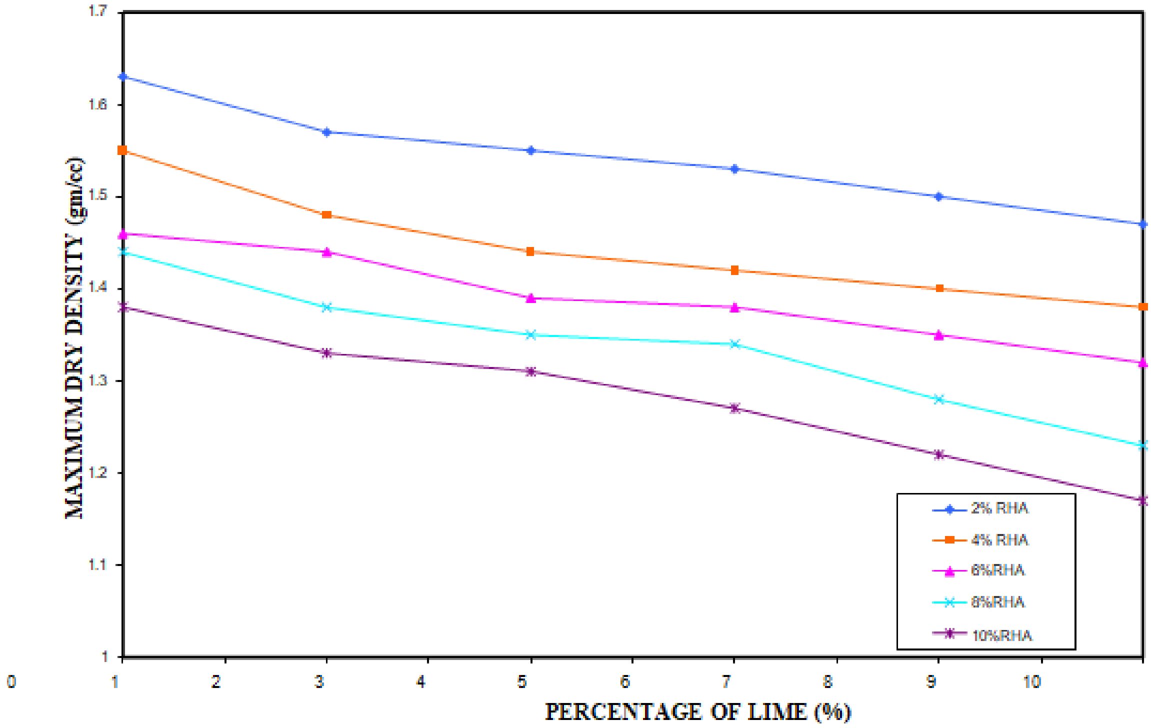
C. Compaction properties

In this section the effect of addition of different admixtures with the original soil in varying proportion has been discussed. In this study the compaction property in terms of optimum moisture content and maximum dry density for original soil and stabilized contained soil.

a. Maximum dry density

The maximum dry density (MDD) continues to decrease with increase in lime content for a given rice husk ash (RHA) content The maximum dry density (MDD) is abrupt but linear like the soil rice husk ash (RHA) mixture. The decrease in

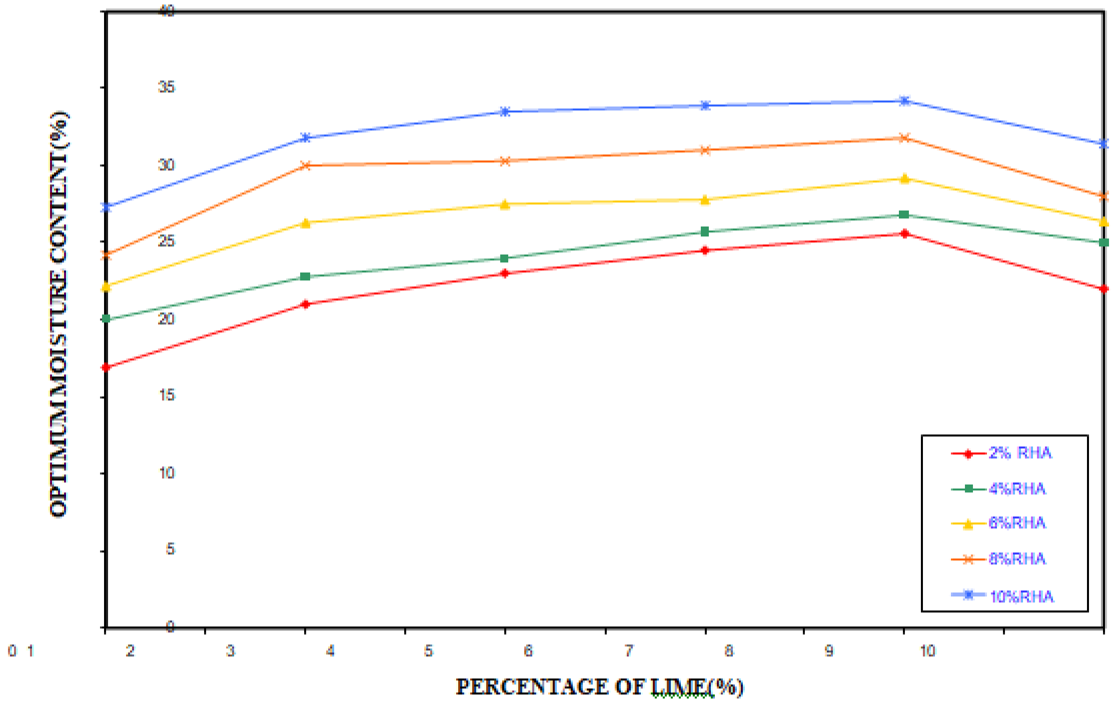
dry density indicates that it required low compaction energy than the virgin soil to attain its maximum dry density (MDD), as a result the cost of compaction will be decreasing. This is due to the flocculation and agglomeration of clay particles caused by cation exchange reaction leading to corresponding decrease in dry density. The decrease in MDD of the lime treated soil is reflection of the increased resistance offered by the flocculated soil structure to the compactive effort. The maximum dry density (MDD) is generally reduced with the increase in combined amount of lime and rice husk ash (RHA) combination. The decreasing trend of maximum dry density (MDD) can be attributed to the cationic exchange of the limewhich induces flocculation and agglomeration of the clay particles. Again decrease in maximum dry density (MDD) with addition of rice husk ash (RHA) may be attributedto the replacement of soil with the rice husk ash (RHA) which have relatively low specific gravity (1.95) as compared to that of original soil, (specific gravity = 2.63). The decrease in maximum dry density (MDD) may also be attributed to coating of the soil particles by rice husk ash (RHA)which results in larger particles with larger voids and hence lesser density (Alhassan, 2008; Okafor et al. 2009).



Graph 5: Variation of Maximum Dry Density with Lime content for different RHA contents

b. Optimum moisture content

The possible cause of increased water demand with increase of lime content may be the requirement of more water for dissociation of lime into Ca^{++} ions and OH- ions to supply The results of the optimum moisture content (OMC) for soil-lime and rice husk ash combinations with different percentages are illustrated in below graph. For soil-limeat 0% rice husk ash (RHA), generally the optimum moisture content (OMC) increases with increasing lime content up to 6% and then decreases. The increase in optimum moisture content (OMC) in spite of the reduced the surface area is caused by flocculation and agglomeration, which is due to the additional fine contents requiring more water in addition to the free lime that needs more water for the pozzolanic reactions. Tmore Ca^{++} ions for the cation exchange reaction. The increase in OMC due to addition of RHA may be attributed to the fact that RHA decreases the quantity of freesilt and clay fraction and as a result quantity of coarser materials with greater surfacearea increases. Hence more water is required to compact the soil-RHA mixtures.

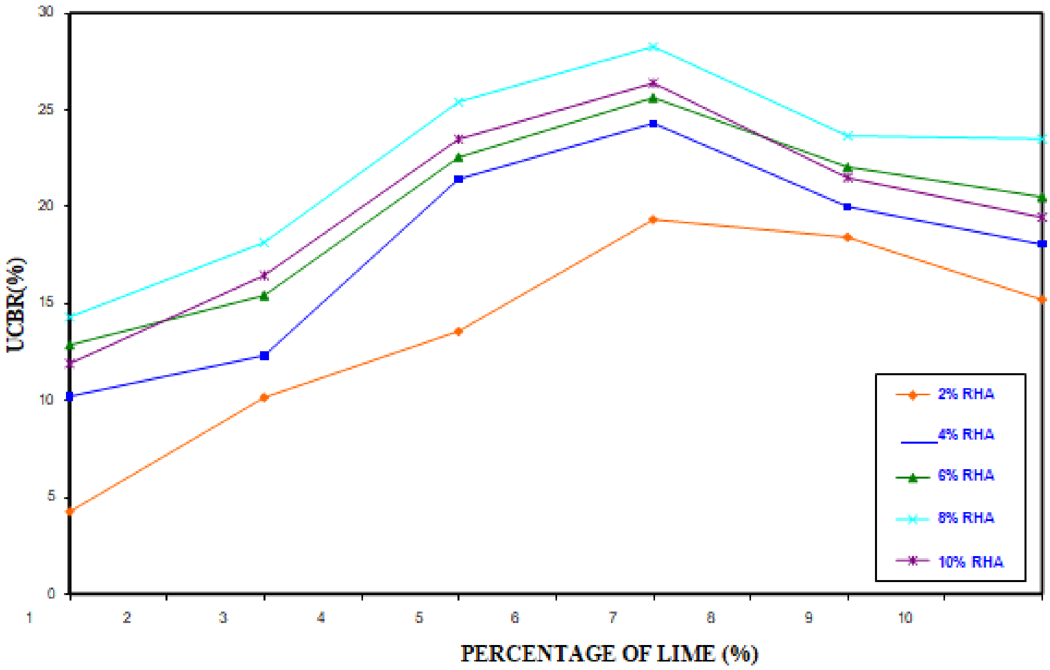


Graph 6: Variation of Optimum Moisture Content with Lime content for different RHA contents

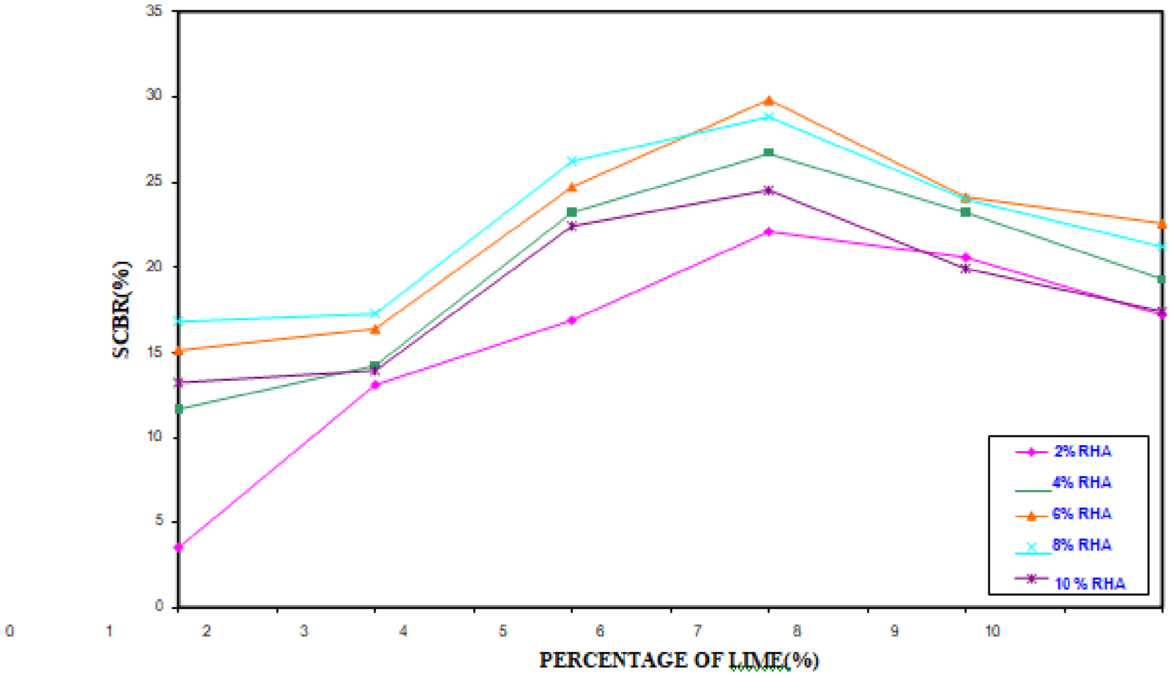
D. Strength properties

In this section the strength characteristics of original soil and admixture mixed soil in terms of CBR and UCS tests have been presented. The CBR tests are performed with different moisture contents such as OMC, OMC+2% and OMC+5% and load vs. penetration curves for various moisture contents are presented in below graphs. The general nature of CBR values of lime admixed soil is increasing with the increase in lime content and in all cases the range of soaked CBR is more than unsoaked CBR. In UCS tests the curing effects have studied upto 180 days with the intervals of 30 days. The curing has marked influence in the strength property of soils mixed with stabilizers like rice husk ash and lime.

a. CBR at OMC

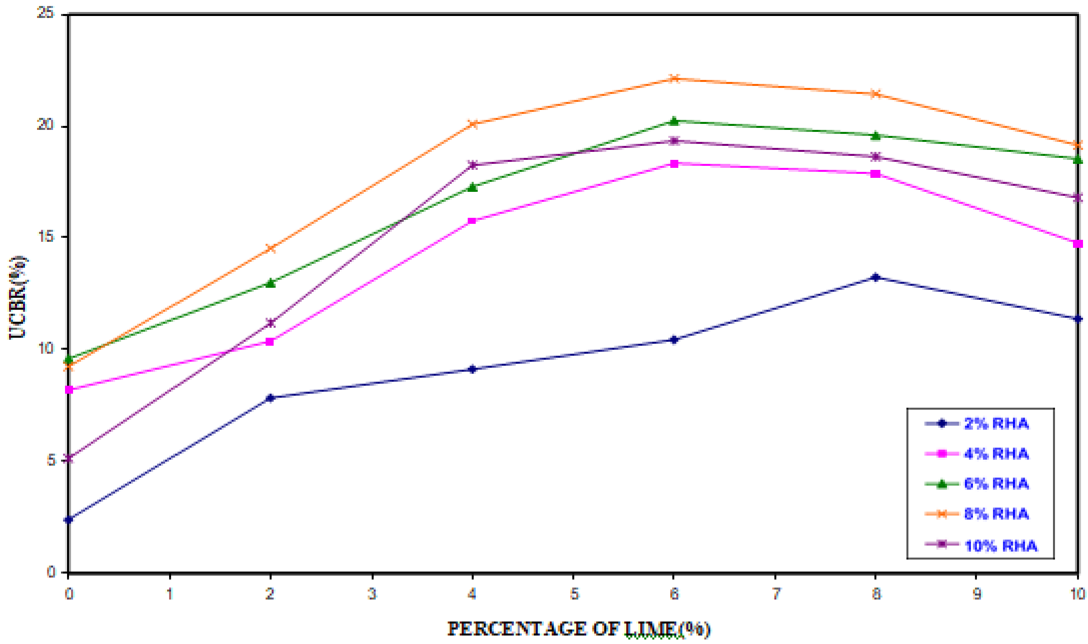


Graph 7: Variation of California Bearing Ratio with Lime and RHA Combinations in unsoaked condition at Optimum Moisture Content

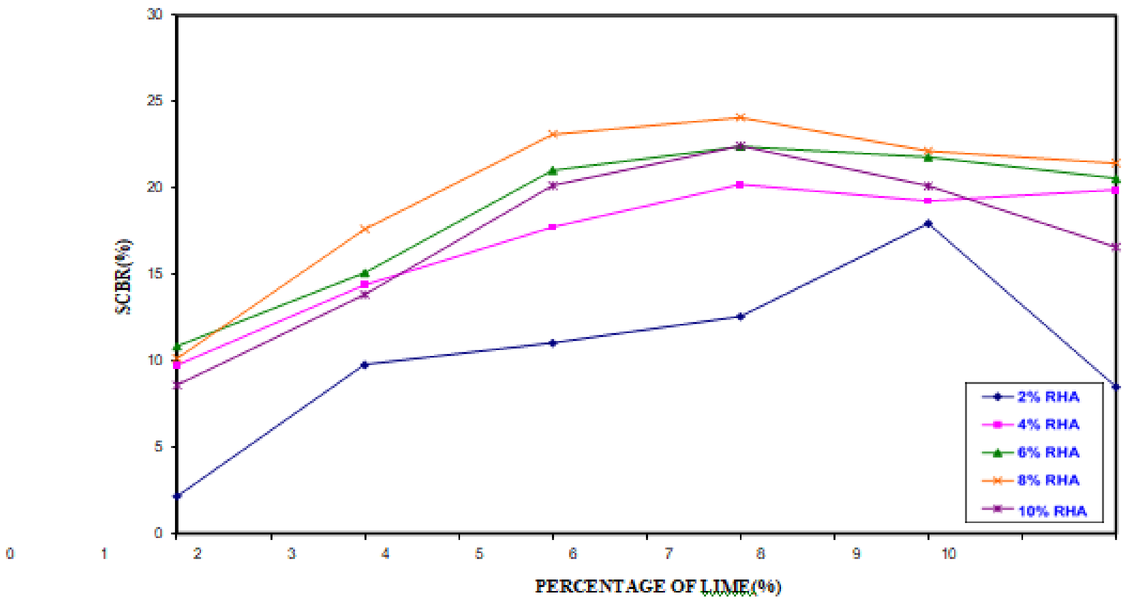


Graph 8: Variation of California Bearing Ratio with Lime and RHA Combinationsin soaked condition at Optimum Moisture Content

b. CBR AT WATER CONTENT ABOVE OMC (OMC+2%, OMC+5%)

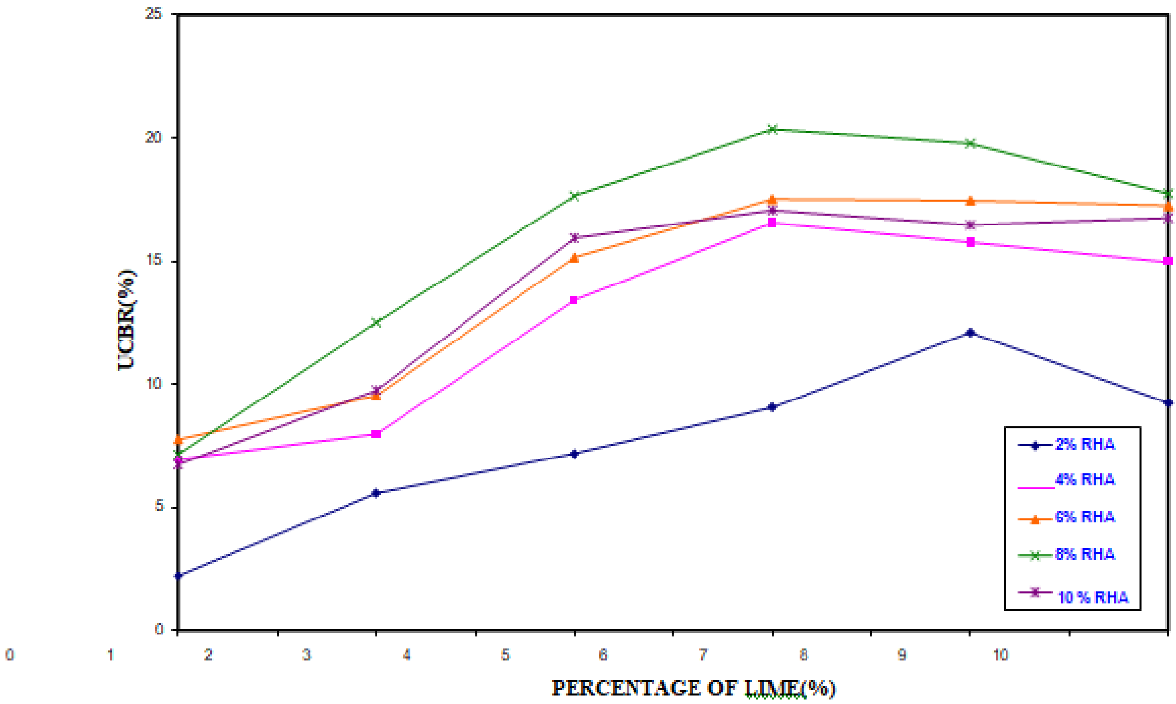


Graph 9: Variation of California Bearing Ratio with Lime and RHA Combinationsin unsoaked condition at 2% higher than Optimum Moisture Content



Graph 10: Variation of California Bearing Ratio with Lime and RHA Combinationsin

soaked condition at 2% higher than Optimum Moisture Content



Graph 11: Variation of California Bearing Ratio with Lime and RHA Combinationsin unsoaked condition at 5% higher than Optimum Moisture Content

VI. SUMMARY

In order to study improvement of clayey subgrade with addition of lime and rice huskash as admixtures, a locally available clayey soil was collected. The soil was mixedwith lime (2%, 4%, 6%, 8%, 10%) and RHA (2%, 4%, 6%, 8%, 10%) by weight individually. The geotechnical properties of clay such as specific gravity, atterberg limits was studied in case of soil, lime and RHA individually and for total 30 mixes with different combinations of soil, lime, RHA with different percentages by weight.The changes in compaction properties with addition of admixtures were also studied. The effects of improvement were studied by conducting CBR and UCS tests. The effect of curing on UCS values for different curing periods was also studied for a maximum period of 180 days. The CBR tests were conducted at different moisture contents e.g., OMC, OMC+2% and OMC+5% to study the strength improvement at higher water contents.

VII. CONCLUSIONS

The following conclusions can be drawn from the present investigation

a) The treatment of soil with addition of admixtures such as lime and RHA has a general trend of decrease in liquid limit and increase in plastic limit and decreaseof plasticity index.
b) The specific gravity decreases with increase of addition of lime up to 2% irrespective of RHA content. But with addition of lime more than 2%, it again increases asymptotically to a constant value and further increase in RHA content it decreases for any lime content.
c) The liquid limit decreases for all soil-lime-rice husk ash combinations and the stabilized soils appear to be suitable for construction as pavement materials for the flexible pavements as is seen from CBR values.The optimum moisture content increases with increasing lime content up to 6% and RHA content up to 12% and then decreases.
d) The strength characteristics in terms of CBR value is found to increase appreciably with addition of RHA at lower lime content when compared to theoriginal soil. This is due to the pozzolanic action of lime and RHA.
e) Soil, when mixed with lime and RHA combinations the CBR values increase appreciably both under soaked and un-soaked conditions.
f) The maximum CBR value of 28.25% is found to occur with the combination of 6% of lime and 8% RHA contents under un-soaked condition and this value increases up to 29.82% for 6% of lime and 6% RHA combination under soaked condition at the optimum moisture content. This should be considered for estimation of optimum quantity of lime rice husk ash to be used for working in the field.
g) The curing period has the influence on the UCS value of admixture contained soil. The UCS value increases with the curing period for a fixed lime and RHA content, up to 9% of RHA and 8% of lime individually and beyond these limiting values the unconfined compressive strength decreases.
h) Further research in the area relevant to the present research may be carried out in the

following directions. Study of improvement of clayey subgrade with other materials like waste rubber tire pieces, fly-ash and low cost materials. Study of dynamic properties of different materials conducting cyclic triaxial tests. Post cyclic change of strength of the materials may also be investigated. The above study may also be supplemented be by conducting field tests and numerical modeling to obtain the effect of improvement of different alternative materials.

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