Soil stabilisation using rice husk and lime sludge

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Abstract **- Soil having poor bearing and shear strength needs stabilization to improve its engineering properties, hence making it suitable for construction purposes. In this study rice husk and lime sludge is used for stabilization as these are being locally available and in this way minimizing the amount of waste to be disposed to the environment reducing pollution. This study reveals around the reinforcement of soil by rice husk and lime sludge and the comparison between engineering properties before and after stabilization. The main objective of this study is to evaluate the effects of rice husk and lime sludge on the strength of disturbed soil by carrying out various tests on two different soil samples. Disturbed samples are collected from two different construction sites i.e. ATS, Greater Noida and Botanical Garden, Noida respectively. In laboratory testing, liquid limit, specific gravity along with grain size distribution is carried out for the classification of soil. For different percentage of rice husk and lime sludge the Proctor Compaction test was carried out. Further at California bearing ratio test is carried out for different fractions of rice husk and lime sludge. The above experimental results with and without rice husk and lime sludge are compared to obtain optimum quantity of rice husk and lime sludge required to stabilize a weak soil along with the inference about effect on bearing capacity and shear strength.**

I. INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement. The civil engineer, in facing the practical problems of stability of soil, has frequently to strike a balance between the need for a careful experimental investigation and the need for simplicity in the means employed. Here, in this study, soil stabilization has been done with the help of randomly distributed rice husk and lime sludge obtained as waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement.

II. SOIL STABLIZATION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

METHODS OF SOIL STABLIZATION

- **MECHANICAL METHOD OF STABILIZATION**

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

- **ADDITIVE METHOD OF STABILIZATION**

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, fly ash etc. are used as chemical additives. Sometimes different locally available materials are also used for reinforcements in the soils such as rice husk and lime sludge.

III. SOIL PROPERTIES

a) SHEAR STRENGTH

Shearing stresses are induced in a loaded soil and when these stresses reach their limiting value, deformation starts in the soil which leads to failure of the soil mass. The shear strength of a soil is its resistance to the deformation caused by the shear stresses acting on the loaded soil. The shear strength of a soil is one of the most important characteristics.

METHODS FOR MEASURING SHEAR STRENGTH:

- **DIRECT SHEAR TEST (DST)**

A direct shear test is generally conducted on cohesionless soils as CD test. It is convenient to perform and gives good results for the strength parameters. This is the most common test used to determine the shear strength of the soil. In this experiment the soil is put inside a shear box closed from all sides and force is applied from one side until the soil fails. The shear stress is calculated by dividing this force with the area of the soil mass. This test can be performed in three conditions- undrained, drained and consolidated undrained depending upon the setup of the experiment.

- **CALIFORNIA BEARING RATIO (CBR)**

California Bearing Ratio is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California bearing ratio (CBR) test is a penetration test developed by California State Highway Department (U.S.A.) for evaluation of the mechanical strength of road subgrades and base courses.

The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads. We are determining the resistance of the subgrade, (i.e. the layer of naturally occurring material upon which the road is built), to deformation under the load from vehicle wheels. To check how strong the ground upon which we are going to build the road. The CBR test is a way of putting a figure on this inherent strength, the test is done in a standard manner so we are able to compare the strengths of different subgrade materials, and we are able to use these figures as a means of designing the road pavement required for a particular strength of subgrade.

b) ATTERBERG'S LIMITS

- **SHRINKAGE LIMIT**

This limit is achieved when further loss of water from the soil does not reduce the volume of the soil. It can be more accurately defined as the lowest water content at which the soil can still be completely saturated.

- **PLASTIC LIMIT**

This limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is non-porous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter.

- **LIQUID LIMIT**

It is the water content of the soil between the liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is measured by the Casagrande's apparatus

c) PARTICLE SIZE DISTRIBUTION

Soil at any place is composed of particles of a variety of sizes and shapes, sizes ranging from a few microns to a few centimeters are present sometimes in the same soil sample. The distribution of particles of different sizes determines many physical properties of the soil such as its strength, permeability, density etc. Particle size distribution is found out by two methods, first is sieve analysis which is done for coarse grained soils only and the other method is sedimentation analysis used for fine grained soil sample. Both are followed by plotting the results on a semi-log graph. The percentage finer N as the ordinate and the particle diameter i.e. sieve size as the abscissa on a logarithmic scale.The curve generated from the result gives us an idea of the type and gradation of the soil. If the curve is higher up or is more towards the left, it means that the soil has more representation from the finer particles; if it is towards the right, we can deduce that the soil has more of the coarse grained particles.

d) SPECIFIC GRAVITY

Specific gravity of a substance denotes the number of times that substance is heavier than water. In simpler words we can define it as the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water. In case of soils, specific gravity is the number of times the soil solids are heavier than equal volume of water.

IV. SOIL ANALYSIS OF THE STUDY

Analysis of soil is done by following steps:

1. Specific gravity of soil
2. Particle size distribution by sieve analysis
3. Determination of soil index properties (Atterberg's Limits)
   i) Liquid limit by Casagrande's apparatus
   ii) Plastic limit
4. Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test
5. Preparation of reinforced soil samples.
6. Determination of the shear strength by: California Bearing Ratio (CBR)

V. RESULT OF SOIL ANALYSIS

SPECIFIC GRAVIT Y

The value of Specific Gravity of both the samples are 2.73for sample 1(Location: ATS, Greater Noida) and 2.26 for sample 2(Location: Botanical Garden, Noida) which shows that sample 1 is clayey and silty in nature and sample 2 is sandy in nature.

Sieve Analysis

The coefficient of uniformity of sample 1and 2 was observed to be 20 and 26.3 respectively and coefficient of curvature as 1.06 and 1.64 respectively, which indicate the soil sample 1 is well graded sand (SW) and soil sample 2 is well graded sand (SW).

Atterberg's Limits

Graph 5.23 and 5.24 shows the variation of Liquid Limit of soil stabilised with different percentage of Lime sludge and Rice Husk Ash. From the graph it can be seen that with increase in percentage of rice husk ash and lime sludge, the Liquid Limit of soil goes on decreasing.

Graph 5.25 and 5.26 shows the variation of Plastic Limit of soil stabilised with different percentage of Lime sludge and Rice Husk Ash. From the graph it can be seen that with increase in percentage of rice husk ash and lime sludge, the Plastic Limit of soil goes on increasing.

Graph 5.27 and 5.28 shows the variation of Plasticity index of soil stabilised with different percentage of Lime sludge and Rice Husk Ash. From the graph it can be seen that with increase in percentage of rice husk ash and lime sludge, the Plasticity index of soil goes on decreasing.

Addition of lime sludge and rice husk ash lowers the liquid limit, raised the plastic limit and reduces the plasticity index of the two soil under study. This will render the clayey soil friable, easy to be pulverized and will reduce the shrinkage. These are favourable conditions for earth roads.

Proctor Compaction Test

Effects of lime sludge and rice husk ash on soil compaction properties are reflected in graph 5.29 and 5.30. From these graphs it is clear that optimum moisture content increases and maximum dry density decreases with increase in lime sludge and rice husk ash in the two soils under studyl. The increase may be due to consumption of more water by lime and the decrease in maximum dry density may be due to increase in OMC.

California Bearing Ratio

Effect of lime waste on CBR value of soil is shown in graph 5.31. From the graph it is evident that CBR value increases with addition of lime sludge and rice husk ash in the two soil under study. CBR value of clayey soil and sandy soil increases with addition of lime sludge and rice husk in all types of sludge. The percentage of increase depends on the type of soil. Overall it can be concluded that lime sludge and rice husk ash stabilised soil can be considered to be good ground improvement technique especially in engineering projects on weak soils where it can act as a substitute to deep/raft foundations, reducing the cost as well as energy.
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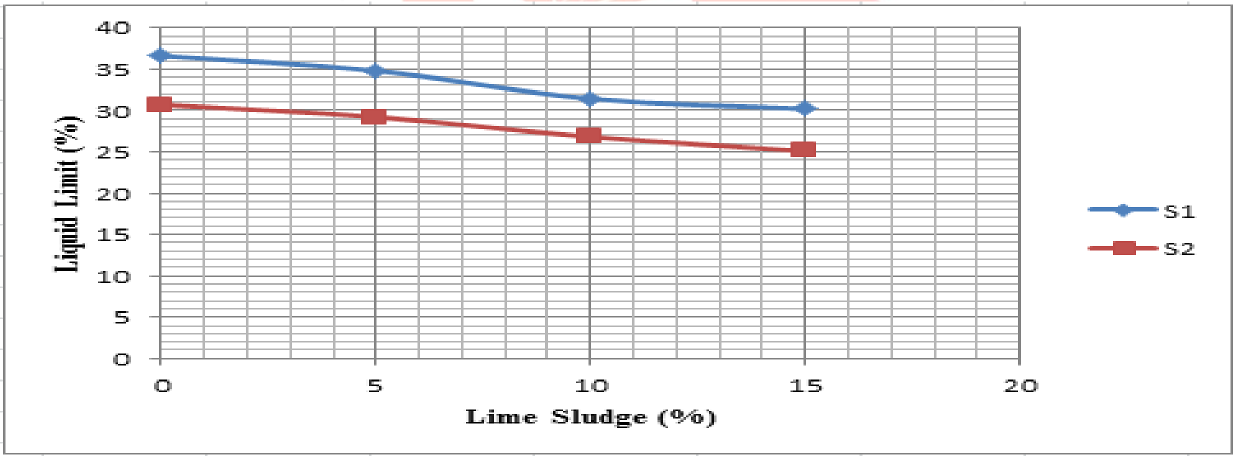
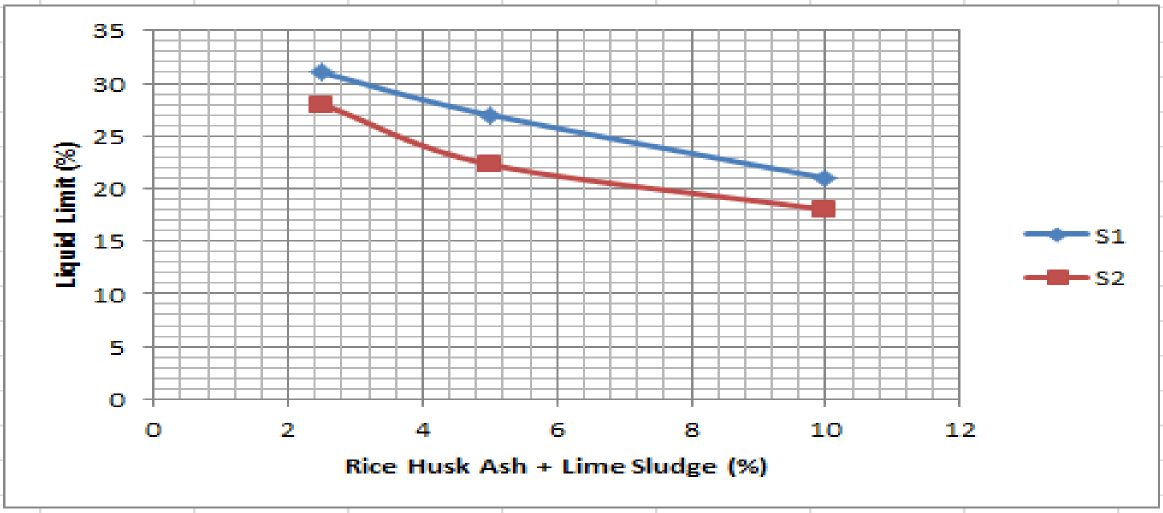
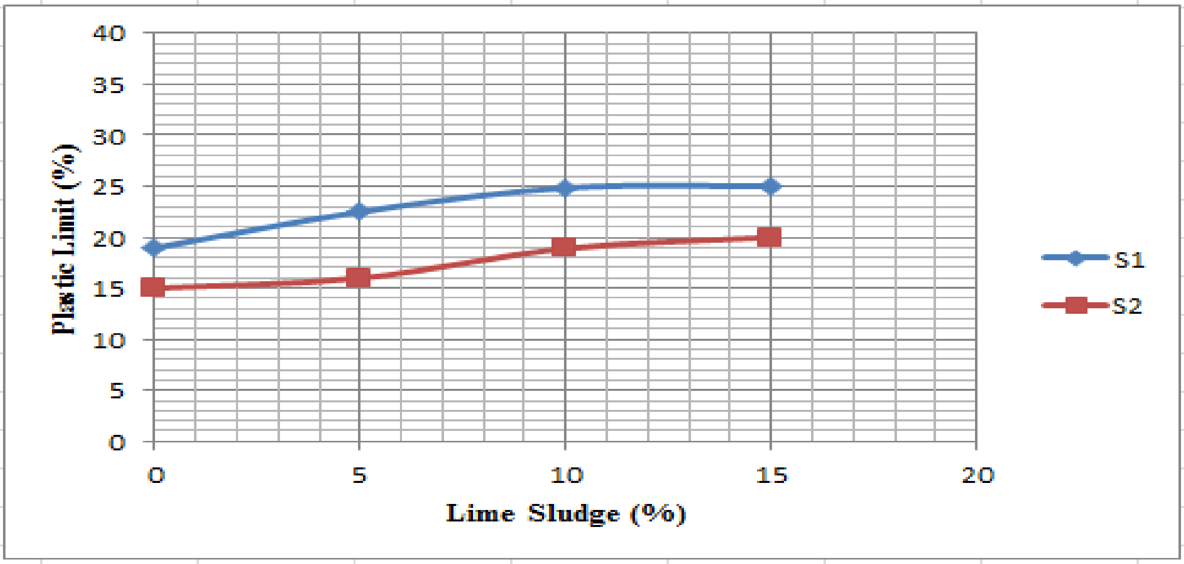


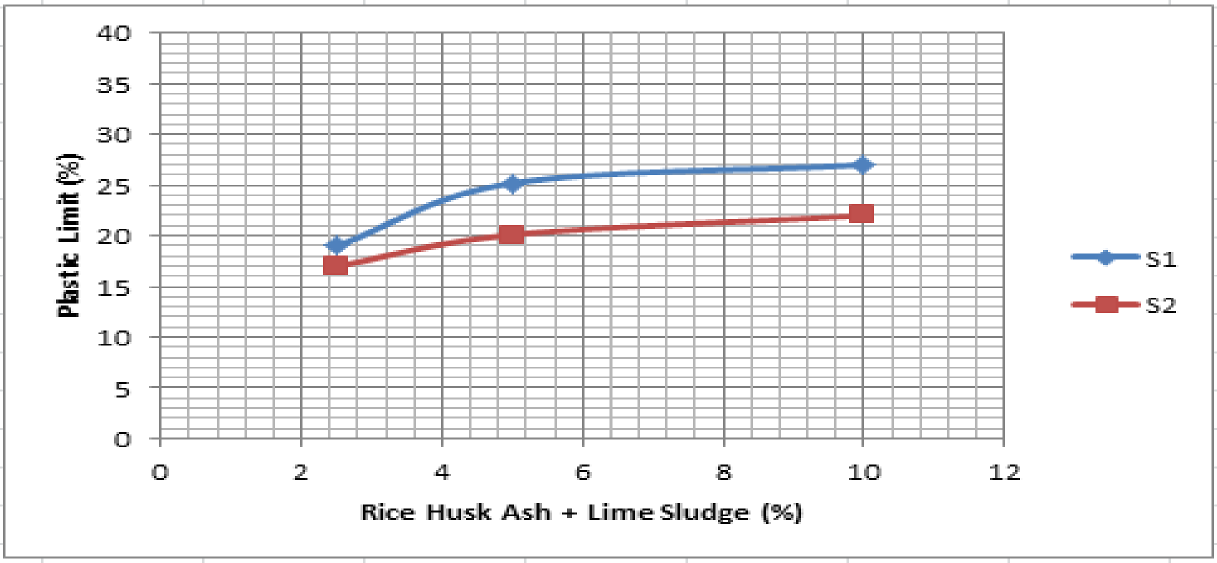
Graph 5.23 Variation of Liquid Limit depending on addition of lime sludge



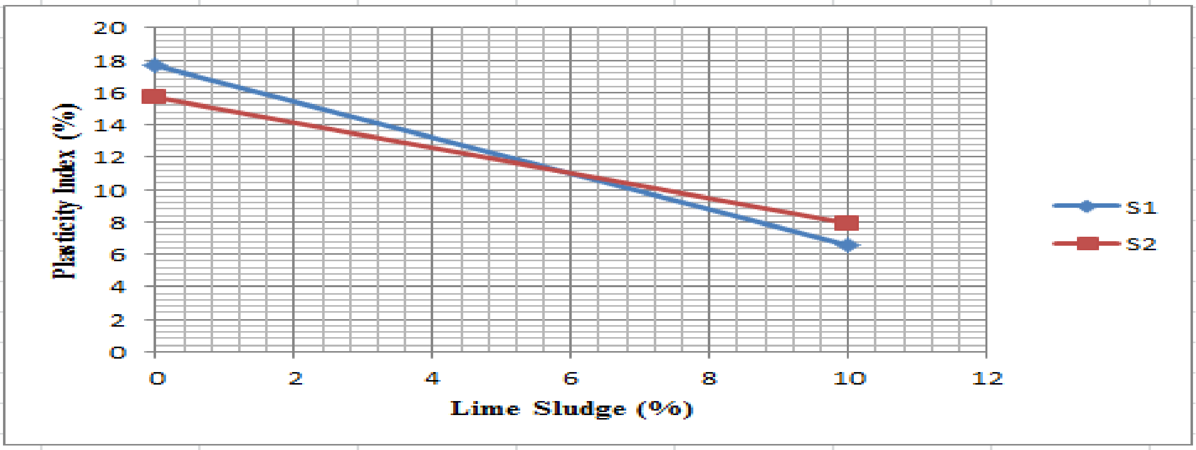
Graph 5.24 Variation of Liquid Limit of lime sludge stabilized soil with rice husk ash



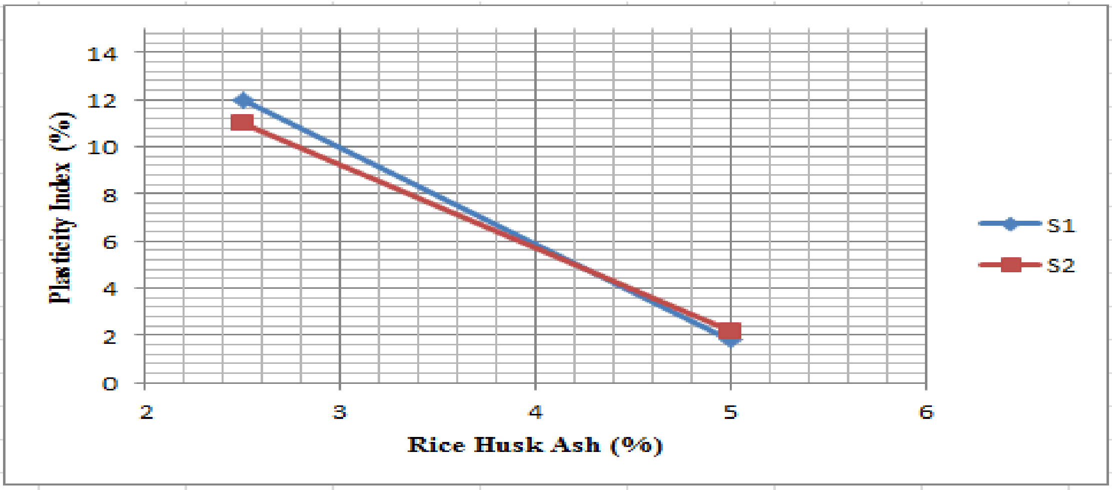
Graph 5.25 Variation of Plastic Limit depending on addition of lime sludge



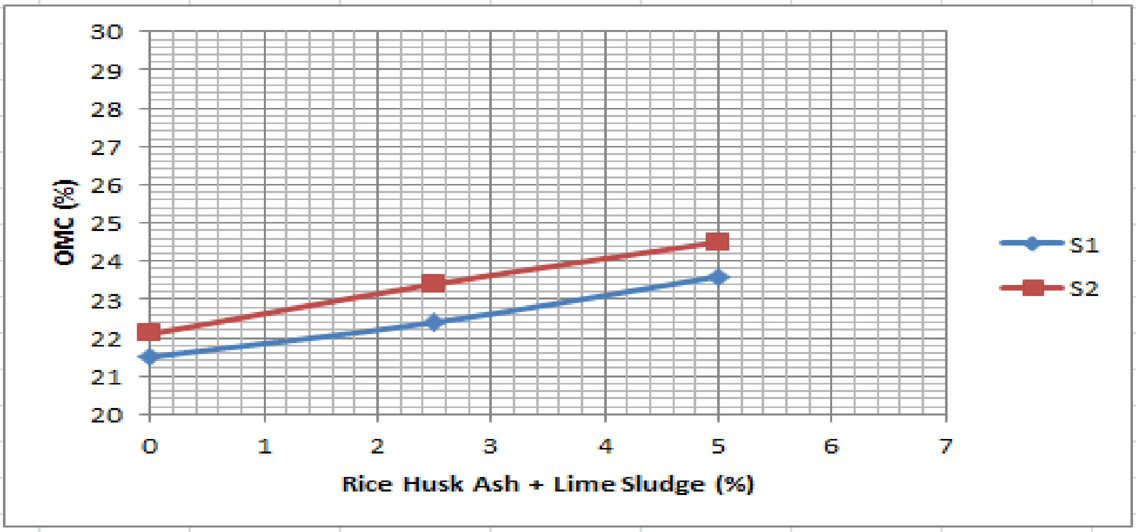
Graph 5.26 Variation of Plastic Limit of lime sludge stabilized soil with rice husk ash



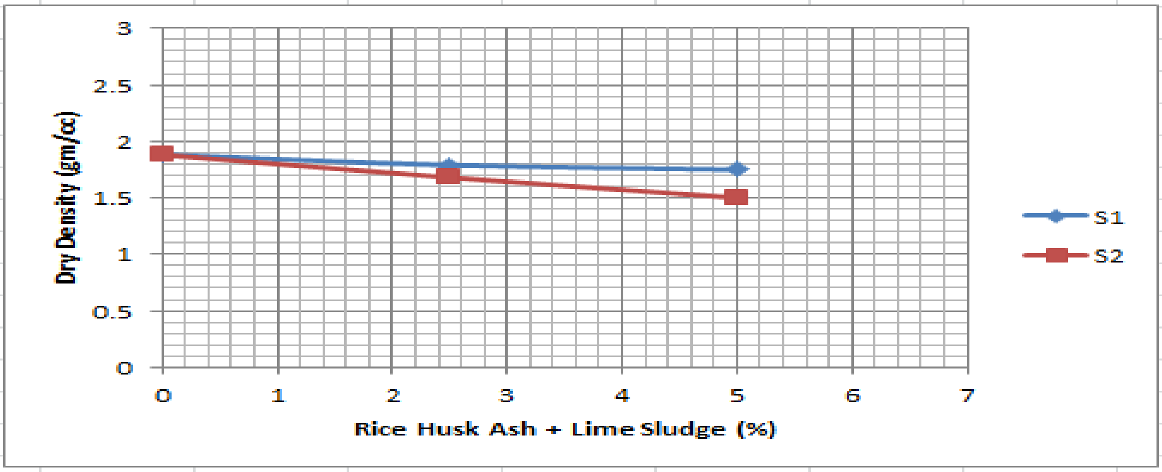
Graph 5.27 Variation of Plasticity Index depending on addition of Lime Sludge



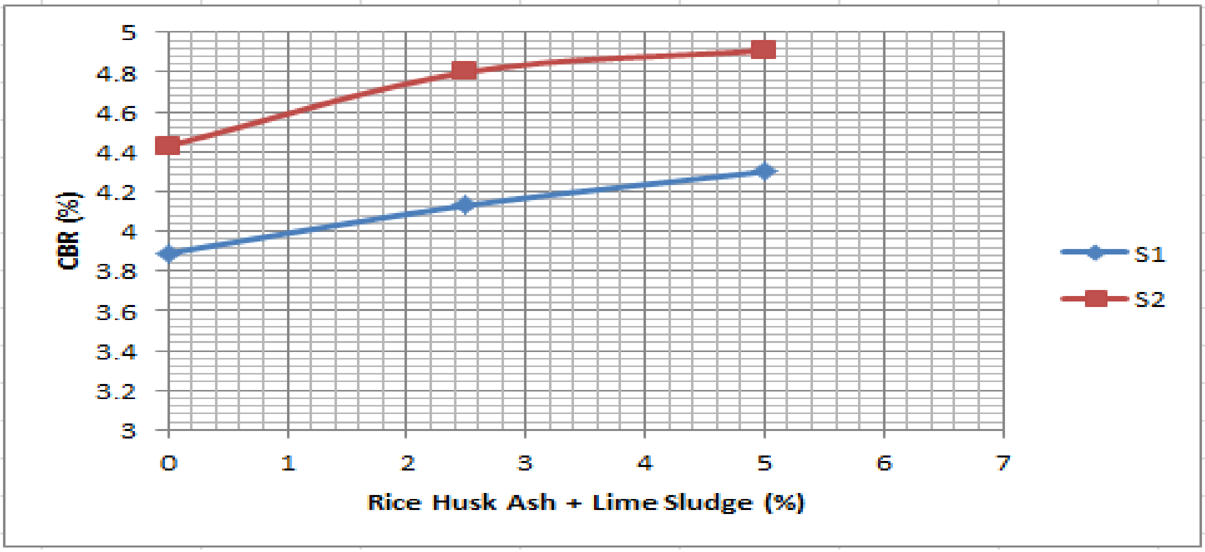
Graph 5.28 Variation of Plasticity Index of Lime Sludge stabilized soil with Rice Husk ash



Graph 5.29 Variation of Optimum Moisture Content of lime sludge stabilized soil with rice husk ash



Graph 5.30 Variation of Maximum Dry Density of lime sludge stabilized soil with rice husk ash



Graph 5.31 Variation of California bearing ratio of lime sludge stabilized soil with rice husk ash

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