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# UTILIZATION OF RICE HUSK ASH AND LIME FOR IMPROVING THE PROPERTIES OF SUBGRADE SOIL

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**ABSTRACT**

*The quality of a flexible pavement depends on the strength of its sub-grade soil. The strength of sub-grade is depends on its properties which is the major parameter 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). The laboratory test results showed marked improvement of strength of soil with the addition of admixtures.*

***Keywords:*** *Flexible pavement, Sub-grade soil, Optimum Moisture Content, Shear Strength, admixture.*

## 1. INTRODUCTION

Development of any country can be closely monitored by the improvement in infrastructural facilities in which transportation plays a key role. The quality and durability of a pavement is greatly affected by the type of subgrade soil over which such pavements are to be constructed. Pavement structure response is very sensitive to the characteristics of the subgrade, which provides the support base for such pavement structure. Now India is making its place in the map of the world as one of the fastest economic growth of this country. As the service-life and performance of the pavements depend to a large context on the strength and stiffness characteristics of subgrade, there is a need to pay attention on the quality of the sub grade. Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. The produced partially burnt husk from the milling plants when used as a fuel also contributes to pollution and efforts are being made to overcome this environmental issue by utilizing this material as a supplementary cementing material. The chemical composition of rice husk is

found to vary from one sample to another due to the differences in the type of paddy, crop, year, climate and geographical conditions. It can be used as a modifier of subgrade strength with hydrated lime.

The surface of the flexible pavement reflects the deformation of sub grade and the subsequent layers due to repetition of traffic loads. So, introduction of reinforcement within the subgrade may reduce such deformation. Reinforce soil is a composite material which is formed by the association of frictional soil and tension resistant elements in the form of sheet, strips, nets or mats of metals, synthetic fabrics or fibre reinforced plastics and arranged in the soil mass in such a way to reduced or suppress the tensile strain which might develop under gravity and boundary forces. It is well known that most granular soils are strong in compression and shear but weak in tension. The performance of such soils can be substantially improved by introducing reinforcing elements in the direction of tensile strains in the same way as in reinforced concrete. Reinforcing elements in the form of rods, wire sheets, strips, membranes such as jute, coir, and bamboo materials in soil is prevalent for a long time.

The current MORTH Specifications require that the subgrade should be compacted to 100% MDD attained by the Modified Protector Test (IS 2720-Part 7). For both major roads and rural roads the material used for subgrade construction should have a dry unit weight of not less than 16.5kN/m3.

## 2. EXPERIMENTAL SETUP

### 2.1 Material Used

The materials which make this project work to achieve the target are locally available soil, rice husk ash, and hydrated lime. Some of these materials collected locally, some were brought from the shop. Physical and engineering properties of the materials were undergoing some laboratory experiments.

The soil sample used in this work was collected from local paddy field of Mohanpur, Jirania, Tripura. From the preferred site, representative sample was collected from a trial borrow pit of depth 1.0 m. Few samples were kept in laboratory for air dry and few were dried in the oven dry machine for 24 hours in 105 to 110 degree Celsius. Soil samples were break down by a wooden hammer to pass it through I.S. sieve 4.75 mm. Soil sample is reddish in colour. Various engineering tests were done to evaluate the physical and engineering properties of the soil

Rice husk ash was collected from the Ranirbazar Rice mill, Tripura, India. The rice husk ash is grey in colour. Few samples were kept in the oven dry machine for 24 hours in 105 to 110 degree Celsius

**Fig 1. Rice Husk Ash**

Calcium Hydroxide, traditionally called hydrated lime, is an organic compound with the chemical formula $Ca(OH)_2$. It is a colourless crystal or white powder and obtained when calcium oxide is mixed with water. It was collected from local market.

| Chemical Name | Composition (%) |
|---|---|
| SiO2 | 4.11 |
| Al2O3 | 3.11 |
| Fe2O3 | 2.70 |
| CaO | 63.70 |
| MgO | 0.44 |
| $CaCO_3$ | 3,80 |
| $CaSO_4$ | 19.26 |
| LOI | 5.81 |

**Table 1: Chemical Composition of Hydrated Lime**

**Fig.2 Lime**

Experimental work consists of various physical and engineering test on the selected materials. In the first stage, all experiments were done on the mother material soil sample. To collect the several information on the selected soil sample tests were done according to IS standard.

**2.2 Apparatus:**

- Grain Size Analysis
- Specific Gravity
- Consistency Index
- Modified Proctor Test

**3. Test Procedures:** The test procedures to find the properties of soil and soil mixtures are Specific gravity (G), grain size analysis, Atterberg's limits (i.e., liquid limit (LL), plastic limit (PL), shrinkage limit (SL), standard Proctor compaction characteristics and modified Proctor compaction characteristics (i.e., optimum moisture content and maximum dry density) were evaluated in accordance with ASTM standards.

**4. RESULT AND DISCUSSION:**

The experimental test results regarding the local soil and rice husk ash and hydrated lime are mentioned here in details. Hydrated lime has been mixed in different percentages (2%, 4%, 6%, 8%, 10%) and rice husk ash has been mixed in different percentages (3%, 6%, 9%, 12%) by dry weight of soil. The grain size analysis, specific gravity, consistency limit is presented here. The maximum dry density (MDD),

optimum moisture content (OMC) on locally available soil and soil mixed with rice husk ash & hydrated lime are presented in details.

The grain size analysis is conducted for the paddy field soil. Dry sieving and hydrometer tests were performed to plot the grain size distribution curve which is presented in Figure 3. The grain size distribution for the soil is presented in Table 2. The inference indicates that the experimented soil comes under the group of silty-clay.

The specific gravity test is conducted for the experimented soil, lime, RHA. It was observed that the specific gravity of soil, lime, RHA is 2.602, 1.94 & 0.94 respectively.

The results of consistency limits i.e. liquid limit (LL), plastic limit (PL), shrinkage limit (SL) and plasticity index of that particular soil with and without admixtures are presented in Table 2 & Table 3. Experimented results show that the liquid limit, plastic limit, shrinkage limit and plasticity index of the soil are 40.2%, 18.9%, 16.4% and 21.3% respectively. The heavy compaction was conducted to determine the maximum dry density (MDD) and optimum moisture content (OMC) of the soil mixed with or without RHA and lime in different percentages. The value of MDD and OMC are presented in Table 2 and Table 3. The MDD and OMC of soil are 16.92 KN/$m^3$, 14.25% respectively. The compaction graphs are presented from Figure 3 to Figure 7 for different conditions.

| Physical properties | Experimental data |
|---|---|
| Specific Gravity | 2.602 |
| Sand Particles (4.75mm-0.075mm, %) | 27.079 |
| Silt Particles (0.075mm-0.002mm, %) | 68 |
| Clay Size (≤0.002mm, %) | 30 |
| Classification | CL |
| AASHO Classification | A-6 |
| Group | Silty Clay |
| Liquid Limit (%) | 40.2 |
| Plastic Limit (%) | 18.9 |

| | |
|---|---|
| Plasticity Index (%) | 21.3 |
| Shrinkage Limit (%) | 16.4 |
| Plasticity | High Plastic |

**Table 2. Physical Properties of Local Soil**

| Engineering properties | Experimental data |
|---|---|
| Maximum Dry Density (KN/m$^3$), Light Compaction | 16.28 |
| Optimum Moisture Content (%), Light Compaction | 12.55 |
| Maximum Dry Density (KN/m$^3$), Heavy Compaction | 16.92 |
| Optimum Moisture Content (%), Heavy Compaction | 14.25 |
| California Bearing Ratio Value Unsoaked (%) | 3.3 |
| California Bearing Ratio Value Soaked (%) | 2.15 |

**Table 3. Engineering Properties of Local Soil**

| Mix No | Soil (%) | Lime (%) | RHA (%) | Liquid Limit (%) | Plastic Limit (%) | Plasticity Index (%) | Shrinkage Limit (%) |
|---|---|---|---|---|---|---|---|
| 1 | 100 | 0 | 0 | 40.2 | 18.9 | 21.3 | 16.4 |
| 2 | 98 | 2 | | 37.7 | 21.1 | 16.6 | 18.7 |
| 3 | 96 | 4 | | 36.2 | 23.1 | 13.1 | 20.3 |
| 4 | 94 | 6 | | 32.8 | 24.9 | 7.9 | 22.5 |
| 5 | 92 | 8 | | 32.3 | 26.1 | 6.2 | 24.6 |
| 6 | 90 | 10 | | 31.4 | 27.8 | 3.6 | 26.2 |
| 7 | 97 | 0 | 3 | 42.3 | 20.4 | 21.9 | 17.8 |
| 8 | 95 | 2 | | 40 | 24 | 16 | 19.9 |
| 9 | 93 | 4 | | 37 | 25.6 | 11.4 | 22.6 |
| 10 | 91 | 6 | | 34.8 | 26.3 | 8.5 | 24.5 |
| 11 | 89 | 8 | | 33.4 | 27.8 | 5.6 | 25.9 |
| 12 | 87 | 10 | | 32.1 | 28.3 | 3.8 | 26.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | 94 | 0 | 6 | 44.3 | 24.9 | 19.4 | 22.3 |
| 14 | 92 | 2 | | 41.5 | 25.6 | 15.9 | 23.2 |
| 15 | 90 | 4 | | 40 | 27.1 | 12.9 | 25.4 |
| 16 | 88 | 6 | | 37.3 | 29 | 8.3 | 26.9 |
| 17 | 86 | 8 | | 36.1 | 29.7 | 6.4 | 28.1 |
| 18 | 84 | 10 | | 34.9 | 30.7 | 4.2 | 29.5 |
| 19 | 91 | 0 | 9 | 45.4 | 26.8 | 18.6 | 24.2 |
| 20 | 89 | 2 | | 43.7 | 28 | 15.7 | 26.4 |
| 21 | 87 | 4 | | 42 | 29 | 13 | 27.2 |
| 22 | 85 | 6 | | 40 | 31.5 | 8.5 | 28.6 |
| 23 | 83 | 8 | | 38.7 | 32.9 | 5.8 | 30.7 |
| 24 | 81 | 10 | | 37.5 | 34 | 3.5 | 31.9 |
| 25 | 88 | 0 | 12 | 46.1 | 28.3 | 17.8 | 26.4 |
| 26 | 86 | 2 | | 44.7 | 30.2 | 14.5 | 28.5 |
| 27 | 84 | 4 | | 42.8 | 31.3 | 11.5 | 29.3 |
| 28 | 82 | 6 | | 41.5 | 32 | 9.5 | 30.1 |
| 29 | 80 | 8 | | 40.6 | 33 | 7.6 | 31.3 |
| 30 | 78 | 10 | | 40 | 34 | 6 | 32.5 |

**Table 4. Laboratory Test Results for Index Properties of Soil-Lime-RHA Mixture**

| Mix No | Soil (%) | Lime (%) | RHA (%) | MDD (%) | OMC (%) |
|---|---|---|---|---|---|
| 1 | 100 | 0 | 0 | 1.692 | 14.25 |
| 2 | 98 | 2 | | 1.629 | 20.23 |
| 3 | 96 | 4 | | 1.616 | 22.08 |
| 4 | 94 | 6 | | 1.602 | 22.84 |
| 5 | 92 | 8 | | 1.58 | 24.83 |
| 6 | 90 | 10 | | 1.56 | 25.76 |
| 7 | 97 | 0 | 3 | 1.614 | 19.64 |
| 8 | 95 | 2 | | 1.537 | 19.86 |
| 9 | 93 | 4 | | 1.502 | 20.36 |
| 10 | 91 | 6 | | 1.498 | 24.03 |
| 11 | 89 | 8 | | 1.482 | 25.13 |

| | | | | | |
|---|---|---|---|---|---|
| 12 | 87 | 10 | | 1.469 | 26.47 |
| 13 | 94 | 0 | 6 | 1.544 | 20.5 |
| 14 | 92 | 2 | | 1.499 | 24.06 |
| 15 | 90 | 4 | | 1.442 | 24.13 |
| 16 | 88 | 6 | | 1.43 | 26.31 |
| 17 | 86 | 8 | | 1.414 | 27.93 |
| 18 | 84 | 10 | | 1.381 | 28.59 |
| 19 | 91 | 0 | 9 | 1.502 | 22.54 |
| 20 | 89 | 2 | | 1.422 | 24.42 |
| 21 | 87 | 4 | | 1.412 | 25.78 |
| 22 | 85 | 6 | | 1.404 | 29.02 |
| 23 | 83 | 8 | | 1.342 | 29.34 |
| 24 | 81 | 10 | | 1.292 | 30.49 |
| 25 | 88 | 0 | 12 | 1.44 | 24.75 |
| 26 | 86 | 2 | | 1.402 | 25.43 |
| 27 | 84 | 4 | | 1.382 | 27.73 |
| 28 | 82 | 6 | | 1.304 | 29.34 |
| 29 | 80 | 8 | | 1.282 | 31.51 |
| 30 | 78 | 10 | | 1.24 | 32.83 |

**Table 5. Laboratory Test Results for Compression Characteristics of Soil-Lime-RHA Mixture**

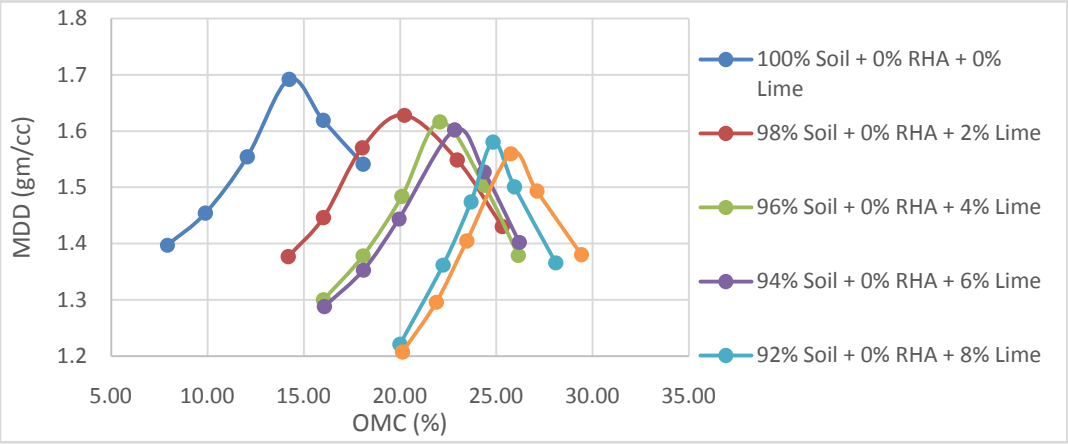


**Figure 3. Dry Density vs. Moisture Content Curve of Soil Mixed with Different Percentage of Lime and O% RHA**

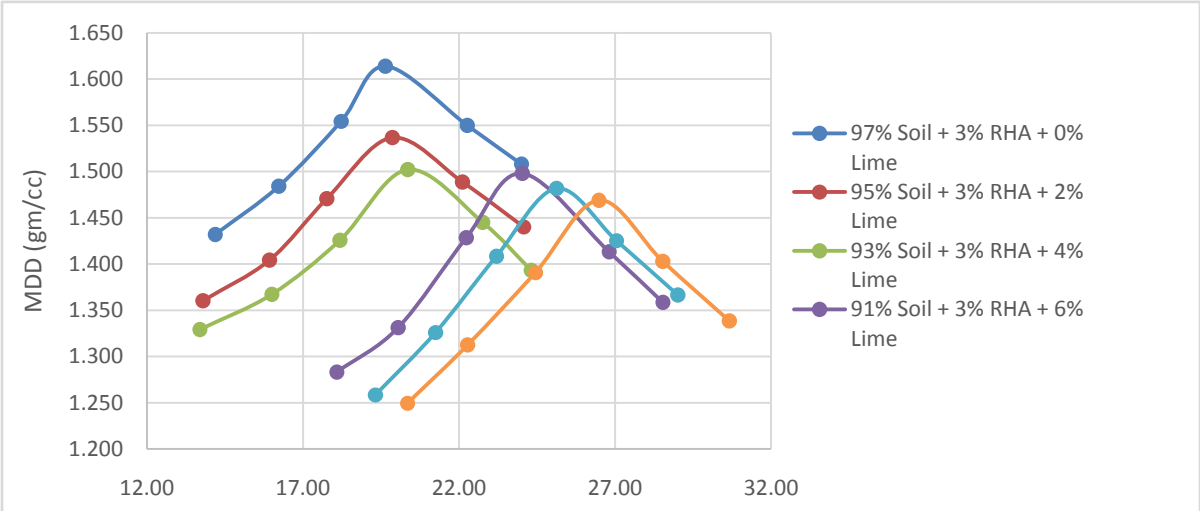


**Figure 4. Dry Density vs. Moisture Content Curve of Soil Mixed with Different Percentage of Lime and 3% RHA**

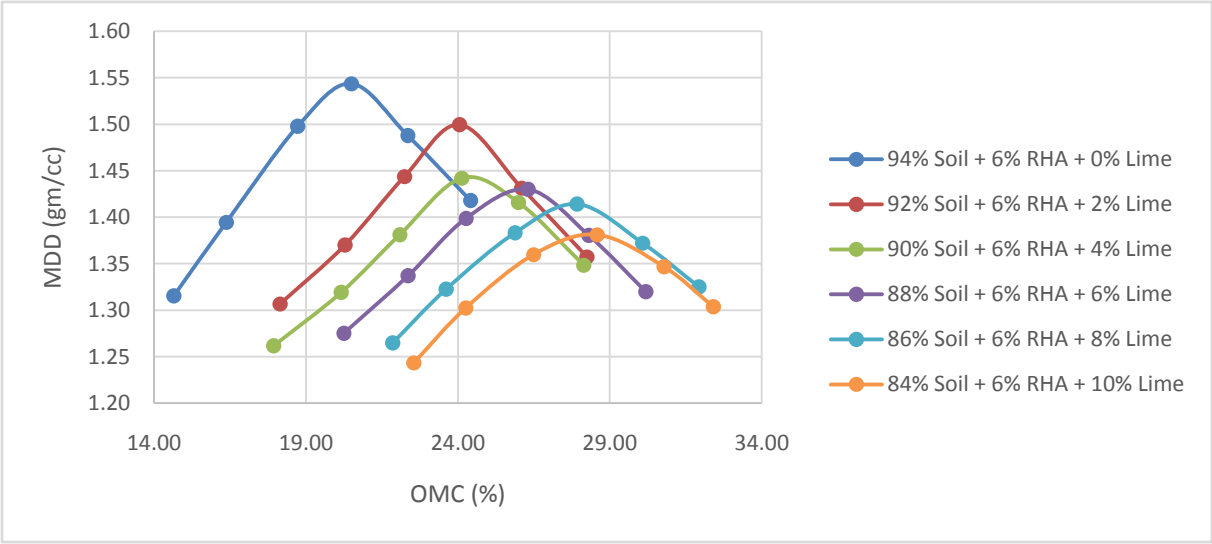


**Figure 5. Dry Density vs. Moisture Content Curve of Soil Mixed with Different Percentage of Lime and 6% RHA**

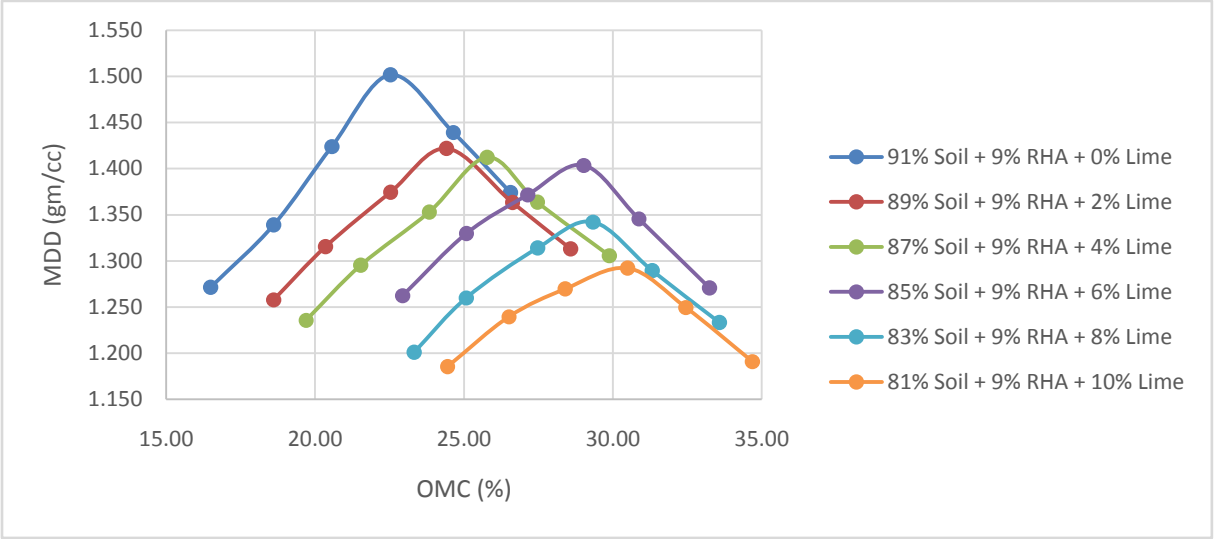


**Figure 6. Dry Density vs. Moisture Content Curve of Soil Mixed with Different Percentage of Lime and 9% RHA**

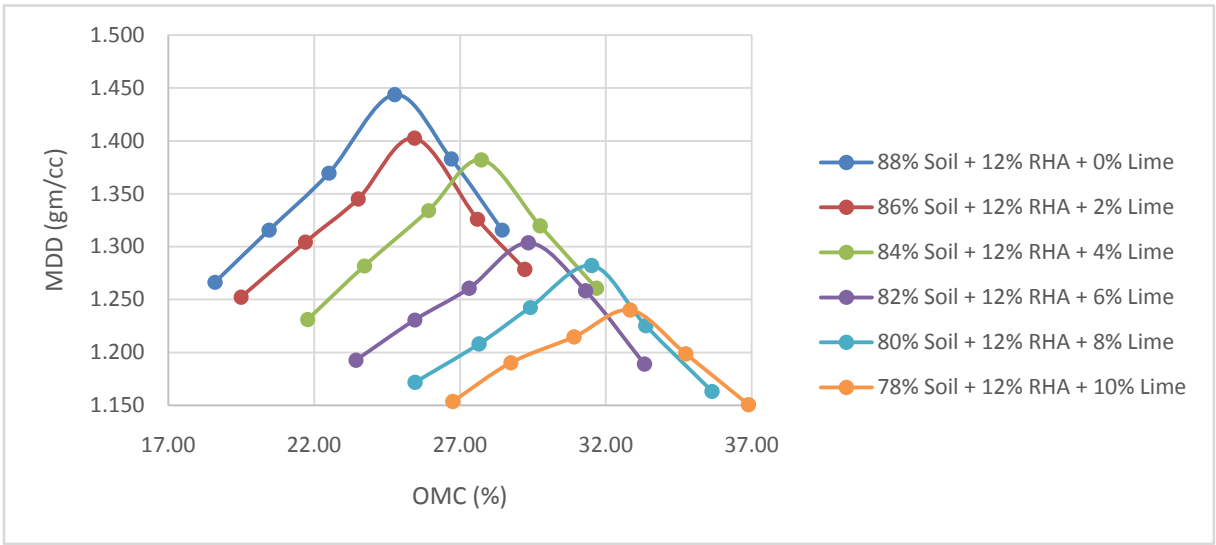


**Figure 7. Dry Density vs. Moisture Content Curve of Soil Mixed with Different Percentage of Lime and 12% RHA**

## 5. Conclusions

The following specific conclusions has been done on the test programme made for soil specimen with or without mixing of RHA & lime in different percentage .

As per the unified classification system the locally available soil in the present study can be classified as silty-clay and the group symbol is CL.

- The specific gravity of the soil sample, lime, RHA are 2.602, 1.94 and 0.94 respectively. So, the specific gravity of the mixture decreases with the increase of admixture content.
- The liquid limit, plastic limit, shrinkage limit and plasticity index of local soil are 40.2%, 18.9%, 16.4 5 and 21.3% respectively.
- The MDD and OMC value of the local soil considerably vary when mixed with RHA and lime. The MDD value of soil-RHA-lime mix decreases with the increase of RHA and lime content while OMC value increases under same condition.
- The MDD and OMC value of the experimented soil is 16.92 KN/$m^3$ and 14.25% respectively.

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