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Soil Stabilization with Rice Husk Ash and Lime Sludge

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ABSTRACT- Soil with low bearing and shear strength requires stabilization to improve its engineering properties and make it suitable for construction. In this study, rice husk and lime sludge are used for stabilization because they are locally available, reducing the amount of waste disposed of to the environment. The main objective of this study is to determine the optimum percentage rice husk and lime sludge for soil stabilization and to assess the effects of Rice husk ash and lime sludge percentage on the Atterberg limits. Apart from that also to assess the effects of Rice husk ash and lime sludge percentage on California Bearing Ratio and on maximum dry density and optimum moisture content.

In this study, RHA and Lime sludge was added to the soil samples and various experiments were conducted on them to understand the effect the addition of these admixtures has on the soil. The RHA was added in percentages of 5,10, 15 and 20 %. The lime sludge was added in the percentages of 5,10,15 and 20 %. The test conducted on these samples were Liquid limit, plastic limit, standard proctor and CBR test. The results of these experiments showed that the addition of these admixtures caused the liquid limit of soil to decrease. The addition of RHA and Lime sludge caused the plastic limit to increase. The OMC increased as the percentage of RHA and lime sludge was increased in the samples. The OMC increased by 33 % for addition of 20 % RHA. The OMC increased by 37 % for addition of 20 % lime sludge. The MDD decreased as the percentage of RHA and lime sludge was increased in the samples. The MDD decreased by 23 % for addition of 20 % RHA. The MDD decreased by 25 % for addition of 20 % lime sludge. The CBR increased by 149 % for 20 % addition of RHA to the sample. The CBR increased by 137 % for 20 % addition of Lime Sludge to the sample. The samples with RHA showed greater improvement in strength compared with Lime Sludge.

KEYWORDS- Soil Stabilization, Waste Reduction, California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), Atterberg Limits

I. INTRODUCTION

The foundation is critical for any land-based structure and must be strong enough to support the entire structure. The soundness of the soil is basic for the steadiness and wellbeing of the construction [1]. This still up in the air by the designing properties of the dirt, explicitly its solidarity and bearing limit. These geotechnical properties are basic in deciding if soil can be utilized as we wish. Assuming the dirt is less steady, its properties should change for it to be helpful to us. Adjustment is liable for this shift [2]. Soil adjustment as a cycle involves different techniques for accomplishing beneficial designing properties in soil. Soil adjustment works on both the strength and toughness of the dirt. These are communicated quantitatively as compressive strength, shear strength, and bearing strength. Soil stabilisation is concerned with increasing soil strength and resistance to water softening by bonding soil particles together, water proofing the particles, or a combination of the two [3]. To ensure that soil stabilisation is cost-effective and based on functional criteria, first determine the inadequate soil properties and then choose the best soil stabilisation technique possible. Soil stabilisation has been practised for some time, and various methods of soil stabilisation are in use. The method of using cement with soil to stabilise the soil has been used in the past and is well validated, but it has recently become less recognised due to the high cost of cement. The negative environmental effects of its production are another reason for its decreased use in recent years [4]. As a result, other options are required. These alternatives must be both less expensive and less damaging to the environment than cement production. Soil stabilisation is the process of changing some soil properties using mechanical or chemical methods to create an improved soil material with all of the desired engineering properties. In general, soils are stabilised to increase their strength and durability or to prevent erosion and dust formation [5]. The main goal is to create a soil material or system that will hold under the design use conditions and for the engineering project's designed life. Soil properties vary greatly between locations, and in some cases even within the same location; soil testing is critical to the success of soil stabilization [6]. Various methods are used to stabilise soil, and each method should be tested in a laboratory with the soil material before being used in the field. If the soil contains medium or coarse sandy particles, mixing RHA will fill the void left by the coarser particles, increasing shearing and bearing capacity due to an increase in chemical bonding other than gravitational force.

A. Soil Stabilization

Soil stabilization is the process of modifying various soil qualities using mechanical or chemical means to generate a better soil material with all of the necessary engineering features. Soils are often stabilised to strengthen their strength and durability or to avoid erosion and dust accumulation [7]. The major goal is to create a soil material or system that will hold under the intended usage circumstances and throughout the life of the engineering project. Exchangeable ions in soil water cause swelling if the soil contains clay minerals such as montmorinolite, as they establish a weak connection between clay particles. Because the clay surface is negatively charged, Si forms a stronger connection than the other metallic ions found in clay minerals [8].

B. Methods of Soil Stabilization

1) Mechanical Method of Stabilization

Soils of varying gradations are mixed together in this technique to get the desired quality in the soil. This can be done on-site or somewhere else where it can be conveniently moved. The resulting mixture is then compressed using standard procedures to get the desired density [9].

2) Additive Method of Stabilization

It refers to the incorporation of produced materials into the soil, which, when done correctly, improves the soil's quality. Chemical additions include materials such as cement, lime, and fly ash. Different locally accessible materials, such as rice husk and lime sludge, are sometimes employed as soil reinforcements [10].

II. OBJECTIVES

- Determine the optimum percentage rice husk and lime sludge for soil stabilization.
- To assess the effects of Rice husk ash and lime sludge percentage on the Atterberg limits.
- To assess the effects of Rice husk ash and lime sludge percentage on California Bearing Ratio and on maximum dry density and optimum moisture content.

III. MATERIAL & METHODOLOGY

A. Soil

Soil from around our grounds was assembled and assessed for geotechnical characteristics and strength as seen in figure 1. The dirt being examined is dark cotton soil, frequently alluded as broad soils. BC soil is a clayey soil with a grayish or dark appearance. It contains the mineral montmorillonite earth. When presented to changes in dampness content, they swell and psychologist quickly. As a result of the great montmorillonite content of this dirt, breaks show up without notice, representing a risk to any structure projects.

Figure 1: Soil

B. Rice Husk Ash

Rice husk ash (RHA) is the debris created by consuming of rice husk. Silica is the primary constituent of rice husk debris. It has been viewed as pozzolonic material because of its high formless silica content. Rice husk for the thesis was purchased from a local vendor in Srinagar area of Kashmir as seen in figure 2.

Figure 2: Rice husk

C. Lime Sludge

Sludge is a semi-strong slurry that can be created from a scope of modern cycles, from water treatment, wastewater treatment or on location disinfection frameworks. Depending of the creation cycle, the ooze can likewise contain a lot of ferric hydroxides, in which case it is generally alluded to as press lime slop. Lime sludge for the thesis was purchased from India mart as seen in figure 3.

Figure 3: Lime sludge

D. Methodology

The Procedure followed are as follows

- The collection of soil samples, RHA and Lime Sludge.
- Performing tests on soil samples to determine the properties, these tests included sieve analysis, specific gravity, liquid Limit, plastic limit, standard proctor test and CBR test.
- Addition of RHA to the soil sample and determine the effect on liquid limit, plastic limit, OMC, MDD and CBR. The addition of RHA was done in the percentages of 5,10,15 and 20 %.
- Addition of Lime sludge to the soil sample and determine the effect on liquid limit, plastic limit, OMC, MDD and CBR. The addition of lime sludge was done in the percentages of 5,10,15 and 20 %.

- The results of these were compared and conclusion was drawn

IV. RESULTS AND DISCUSSION

A. *Sieve Analysis*

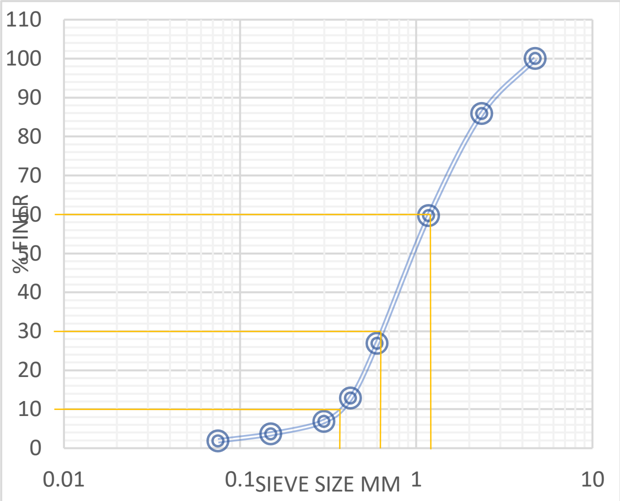

Figure 4: Soil Grain Size Distribution Graph

Co- efficient of curvature Cc = (D30)2/ (D10×D60) = 0.96
Co-efficient of uniformity Cu = D60/D10 = 3.98
where D60 is the size of sieve through which 60 % of the particles pass D30 is the size of the sieve through which 30 % of the particles pass and D10 is the sieve size through which 10 % of the particles pass, calculated from figure 4.

B. *Specific Gravity Test*

Specific Gravity is the ratio of density of a material to the density of standard or reference substance.

Calculations: $G_s = \frac{Mass of soil}{mass of water displaced by soil}$

$$G = \frac{M2 - M1}{(M2 - M1) - (M3 - M4)}$$

= 2.52

C. *Liquid Limit Test*

The Liquid tests were carried first for soil samples without any admixtures and after that was carried out for soils with varying percentages of RHA in the percentages of 5 %, 10%, 15 % and 20 %. Then Lime sludge was added to the soil samples in the percentages of 5%, 10 % ,15% and 20 %.

Calculations: Water content = $\frac{M2-M3}{M3-M1}$

= 58.33 %

Table 1: Values of liquid limit for varying percentages of Rice husk ash

Rice husk ash (%)	Liquid limit (%)
0	58.33
5	56.34
10	53.78
15	50.32
20	48.45

The values of Liquid limit decrease as the percentage of RHA are increased in the soil samples as seen in table 1. The lowest value of liquid limit was obtained at 20 % of addition of RHA to the soil sample.

Table 2: Values of liquid limit for varying percentages of Lime Sludge

Lime Sludge (%)	Liquid limit (%)
0	58.33
5	57.14
10	54.34
15	51.25
20	49.36

The values of Liquid Limit decrease as the percentage of Lime sludge are increased in the soil. The lowest value of liquid limit for lime sludge addition is found at 20% addition as seen in table 2.

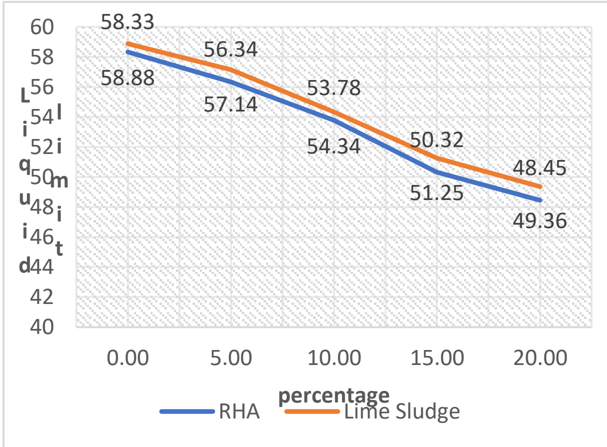

Figure 5: Liquid Limit VS Percentage addition

Figure 5 is a graph plotted between Liquid Limit and percentages of RHA and Lime Sludge.

D. *Plastic Limit Test*

The Plastic Limit tests were carried first for soil samples without any admixtures and after that was carried out for soils with varying percentages of RHA in the percentages of 5 %, 10%, 15 % and 20 %. Then Lime sludge was added to the soil samples in the percentages of 5%, 10 % ,15% and 20 %.

Calculations: Water content = $\frac{M2-M3}{M3-M1}$ = 36.36 %

Table 3: Plastic limit test values for soil with RHA

Rice husk ash (%)	Plastic limit (%)
0	36.36
5	38.12
10	41.14
15	42.56
20	44.39

The values of plastic limit for soil samples in which RHA has been added in varying percentages saw an increase in the plastic limit value as the percentage of RHA was increased in the soil as seen in table 3.

Table 4: Plastic limit test values for soil with Lime sludge

Lime Sludge (%)	Plastic limit (%)
0	36.36
5	37.43
10	38.44
15	40.86
20	41.67

The above table shows the values of plastic limit for soil with lime sludge added in different percentages. From the values it can be seen as the percentage of lime sludge is increased in the soil there is an increase in the plastic limit of the soil. The highest value of plastic limit is obtained at 20 percent addition of lime sludge as seen in table 4.

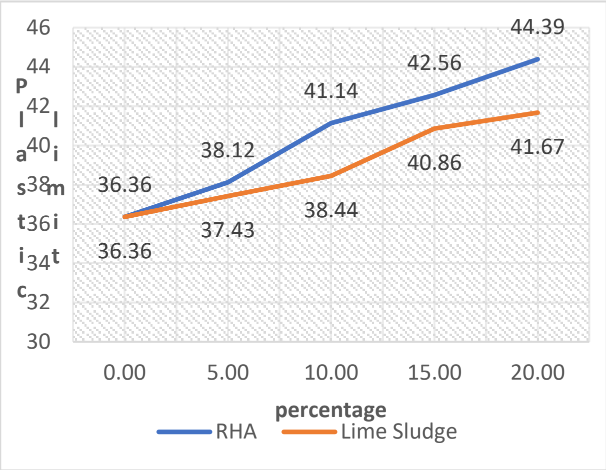

Figure 6: Plastic Limit VS Percentage addition

Figure 6 is a graph plotted between Plastic Limit and percentages of RHA and Lime Sludge.

E. Plasticity Index

The values of plasticity index are obtained by subtraction of plastic limit from the liquid limit.

Ip=Wl– Wp

Table 5: Plasticity index test values for soil with RHA

Rice husk ash (%)	Plasticity index (%)
0	21.97
5	19.02
10	12.64
15	7.76
20	4.06

Table 5 shows the values of plasticity index for various percentages of RHA.

Table 6: Plasticity index test values for soil with Lime Sludge

Lime Sludge (%)	Plasticity index (%)
0	21.97
5	19.71
10	15.90
15	10.39
20	7.69

Table 6 shows the values of plasticity index for various percentages of Lime Sludge.

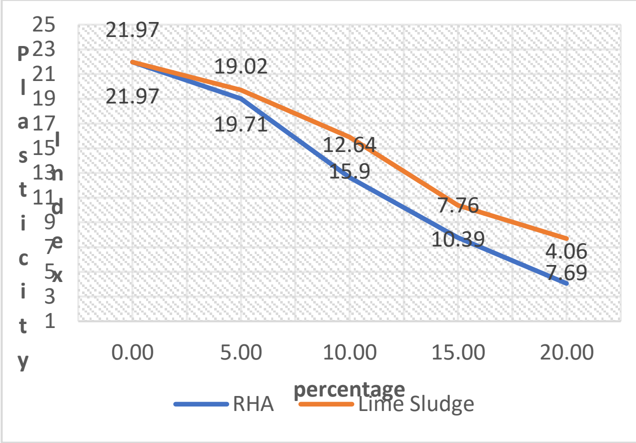

Figure 7: Plasticity index VS Percentage addition

Figure 7 is a graph plotted between Plasticity index and percentages of RHA and Lime Sludge.

F. Standard Proctor Test

The Proctor test was performed first for soil without any admixtures present and then for soil with RHA and Lime sludge added. The RHA addition was done in the percentage of 5,10,15 and 20 %. The lime sludge was added in percentages of 5, 10, 15 and 20 percent. The values of OMC and MDD are obtained and the results are compared using graphs.

The values of OMC and MDD are obtained from the above table. A graph is plotted between Moisture content and dry density. The optimum of the values of Moisture content is taken as OMC and the of dry density is taken as MDD.

Table 7: Values of OMC and MDD at varying percentage of Rice husk ash

Rice husk ash %	OMC (%)	MDD (gm/cc)
0	14.8	1.72
5	15.8	1.63
10	17.3	1.58
15	18.8	1.47
20	19.7	1.32

The table above show the values of OMC and MDD for various percentages of RHA added to the soil. The OMC increases as the percentage of RHA added to the soil is increased. The MDD decreases as the percentage of RHA is increased in the soil as can be seen from table 7.

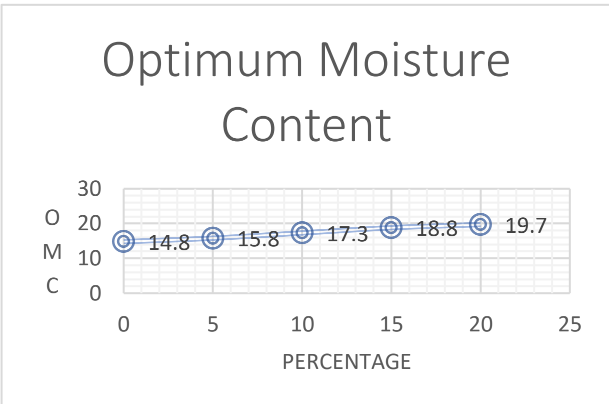

Figure 8: Optimum Moisture Content VS RHA Percentage addition

Figure 8 is a graph plotted between OMC and RHA percentages in soil.

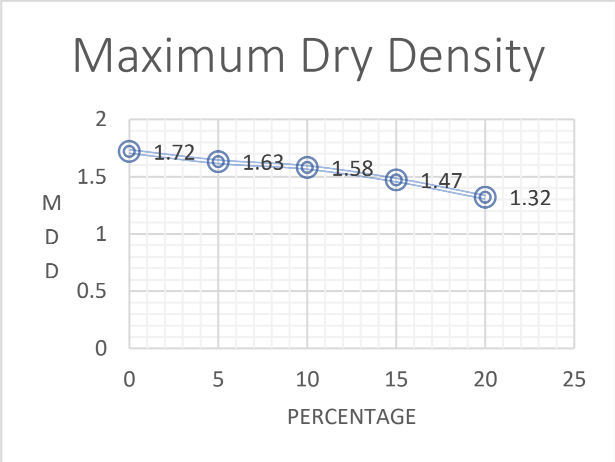

Figure 9: Maximum Dry Density VS RHA Percentage addition

Figure 9 is a graph plotted between MDD and RHA percentages in soil.

Table 8: Values of OMC and MDD at varying percentage of Lime Sludge

Lime Sludge %	OMC (%)	MDD (gm/cc)
0	14.8	1.72
5	16.1	1.60
10	17.7	1.52
15	19.3	1.42
20	20.4	1.28

The table above show the values of OMC and MDD for various percentages of Lime sludge added to the soil. The OMC increases as the percentage of Lime Sludge added to the soil is increased. The MDD decreases as the percentage of Lime Sludge is increased in the soil as can be seen in table 8.

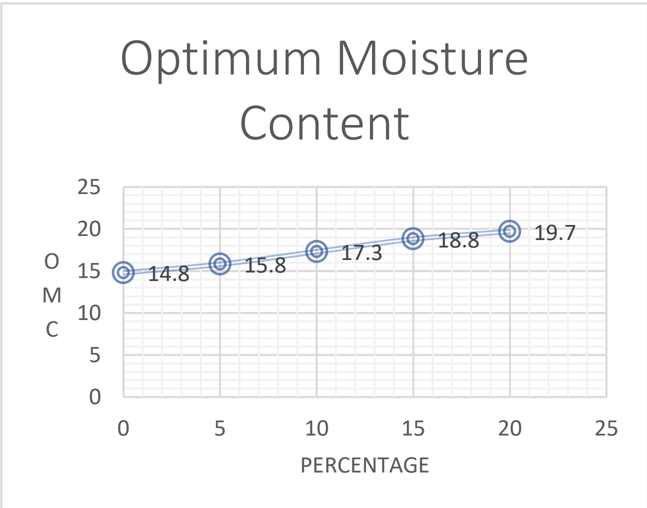

Figure 10: Optimum Moisture Content VS Lime Sludge Percentage addition

Figure 10 is a graph plotted between OMC and Lime Sludge percentage added in soil.

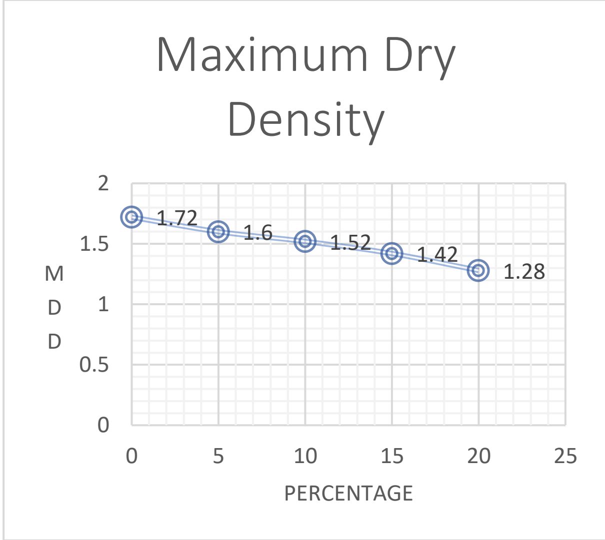

Figure 11: Maximum Dry Density VS Lime Sludge Percentage addition

Figure 11 is a graph plotted between MDD and Lime Sludge percentage added in soil.

The above graph is plotted between the MDD of the soil samples with various percentages of Lime Sludge added as admixture. It can be seen that as the percentage of Lime Sludge is increased in the soil the MDD decreases. The MDD for all the samples with Lime sludge in the percentages of 5,10,15 and 20 % have MDD less than that of soil in which no admixture has been added.

The comparison of MDD for RHA and Lime sludge addition show that the addition of lime sludge causes more decrease in MDD when compared with RHA.

G. California Bearing Ratio Test

The CBR test was performed on soil and then on soils in which admixtures had been added. The values of the CBR for soils with RHA and Lime sludge were compared.

The CBR test was performed on specimen of soil which were kept in soaked condition.

The values of load for 2.5 mm and 5 mm were selected from all the values from the above table. When the load applied was 28.11 kg the penetration was 2.5 mm. The value of CBR found after applying the formula was found out to be 2.04 %. When the load is increased to 37 kg the penetration obtained is 5 mm. The value of CBR at this penetration is 1.8 %.

Thus, the CBR value obtained is 2.04 %.

Table 9: CBR values at 2.5 mm penetration for soil with varying percentage of RHA

Rice husk ash (%)	CBR in % at 2.5 mm penetration
0	2.05
5	3.14
10	4.38
15	4.95
20	5.12

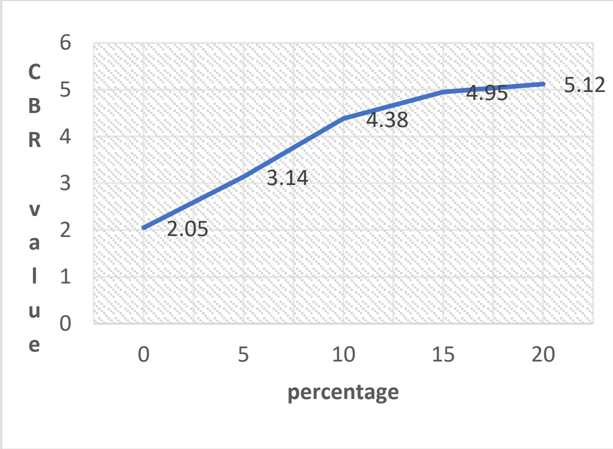

Figure 12: CBR values VS Lime Sludge percentage in soil

The CBR values for soil increase as the percentage of RHA is increased in the soil. The values of CBR are for soaked condition as seen in table 9. The most increase in CBR value was observed for 20 % of RHA addition. The increase is of 149 % for 20 % replacement, as seen in Figure 12.

Table 10: CBR values at 2.5 mm penetration for soil with varying percentage of RHA

Lime Sludge (%)	CBR in % at 2.5 mm penetration
0	2.05
5	2.94
10	3.47
15	4.15
20	4.87

Table 10 shows the values of CBR at 2.5 mm penetration for varying percentages of RHA added in soil.

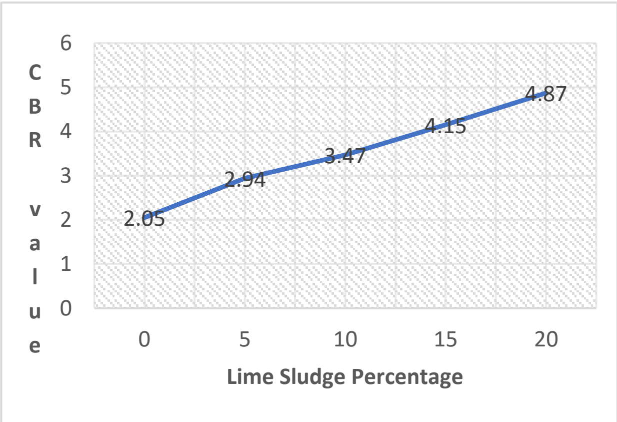

Figure 13: CBR values VS Lime Sludge percentage in soil

The CBR values saw an increase as the percentage of Lime sludge was increased in the soil as seen in figure13. This increase was maximum for addition of lime sludge at a percentage of 20. The percentage increase in CBR was calculated at 137%. This increase is less when compared with the increase caused by addition of RHA.

V. CONCLUSION

- The addition of RHA and Lime sludge to the soil sample caused a decrease in the Liquid Limit of soil. However, the decrease in case of Lime sludge was less when compared with RHA.
- The addition of RHA and Lime sludge caused the plastic limit to increase. The increase in the plastic limit was more in the samples with RHA as compared to samples with Lime sludge.
- The OMC increased as the percentage of RHA and lime sludge was increased in the samples. The OMC increased by 33 % for addition of 20 % RHA. The OMC increased by 37 % for addition of 20 % lime sludge.
- The MDD decreased as the percentage of RHA and lime sludge was increased in the samples. The MDD decreased by 23 % for addition of 20 % RHA. The MDD decreased by 25 % for addition of 20 % lime sludge.
- The CBR increased by 149 % for 20 % addition of RHA to the sample.
- The CBR increased by 137 % for 20 % addition of Lime Sludge to the sample.

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