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Utilization of Rice Husk Ash in Soil Subgrade Stabilization

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ABSTRACT : Soil stabilization has been found to be very effective in upgrading the bearing capacity of weak soil subgrade. The stabilizing agent, for cost efficiency, ought to provide a cheaper alternative to other possible processes. With the rapid industrialization efforts around the globe, enormous quantities of waste materials are generated and there has not been adequate mechanism for recycling and re-use of such wastes to reduce the consequent environmental problems and hazardous situations created as a result. The objective of the study is to upgrade subgrade soilfrom generally available in Haryana State using rice husk ash. The laboratory investigation carried out on the natural soils shows that these falls under silt of low plasticity (ML type) and silty sand (SM types) using Indian Standard Classification System, after that testing program conducted on natural soil samples and mixed with different percentages of rice husk ash included Atterberg limits, specific gravity, modified proctor test and CBR test. It was found that liquid limit increased with addition of rice husk ash while plasticity index of ML type soil decreased but SM type is a non-plastic soil. The results obtained show that the increase in rice husk ash content increase in OMC but decrease the MDD. Also, the CBR value of both soils is considerably improved with rice husk ash content. So in order to achieve both the need of improving the properties of soil subgrade and also to make use of the agricultural wastes, the present experimental study has been taken up.

Keywords: Materials, Rice Husk Ash and Soil Stabilization.

1 INTRODUCTION

1.1 General

An extensive and good quality road network is one of the majorparameters for the development of a country's social and economic condition. The basic necessity for a good quality road structure is good and strong subgrade over which the road is constructed.But in many parts of the country, the sub-soil is of poor quality due to low strength and high compressibility. So there is a necessity for improving properties of soil subgrade which can improve the bearing strength of the subgrade soil by using admixtures like fly ash, rice husk ash lime etc. With the ever increasing demand and consumption of cement and in the backdrop of waste management, scientists and researchers all over the world are always in quest for developing alternate binders that are environment friendly and contribute towards sustainable management. Rice husk ash which is a agricultural wastes can be used as a stabilizer.

The main objective of this research paper is to perform CBR (California Bearing Ratio) test on natural soils and mixed with different percentage of rice husk ash in order to observe the effect of these admixtures on CBR values of soils

1.2 Soil Stabilization

Soil Stabilization is the process of improving the engineering properties of the soil subgrade and thus making it more stable. In its broadest senses, stabilization includes increasing load bearing capacity of soil subgrade, to reduce permeability and to reduce compressibility of soil subgrade.

The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils.

Generally the weaker subgrade soil can be tackled in two ways. In the first process weaker soil may be replaced by superior soil, this is not an engineered solution of the problem also this may be very expensive especially when fill material is borrowed from a distant place. Second alternative is to improve the engineering properties of the soil by means of stabilization using different admixtures.

Benefits of the stabilization process can include reduction in plasticity, reduction in pavement thickness, elimination of excavation materials hauling or handling and lower permeability.

1.3 Objective of Present Study:

The objectives of present study are determination the properties of the selected soil subgrade and admixtures, improvement CBR value of soil subgrade using RHA which are waste material and determination the performance stabilized soil subgrade with an optimum of RHA and its suitability as a soil Stabilizer.

2 LITERATURE REVIEWS

Dr. Robert M. Brooks (2009) "Soil stabilization with fly ash and rice husk ash" The objective of this paper is to upgrade expansive soil as a construction material using rice husk ash (RHA) and fly ash, which are waste materials. Remolded expansive clay was blended with RHA and fly ash and strength tests were conducted. The potential of RHA-fly ash blend as a swell reduction layer between the footing of a foundation and subgrade was studied. In order to examine the importance of the study, a cost comparison was made for the preparation of the sub-base of a highway project with and without the admixture stabilizations. Stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the fly ash content was increased from 0 to 25%. When the RHA content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97% while CBR improved by 47%. Therefore, an RHA content of 12% and a fly ash content of 25% are recommended for strengthening the expansive subgrade soil. A fly ash content of 15% is recommended for blending into RHA for forming a swell reduction layer because of its satisfactory performance in the laboratory tests.

Grytan Sarkar, Md. Rafiqul Islam, Dr. Muhammed Alamgir and Dr. Md. Rokonuzzaman (2012) demonstrates the effects of rice husk ash on the geotechnical properties of soil in stabilized forms specifically strength, workability, compaction and compressibility characteristics. Therefore, laboratory tests such as compaction, Atterberg limits, free swell index, unconfined compressive strength, direct shear and consolidation tests for different percentages of rice husk ash content and original soil samples were performed. The test results of study shows that the soil can be made lighter which leads to decrease in dry density and increase in moisture content and reduced free swelling and compressibility due to the addition of rice husk ash with the soil. Besides that the unconfined compressive strength and shear strength of soil can be optimized with the addition of 10% rice husk ash content.

Mohammed Y. Fattah, Falah H. Rahil, Kawther and Y. H. Al-Soudany (2013)experimental study carried out on three different soils improved with different percent of rice husk ash. Samples were brought from different sites of Iraq. The testing program conducted on the clayey soil samples mixed with different percentages of rice husk materials, included Atterberg limits, specific gravity, compressibility, unconfined compression test and consolidation test. It was found that the liquid limit of the three soils has been decreased by about (11-18) % with the addition of 9% RHA, while the plasticity index decreased by about (32-80) %. Treatment with rice husk showed a general reduction in the maximum dry unit weight with increase in the rice husk content to minimum values at 9% rice husk content. The optimum moisture content generally increased with increase in the RHA content. There is enormous increase in the unconfined compressive strength with increase in rice husk content for the soil to its maximum at RHA between (6-8) %.

M. Prakash and Dr. J. Jeyanthi (2013) "Effect of rice husk ash and fly ash on engineering properties of expansive soil" In this study, waste materials such as tice husk ash and fly ash are added to the expansive soil which resulted in considerable improvement in the strength characteristics of the expansive soil. Initially, the clay soil was obtained when mixed with FA and it was found that the maximum Unconfined Compressive Strength (UCS) of clay soil was obtained when mixed with 20% FA. Further, the optimum value of 20% FA was replaced partially with RHA in varying proportions by dry weight of soil with an increment of 5%. Atterberg's limits, maximum dry density (MDD), UCS and California Bearing Ratio (CBR) were the properties taken into consideration. UCS of clay soil after replacing by RHA increased by 30% and CBR increased by 10.5%. This increase in percentage was obtained for the proportion 15% RHA and 5% FA.

A.K. Singhai and S.S. Singh (2014) "Laboratory study on soil stabilization using fly ash and rice husk ash" The objective of this paper is to upgrade expansive soil as a construction material using rice husk ash (RHA) and fly ash, which are waste materials. Soil is a peculiar material. Some waste materials such Fly Ash, rice husk ash, pond ash may use to make the soil to be stable. Addition of such materials will increase the physical as well as chemical properties of the soil. Some expecting properties to be improved are CBR value, shear strength, liquidity index, plasticity index, unconfined compressive strength and bearing capacity etc. The objective of this study was to evaluate the effect of Fly Ash and Rice husk ash to improve the performance of black cotton soil. In this paper black cotton soil is treated with fly ash (5%,10%,15%,20%,25%) and rice husk ash (10%,15%,20%,25%,30%) and examine after 28 days of curing.

S.Chakraborty , S.P.Mukherjee , S.Chakrabarti and B.C.Chattopadhyay (2014)"Improvement of Sub Grade by Lime and Rice Husk Ash Admixtures" The quality of a flexible pavement depends on the strength of its sub-grade soil. The strength of sub-grade is the major parameters for determining the thickness of pavement. In case of the flexible pavement the sub-grade must be uniform in terms of geotechnical properties like shear strength, compressibility etc. Materials selected for use in the construction of sub-grade must have to be of adequate strength and at the same time it must be economical for use. In view of the above the present investigation has been carried out with easily available materials like lime and rice husk ash mixed individually and also in combination with locally available clayey soil in different proportions at optimum moisture content (OMC). Since CBR is an important criterion in flexible pavement design, the strength improvement has been found in terms of CBR in the present study. The laboratory test results shown marked improvement of strength of soil with the addition of admixtures in respect of California Bearing Ratio (CBR) in unsoaked and soaked condition.

3 MATERIALS USED

3.1 Soil Samples

For the present study, soils are collected form two different places of district Jind (Haryana). The soil was excavated from a depth of 1.5m from natural ground level.

3.2 Rice Husk Ash

Rice husk is an agricultural waste obtained from milling of rice. When rice husk is burnt under controlled temperature, ash is produced and about 17% - 25% of rice husk's weight remains ash and rice husk ash is also a pozzolanic material that could be potentially used to improve the bearing strength of the subgrade. For the present study rice husk ash collected from the Vita Milk Plant, Jind (Haryana).

4 LABORATORY STUDIES

The testing program conducted on the selected soil samples included determination Atterberg's limits, grain size distribution, specific gravity of soil samples and admixtures, maximum dry density, optimum moisture content and CBR value mixed with different percentage of rice husk ash.

4.1 Liquid Limit: The liquid limit test was conducted on samples passing 425µ sieve; natural soil and soil mixed different proportions rice husk ash using casagrande's liquid limit apparatus as per the procedures laid down in IS 2720: Part 5: 1985.

4.2 Plastic Limit: The plastic limit test was conducted on samples passing 425µ sieve; natural soil and soil mixed different proportions rice husk ash as per specifications laid down in IS 2720: Part 3: 1985.

4.3 Grain Size Distribution: Grain size distribution method is used to evaluate the uniformity of soil particles, and to classify soil type. The soil sample passing through 4.75mm sieve is taken for sieve analysis. The sieve analysis method is used in the present study for grain size distribution as per the procedure laid down in IS 2720: Part 4: 1985.

4.4 Specific Gravity: The specific gravity test was conducted using pycnometer bottle on the soils and admixtures in accordance with IS 2720: Part 3: 1980.

4.5 Modified Proctor Test: The modified Proctor test was developed to represent heavier compaction than that in the standard proctor test. The test is used to simulate the field conditions where heavy rollers are used. The Indian Standard Code IS 2720: Part 8-1983 gives the specifications and guidelines for heavy compaction test.

4.6 California Bearing Ratio Test: The CBR test was conducted on samples passing 19mm sieve and retained 4.75mm sieve; natural soil and soil mixed different proportions rice husk ash using CBR test machine as per the procedures laid down in IS 2720: Part 16: 1987.

5 RESULTS AND DISCUSSIONS

The study explains the effect of different rice husk ash percentages on different selected soils. The results of this study with their discussions are presented in the following paragraphs.

5.1 Results of Atterberg's Limit Test:

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5.1.1 Results of Atterberg's Limit Test on Jind City (ML type) Soil:

Soil index properties are used extensively by engineers to discriminate between the different kinds of soil within a broad category. The index properties of soil are obtained from Atterberg limit test results. The Atterberg limits are a basic measure of the nature of a fine grained soil. The test results of Atterberg limits of Jind City Soil is shown in Table 1

Table 1 Atterberg limit test results of JindCity Soil

RHA %	Liquid Limit	Plastic Limit	Plasticity Index
0	26.45	23.07	3.38
4	25.83	22.76	3.07
8	26.74	24.02	2.72
12	28.32	25.75	2.57

Figure 1 shows the variation of liquid limit, plastic limit and plasticity index of ML soil with different proportions RHA respectively.

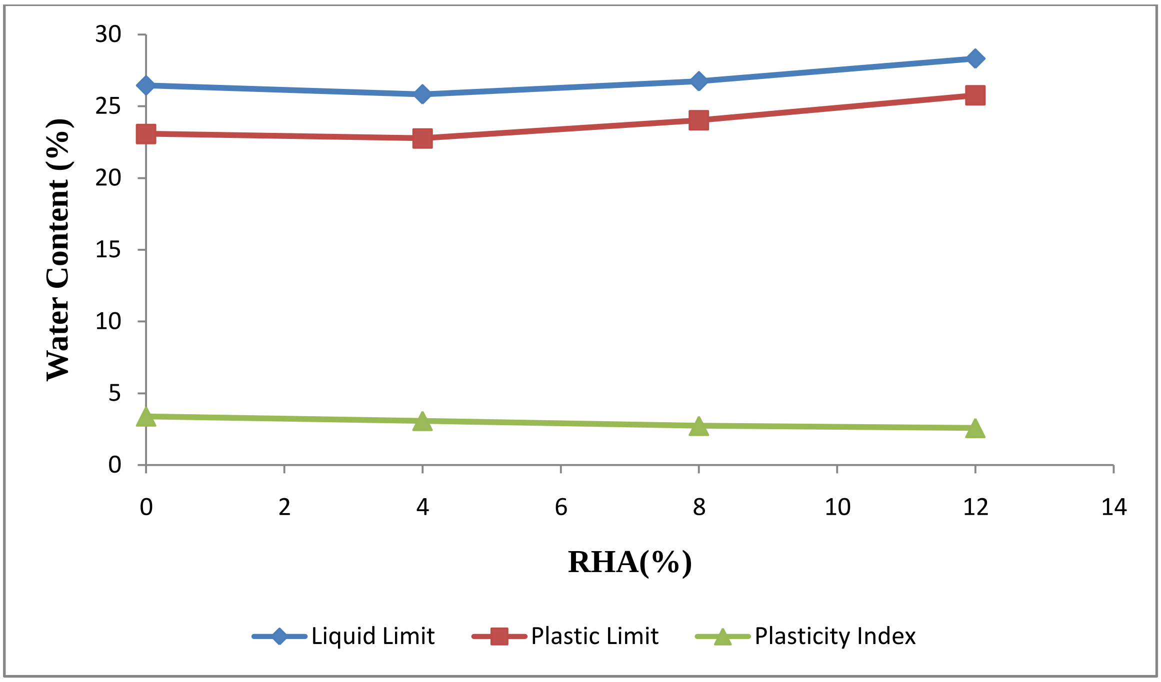

Figure 1 Variation of LL, PL and PI of Jind City Soil + RHA mixes

5.1.2 Results of Atterberg's Limit Test on Uchana (SM type) Soil:

The test results of Atterberg limits of Uchana Soil is shown in Table 2

Table 2Atterberg limit test results of Uchana Soil

RHA %	Liquid Limit	Plastic Limit	Plasticity Index

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0	23.67	-	Non Plastic
4	24.52	-	Non Plastic
8	25.78	-	Non Plastic
12	26.42	-	Non Plastic

Figure 3 shows the variation of liquid limit and plasticity index of soil cannot be find out because soil is non-plastic with different proportions RHA respectively.

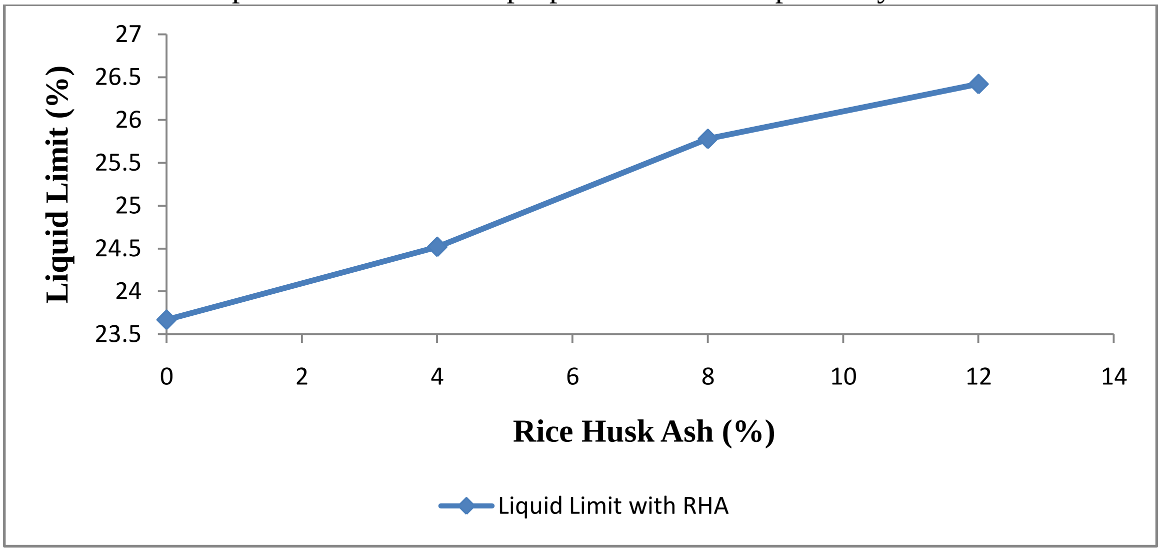

Figure 3 Variation of Liquid Limit of Uchana Soil + RHA mixes

5.2 Result of Sieve Analysis

Grain size distribution of the soils is shown in Table 3. According IS classification system, the first soil classified as ML and second soil is classified as SM type.

Table 3 Grain size Distribution of soils and admixtures

Soil	Gravel Size (+ 4.75 mm)	Sand Size (4.75 mm – 0.075 mm)	Silt & Clay Size (<0.075 mm)
Jind City Soil	0	27.4	72.6
Uchana Soil	0	62.4	37.6
RHA	0	91.5	9.5

5.3 Results of Specific Gravity Test

The specific gravity is determined by pycnometer bottle and results are shown in Table 4.

Table 4 Specific Gravity of Selected Soils and Admixtures

Types of Soil/ Admixture	Specific Gravity
ML Soil	2.67
SM Soil	2.66

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RHA	2.02

5.4 Results of Modified Proctor Tests

5.4.1 Variation of MDD and OMC of ML soil mixes

In the present study a series of compaction tests were carried out on soil with varying proportion of rice husk ash and the variation in maximum dry density (MDD) and optimum moisture content (OMC) tabulate in Table 5

Table 5 MDD and OMC of ML soil mixes

Types of Soil Mixes	MDD (g/cc)	% decrease in MDD	OMC	% Decrease in OMC
ML Soil Only	1.947		12.4	
ML+ 4% RHA	1.88	3.44	13.32	7.42
ML+ 8% RHA	1.768	9.19	14.56	17.42
ML+ 12% RHA	1.721	11.61	14.98	20.81

Figure 4 shows the variation of maximum dry density (MDD) and optimum moisture content (OMC) of ML type soil with different proportions of rice husk ash.

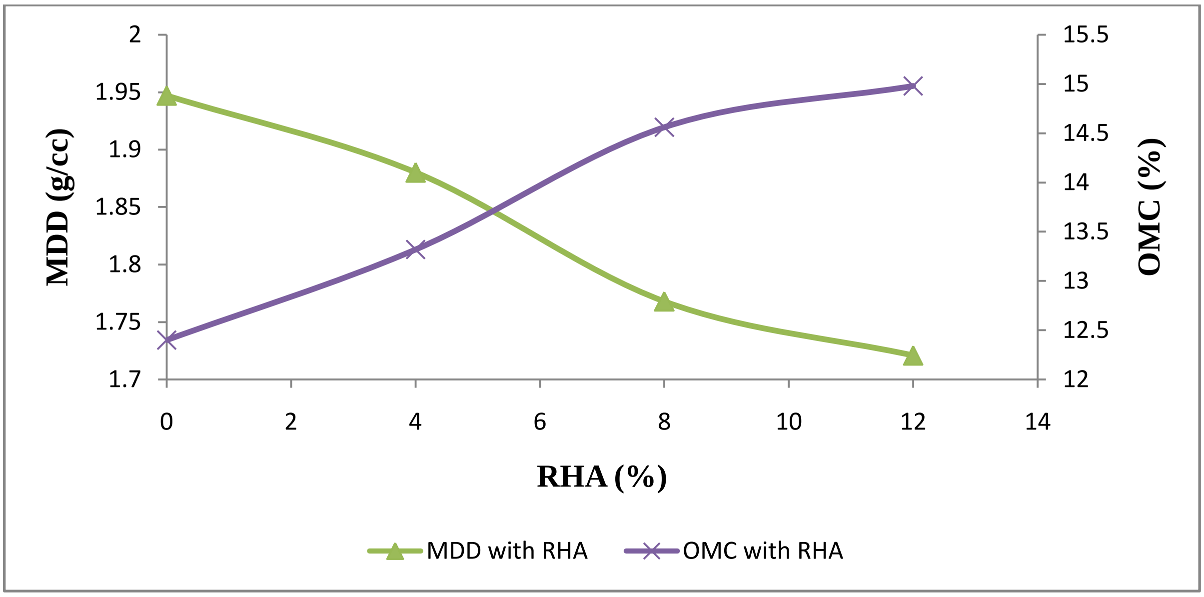

Figure 4 Variation of MDD and OMC of ML type Soil with RHA mixes

5.4.2 Variation of MDD and OMC of SM soil mixes

The variation of maximum dry density (MDD) and optimum moisture content (OMC) with different rice husk ash (RHA) content mixed with soil is tabulated in Table 6.

Table 6 MDD and OMC of SM soil mixes

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Types of Soil Mixes	MDD (g/cc)	% decrease in MDD	OMC	% Decrease in OMC
SM Soil Only	1.895		10.4	
SM+ 4% RHA	1.826	3.6	11.2	7.7
SM+ 8% RHA	1.73	8.7	12.76	22.7
SM+ 12% RHA	1.696	10.5	13.47	29.5

Figure 5 shows the variation of maximum dry density and optimum moisture content of SM type soil with different proportions of rice husk ash.

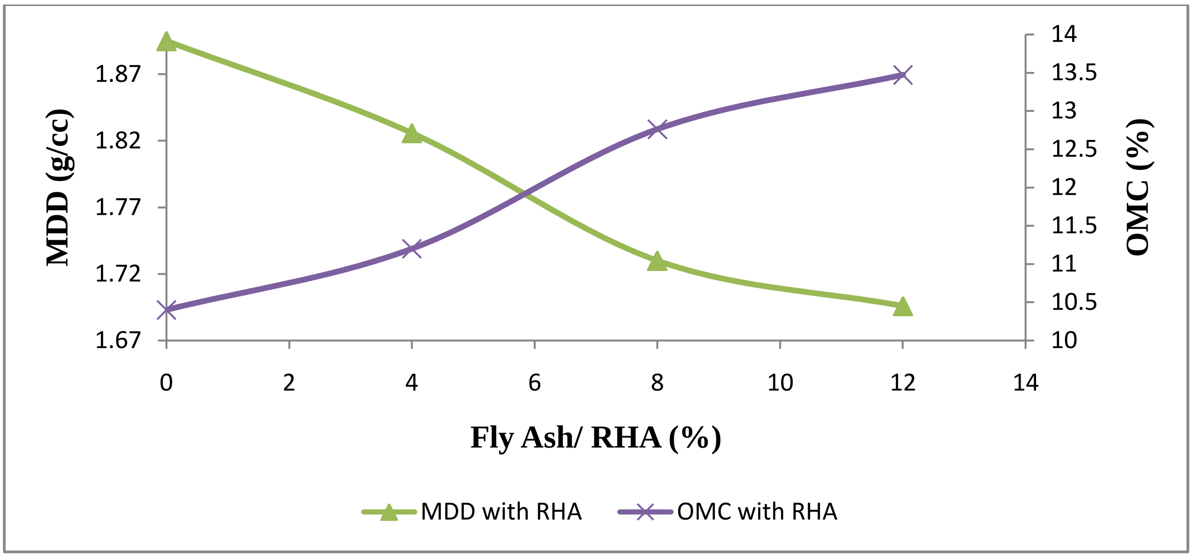

Figure 5 Variation of MDD and OMC of SM type Soil with fly ash/ RHA mixes

5.5 Results of CBR Tests

California bearing ratio value for various proportions of RHA are tabulated to determine the suitable proportion for the soil samples. The test results of CBR test are shown in Table 4

Table 7 Increase/Decrease in CBR of soils with Fly Ash and RHA

Soil Type	% Increase/Decrease in CBR			
	RHA (%)			
	0	4	8	12
ML	5.94	6.27	6.6	6.77
SM	9.57	10.07	10.4	10.24

Figure 6 and 7 shows the variation in CBR value of ML type and SM type soil with different proportions of rice husk ash respectively.

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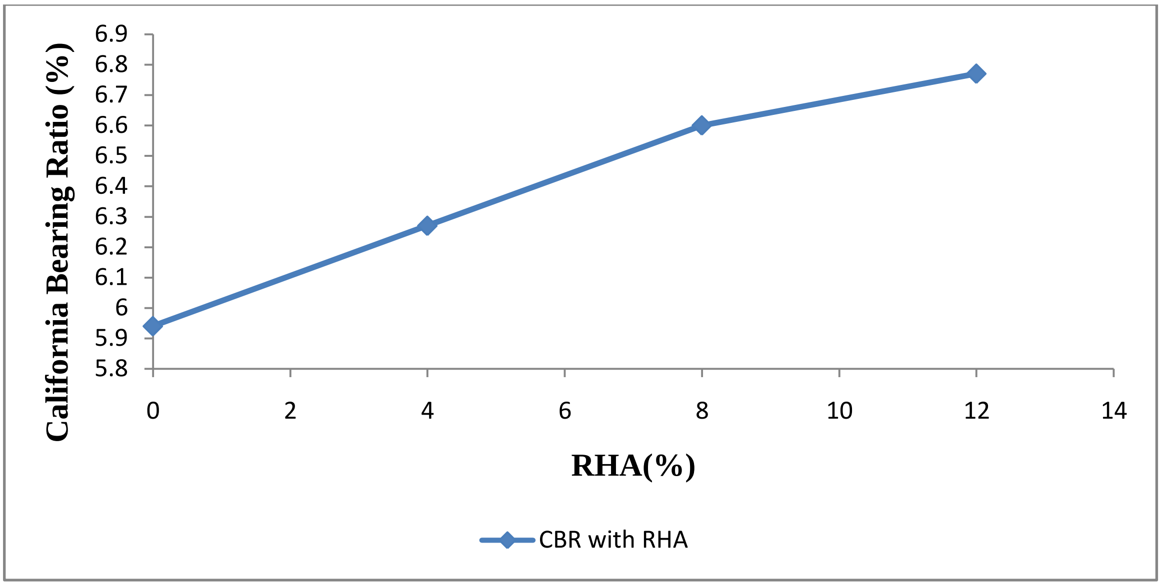

Figure 6 Variation of CBR of ML type Soil + fly ash/ RHA mixes

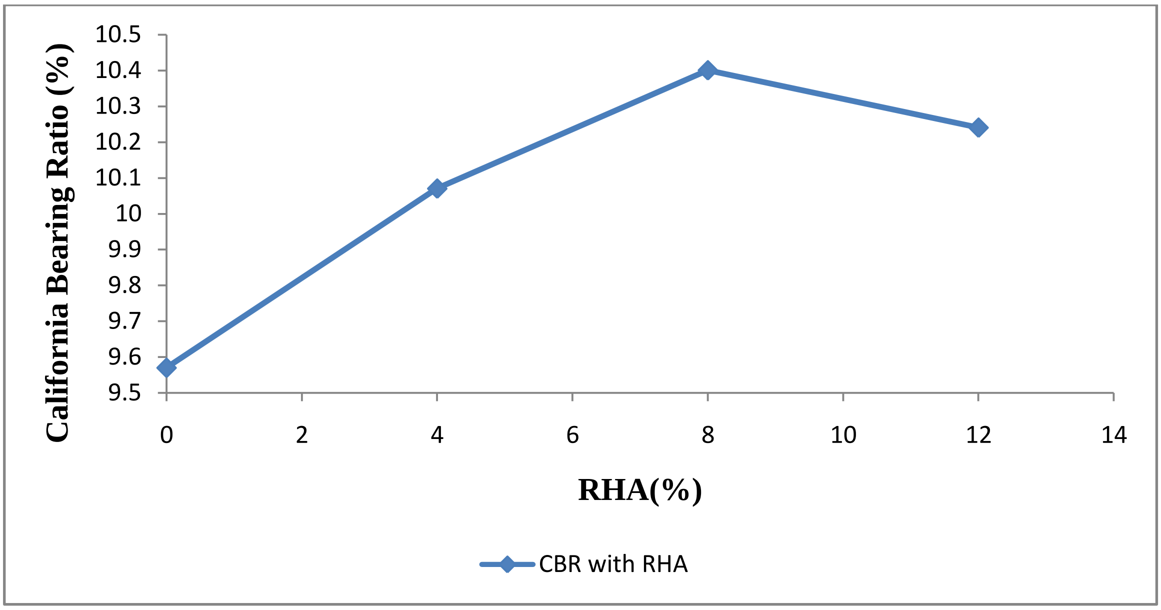

Figure 7 Variation of CBR of SM type Soil + RHA mixes

6 CONCLUSIONS

From the results of the investigation carried out within the scope of the study, the following conclusions can be drowned.

1. It is observed with addition of rice husk ash liquid limit of both increases but plasticity index of ML type soil decreases while plasticity Index of SM type soil cannot be determined so this soil is a non-plastic soil.

2. From the results of grain size distribution soils are classified as ML type and SM type according IS classification system.

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3. With addition of RHA maximum dry density of both soils decreases and OMC increases.

4. CBR value of ML type and SM type increase with increase in proportion of rice husk ash, but CBR value of SM type soil decreases with addition of 12 % rice husk ash.

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