Soil Stabilization using Rice Husk Ash, Lime and Jute

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Abstract

Every millions of year of tonnes of pozzolanic material is produced all over India which is categorized as hazardous material. It is better to use such pozzolonic material in variety of ways, including construction fill, roadbeds or cement admixture. In this project following pozzolanic materials such as Rice Husk Ash (RHA), jute and lime are used for improving the properties of clayey soil, in order to start construction in a weak and less stable soil. The proposed project is to examine how much strength can be attained by clayey soils when stabilized using RHA, jute and lime. The first step is to find out the index properties of the soil by consistency limits, specific gravity determination and wet sieve analysis. These are basically done to get an idea of the properties of the soil. In this project it is decided to do following tests viz; specific gravity determination, consistency limits, wet sieve analysis, hydrometer test, compaction test, California bearing ratio test, Unconfined compressive strength test. It is found that, the addition of RHA, jute and lime to soil improved the strength characteristics of soils.

Keywords: *RHA, OMC, MDD, UCS, CBR, Jute.*

I. INTRODUCTION

Nowadays the construction of structures seems to be difficult due to the insufficient land availability. For the further development in construction, it seems to extend the construction towards the paddy fields. But the sub grade layer of pavement consists of clayey soil and it undergoes failure. Thus concession on such type of soil is required to improve the engineering properties of soil or replace the soil itself. Replacing the existing soil might not be a practical and feasible option. Thus it is required to stabilize the soil. RHA, jute and lime are helpful in improving the geotechnical properties of soil. Due to low cost and one of the effective ways of reinforcing the soil, the combination of RHA, Lime and Jute proves to be effective.

The long term performance of any construction project depends on the stability of the underlying soil. Stabilized soil is, in general, a composite material that results from combination and optimization of properties in individual consistent materials. The major classifications are mechanical stabilization, hydraulic stabilization, physical & chemical stabilization and stabilization by inclusion and confinement. The materials used for stabilization in this project are RHA, Lime and Jute. The lower cost of these materials makes an attractive alternative, if adequate performance can be obtained.

B. Pandey.et.al (2013) conducted this project by adding Pozzolanic materials such as Fly Ash, Jute, Lime and water proof compounds for improving the properties of black cotton soil. They conducted a series of Proctor test and C.B.R test have been carried out including Atterberg's limit on soil mixed with jute fiber of different diameters (2-8mm) and lengths (.5-2mm) in different percentage(.2%-1%) to find out optimal quantity and also different quantity of fly ash(10%,15%,20% and 25%) and (1%-5%). It is concluded that mixing of 1% jute fiber, 20% fly ash and 5% lime together in a soil gives better result as compared to individually addition of each material for soil improvement and reduces the cost of road (black cotton soil) near about 50-60% and improves the C.B.R values near about 80-20 times.

Harshita Bairagi.et.al (2014) studied the effect of jute fibers on engineering and strength properties of lime treated with black cotton soil. Soil samples containing 0%, 1%, 2% to 5% of jute fibers were prepared and index properties were evaluated as per IS code specifications. The test results showed significant decrease in expansive behavior of black cotton soil. If black cotton soil is mixed with 5% lime and jute fibers from 0% to 5% soil by weight of black cotton soil, and there is significant increase in CBR and unconfined compressive strength. From there series of test conducted on black cotton soil mixed with lime and jute fibers, they concluded that the OMC values increases and Maximum Dry Densities decreases. It can be concluded that addition of jute fibers to lime stabilized Bcc soil decreases its swelling behavior and increase the CBR and unconfined compressive strength properties.

Akshaya Kumar Sabat studied the effect of polypropylene fiber on engineering properties of rice husk ash –lime stabilized expansive soil. He concluded that the addition of Rice Husk and Lime decreases the MDD and increases the OMC of the expansive soil. MDD goes on decreasing and OMC goes increasing with increase in percentage of polypropylene fiber in the rice husk ash –lime stabilized expansive soil. Addition of rice husk ash and lime increases the UCS and soaked CBR of the

expansive soil with the addition of polypropylene fiber.

H.N Ramesh.et.al (2010) studied "Compaction and strength behavior of lime-coir fiber treated Black Cotton soil". The effect of aspect ratio, percentage fiber on the behavior of the composite soil specimen with curing is isolated and studied. They concluded that Addition of lime to BC soil increases the strength and it has been observed that 4% lime by weight is found to be optimum. Addition of optimum lime to BC soil increases the strength and the sample become brittle with curing, Addition of 1.0% coir fiber with aspect ratio of 20 and 0.5% coir fiber with aspect ratio 80increases the strength of BC soil compared with other coir fiber combinations, the strength of BC soil reinforced with 0.5% coir fiber with aspect ratio 80 is higher than 1.0% coir fiber with aspect ratio of 20 and lime treated BC soil reinforced with 1.0% coir fiber with aspect ratio of 20 increases the strength and reduces the brittle behavior of soil specimen, whereas with 0.5% coir fiber and aspect ratio of 80 strength increase is marginal and Addition of 4% lime to soil with 1% coir fiber increases strength and improves ductility and beneficial effect is more with aspect ratio of 20.

II. OBJECTIVES AND SCOPE OF THE INVESTIGATION

A. *Objective*

- To study the effect of RHA, Lime and Jute on the properties of soil.
- To determine the suitable material for the soil sample collected.
- To study the subgrade strength characteristics of stabilized clayey soil by studying the variations of CBR values under soaked and un-soaked conditions.
- This research aims at technical properties like specific gravity, liquid limit, plastic limit, and compaction& CBR % characteristic individually.
- To study the most appropriate combination.

B. *Scope of the Work*

In many areas of Kerala the main problem in construction is the poor bearing capacity of the soil. Most of these areas are covered with clay of very soft consistency. Hence it is necessary to find some methods to improve the soil and thereby make it suitable for construction. The following pozzolanic materials such as RHA, Jute and Lime are used for improving the properties of clayey soil. Rice husk is an agricultural waste obtained from milling of rice. Its use will considerably reduce the cost of construction and as well reduce the environmental hazards it cause. Jute is a readymade material, cheap, easy laying in field and biodegradable. Jute has high moisture absorption, excellent durability and high initial tensile strength.

III. EXPERIMENTAL PROGRAMME

A. *Materials*

1) *Clay*

Clay refers to naturally occurring material composed primarily of fine- grained minerals, which is generally plastic at appropriate water contents and will harden when fired or dried. The minerals found in clay are generally silicates less than 2 microns (one millionth of a meter) in size, about the same size as a virus. Clays are very abundant at the earth's surface; they form rocks known as shales and are a major component is nearly all sedimentary rocks. The small size of particle and their unique crystal structures give clay materials special properties, including cation exchange capabilities, plastic behavior when wet, crystalitic abilities, swelling behavior, and low permeability's.

There are four main groups of clay minerals such as Kaolinite group, Bentonite and Calcium Montmorillonite group, Illite group, Smectite group

2) *Jute*

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced from plants in the genus Corchorus. Jute is one of the most affordable natural fibers and is second only to cotton in amount produced and variety of uses of vegetable fibers. Jute fibers are composed primarily of the plant materials cellulose and lignin. The industrial term for jute fiber is raw jute. The fibers are off-white to brown, and 1–4 meters (3–13 feet) long. Jute is also called "the golden fiber" for its color and high cash value. Jute fiber is 100% bio-degradable and recyclable and thus environmentally friendly. Jute has low pesticide and fertilizer needs. It has high tensile strength, low extensibility, and ensures better breathability of fabrics.

3) *Lime*

In the longer term, lime stabilization provides performance benefits that reduce maintenance costs. In addition to stabilization of new materials, lime is an excellent choice for the reclamation of road bases. As more and more governmental entities are choosing to reclaim existing roadbases rather than replace them, this use of lime will become even more important. Lime stabilization is not difficult to carry out. After proper mix design and testing is performed, in-place mixing is usually used to add the appropriate amount of lime to soil, mixed to an appropriate depth. Pulverization and mixing is used to thoroughly combine the lime and soil. For heavy clays, preliminary mixing may be followed by 24 to 48 hours (or more) of moist curing, followed by final mixing. For maximum development of strength and durability, proper compaction is necessary.

*4) **Rice Husk Ash***

Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. It is estimated that about 70 million tons of RHA is produced annually worldwide. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica. So for every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated.

Table I Chemical Composition of Rice Husk Ash

Constituent	Composition (%)
SiO_2	82.6
Al_2O_3	0.4
Fe_2O_3	0.5
CaO	0.9
K_2O	1.8
MnO	0.3
SO_3	< 0.1
MgO	0.7
P_2O_5	0.9
Loss On Ignition (LOI)	11.9

IV. METHODOLOGY OF EXPERIMENT

The material used in this project is clayey soil which is taken from the paddy field. RHA was produced by burning in open-air. Jute fiber is used throughout this project to reinforce the soil. Jute fiber was obtained from the local market. Commercially available Quick Lime was also obtained from the local market. The natural water content of the given clayey soil is obtained. Consistency limits were obtained. Liquid limit was obtained using Cassagrande's apparatus. Plastic limit was determined by rolling soils into threads of 3 mm diameter. Shrinkage limits was found out by preparing shrinkage pats and using mercury.

Table II Basic Properties of Clayey Soil

Specific gravity	2.69
Water Content	53.39%
Grain size distribution	
• Gravel	0%
• Sand	3.9%
• Silt	30.38%
• Clay	65.07%
Liquid Limit	41%
Plastic Limit	21.635%
Plasticity Index	19.365%
Toughness index	0.45
Shrinkage limit	27.31%
Percentage of fine (passing 75 μ)	77.3%
Maximum Dry density (g/cc)	1.76 g/cc
Optimum Moisture Content	14.7%
Indian Standard Classification System	CI

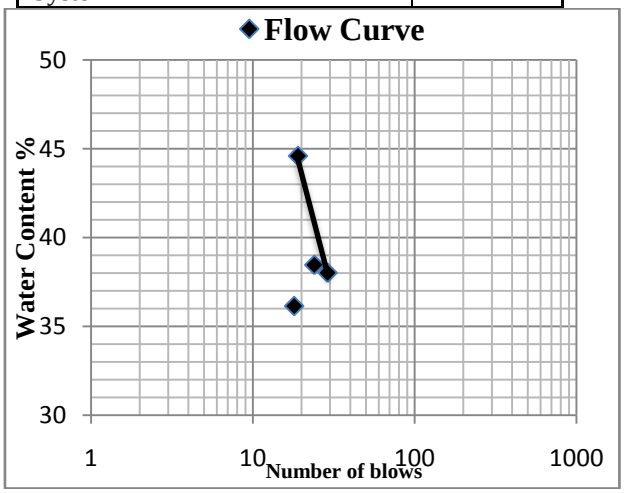

Fig. 1 Flow Curve

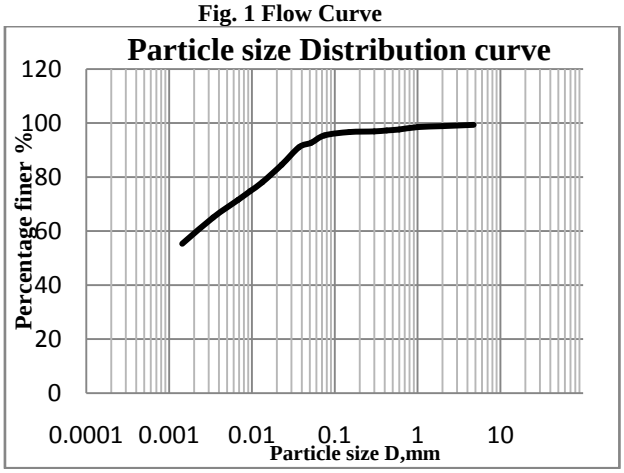

Fig.2 Particle Size Distribution Curve using Hydrometer Test

V. RESULTS AND DISCUSSION

A. Effect of Lime and RHA on dry density and moisture content of clayey soil

Table III OMC and MDD for Different Percentage Lime & RHA for Soil

% of Lime and RHA	OMC (%)	MDD (g/cc)
2	22.00	1.672
4	21.43	1.691
6	16.50	1.798
8	15.00	1.750

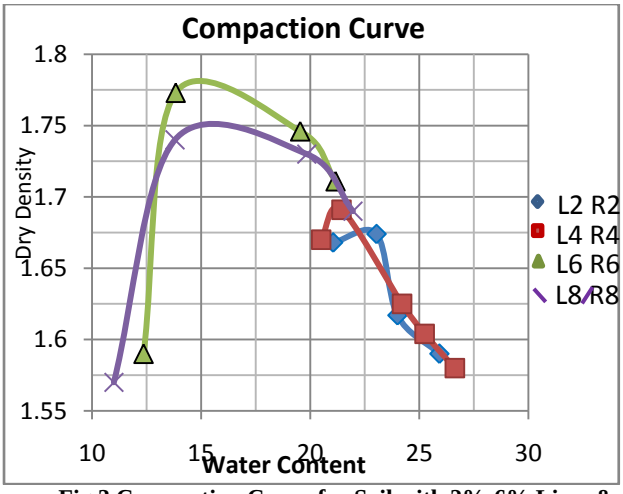

Fig.3 Compaction Curve for Soil with 2%-6% Lime & RHA

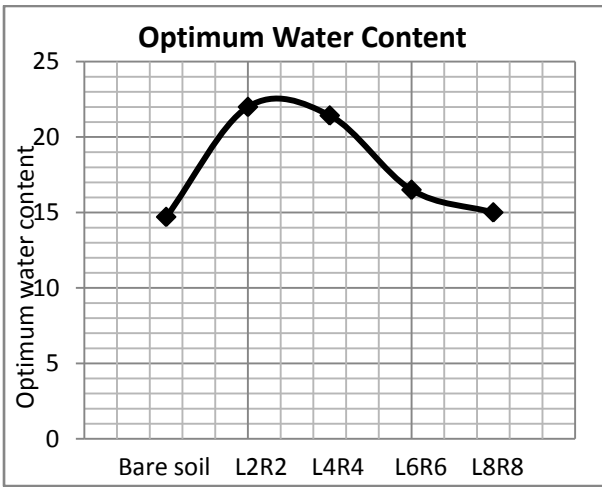

Fig.4 Influence of Lime & RHA on OMC of Soil

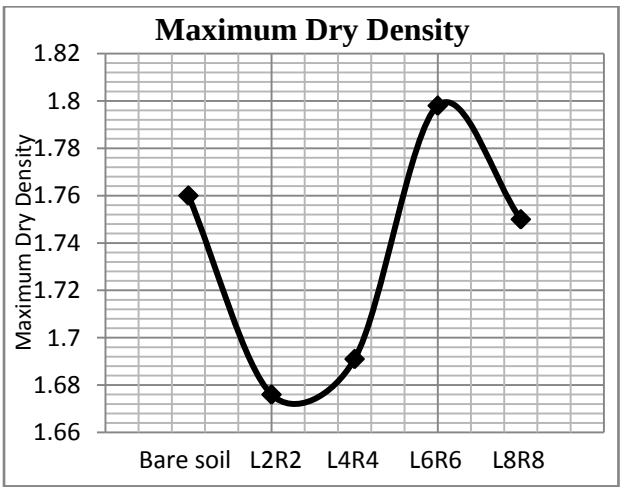

Fig.5 Influence of Lime & RHA on MDD of Soil

From the compaction test carried out on various percentage of lime and RHA, it was found that 6% lime and 6% RHA denoted by L6R6 was found to be optimum, as it gives Maximum Dry Density. In the later experimental studies, this optimum value is taken along with various percentages and aspect ratios of jute.

B. Effect of Lime, RHA and Jute on Dry Density and Moisture content of Clayey Soil

Table Iv Consolidated Results For Standard Proctor Test

Combination	OMC (%)	MDD (g/cc)
Bare soil	14.7	1.9
L2 R2	22	1.676
L4 R4	21.43	1.691
L6 R6	16.5	1.798
L6 R6, 0.5 jute of aspect ratio 10	18.5	1.725
L6 R6, 1 jute of aspect ratio 10	18.95	1.645
L6 R6, 1.5 jute of aspect ratio 10	20.5	1.625
L6 R6, 2 jute of aspect ratio 10	20.6	1.582
L6 R6, 0.5 jute of aspect ratio 15	12	1.68
L6 R6, 1 jute of aspect ratio 15	12.1	1.64
L6 R6, 1.5 jute of aspect ratio 15	12.5	1.635
L6 R6, 2 jute of aspect ratio 15	24	1.615
L6 R6, 0.5 jute of aspect ratio 20	25	1.675
L6 R6, 1 jute of aspect ratio 20	25.1	1.645
L6 R6, 1.5 jute of aspect ratio 20	25.4	1.64
L6 R6, 2 jute of aspect ratio 20	27.2	1.58
L6 R6, 0.5 jute of aspect ratio 25	21.8	1.61
L6 R6, 1 jute of aspect ratio 25	25.8	1.605
L6 R6, 1.5 jute of aspect ratio 25	29	1.57
L6 R6, 2 jute of aspect ratio 25	32.7	1.52

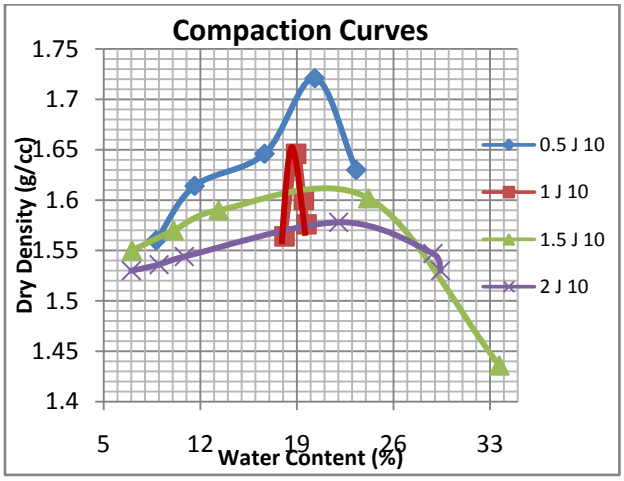

Fig.6 Compaction Curve for various % Jute of Aspect Ratio 10 in Optimum Soil-Lime-RHA mixture

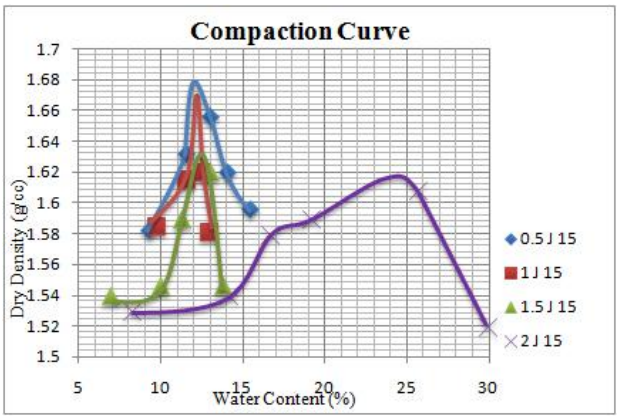

Fig.7 Compaction Curve for Various % Jute of Aspect Ratio 15 in Optimum Soil-Lime-RHA Mixture

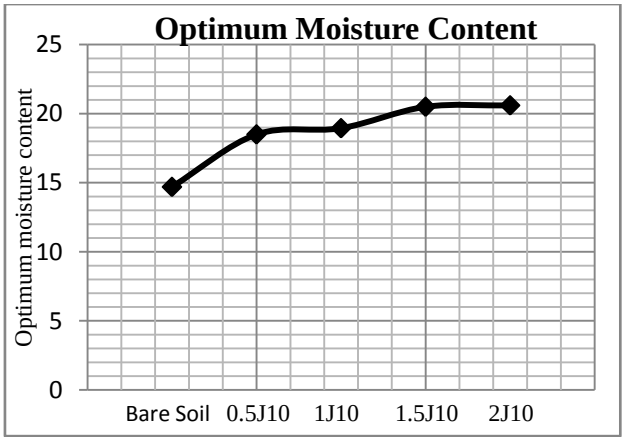

Fig.10 Influence of various % Jute of Aspect Ratio 10 in Optimum Soil-Lime-RHA Mixture on OMC of Soil

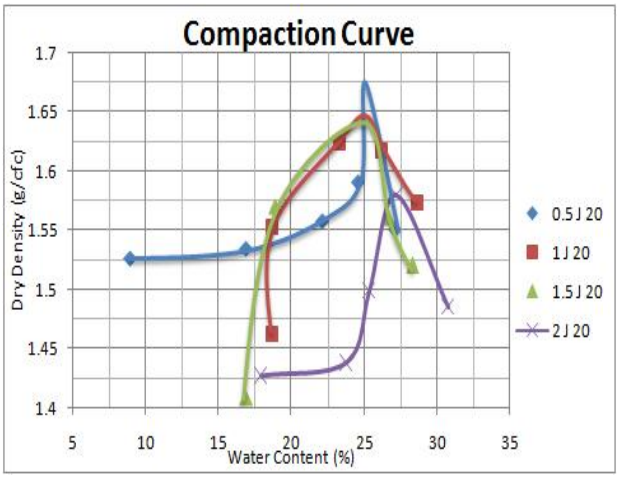

Fig. 8 Compaction Curve for Various % Jute of Aspect Ratio 20 in Optimum Soil-Lime-RHA Mixture

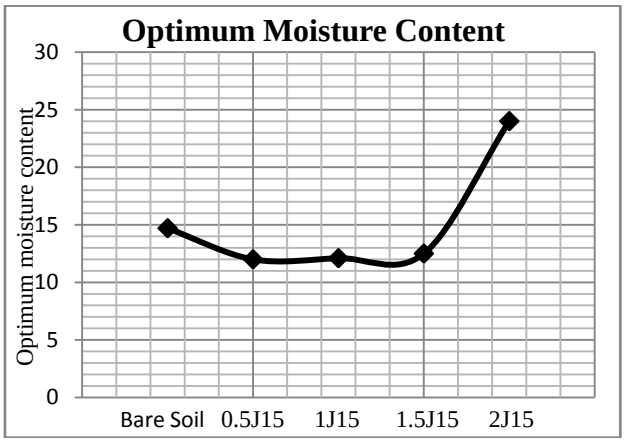

Fig.11 Influence of Various % Jute of Aspect Ratio 15 in Optimum Soil-Lime-RHA Mixture on OMC of Soil

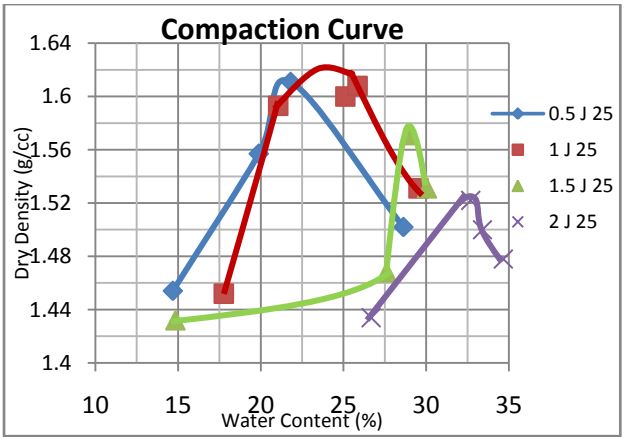

Fig.9 Compaction Curve for Various % Jute of Aspect Ratio 25 in Optimum Soil-Lime-RHA Mixture

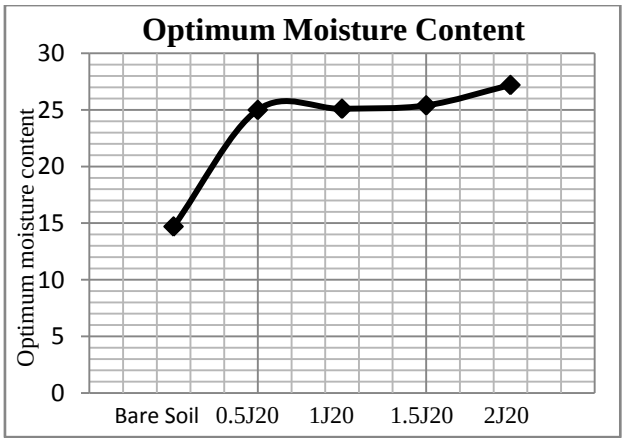

Fig.12 Influence of Various % Jute of Aspect Ratio 20 in Optimum Soil-Lime-RHA Mixture on OMC of Soil

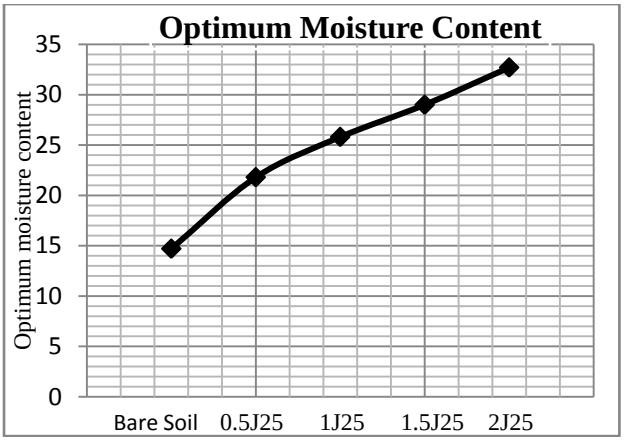

Fig.13 Influence of Various % Jute of Aspect Ratio 25 in Optimum Soil-Lime-RHA Mixture on OMC of Soil

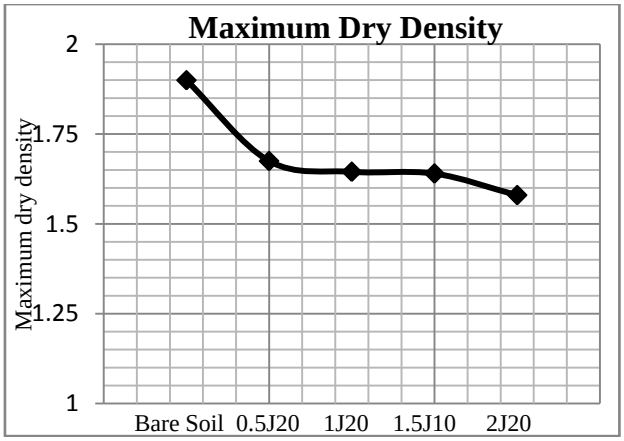

Fig.16 Influence of Various % Jute of Aspect Ratio 20 in Optimum Soil-Lime-RHA Mixture on MDD of Soil

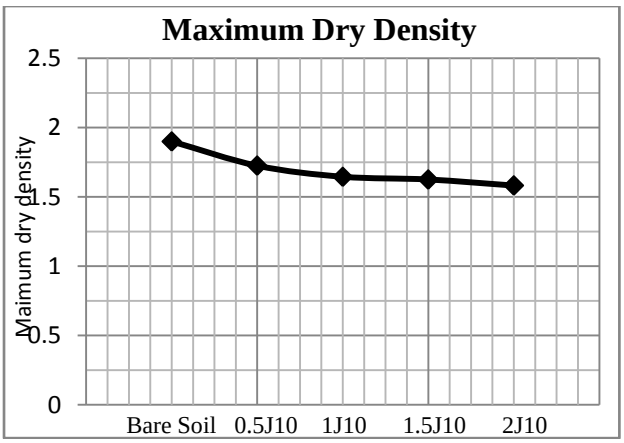

Fig.14 Influence of Various % Jute of Aspect Ratio 10 in Optimum Soil-Lime-RHA Mixture on MDD of Soil

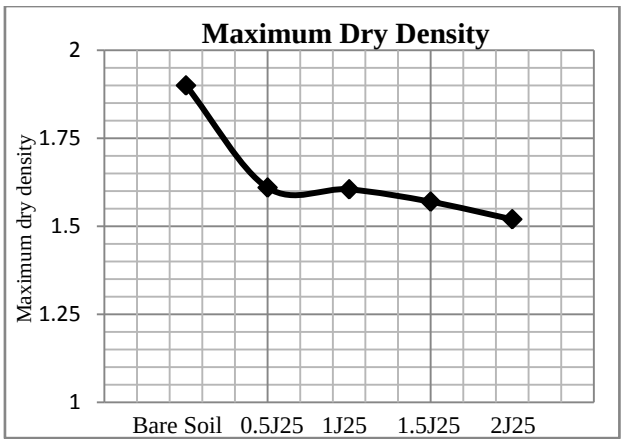

Fig.17 Influence of various % Jute of Aspect Ratio 25 in Optimum Soil-Lime-RHA Mixture on MDD of Soil

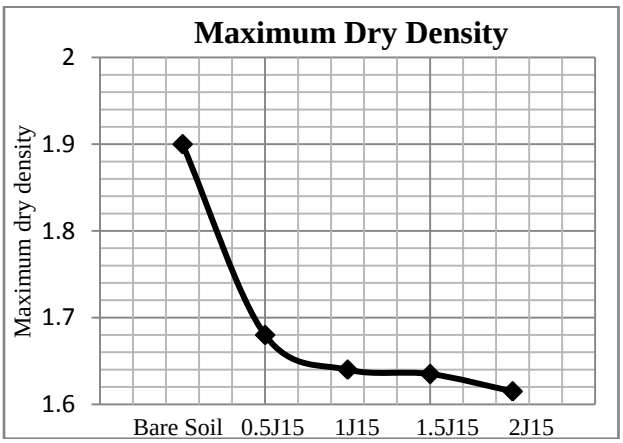

Fig.15 Influence of various % Jute of Aspect Ratio 15 in Optimum Soil-Lime-RHA mixture on MDD of Soil

C. Effect of Lime, RHA and Jute on Unconfined Compressive Strength of clayey soil

Table V Consolidated results for Unconfined Compressive Strength (UCS)

Combination	UCS
Bare soil	0.0289
L6 R6, 0.5 jute of aspect ratio 10	0.0382
L6 R6, 1 jute of aspect ratio 10	0.0573
L6 R6, 1.5 jute of aspect ratio 10	0.0762
L6 R6, 2 jute of aspect ratio 10	0.092
L6 R6, 0.5 jute of aspect ratio 15	0.0474
L6 R6, 1 jute of aspect ratio 15	0.0577
L6 R6, 1.5 jute of aspect ratio 15	0.4133
L6 R6, 2 jute of aspect ratio 15	0.1294
L6 R6, 0.5 jute of aspect ratio 20	0.476
L6 R6, 1 jute of aspect ratio 20	0.0745
L6 R6, 1.5 jute of aspect ratio 20	0.1331
L6 R6, 2 jute of aspect ratio 20	0.2355
L6 R6, 0.5 jute of aspect ratio	0.1044

25	
L6 R6, 1 jute of aspect ratio 25	0.1325
L6 R6, 1.5 jute of aspect ratio 25	0.2439
L6 R6, 2 jute of aspect ratio 25	0.4375

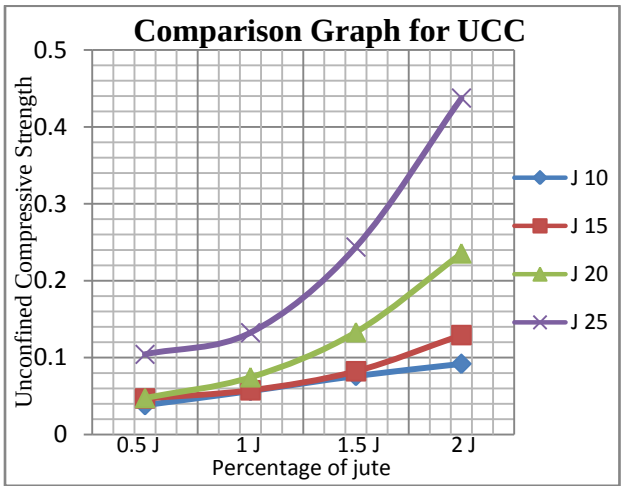

Fig.18 UCS for Various % and Aspect Ratio of Jute in Optimum Soil-Lime-RHA Mixture

D. Effect of Lime, RHA and Jute on California Bearing Ratio of Clayey Soil

Table VI Consolidated Result for California Bearing Ratio

Combination	CBR(%)
Bare soil	20.92
L6 R6, 0.5 jute of aspect ratio 10	39.9
L6 R6, 1 jute of aspect ratio 10	46.22
L6 R6, 1.5 jute of aspect ratio 10	53.43
L6 R6, 2 jute of aspect ratio 10	56.54
L6 R6, 0.5 jute of aspect ratio 15	43.8
L6 R6, 1 jute of aspect ratio 15	46.72
L6 R6, 1.5 jute of aspect ratio 15	57.47
L6 R6, 2 jute of aspect ratio 15	59.37
L6 R6, 0.5 jute of aspect ratio 20	44.28
L6 R6, 1 jute of aspect ratio 20	49.64
L6 R6, 1.5 jute of aspect ratio 20	61.31
L6 R6, 2 jute of aspect ratio 20	62.29
L6 R6, 0.5 jute of aspect ratio 25	45.74
L6 R6, 1 jute of aspect ratio 25	62.77
L6 R6, 1.5 jute of aspect ratio	63.26
25	
L6 R6, 2 jute of aspect ratio 25	70.07

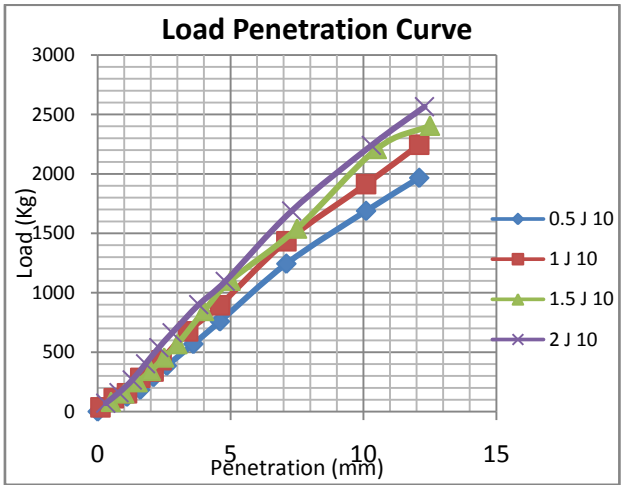

Fig.19 Load Penetration Curve for various % Jute of Aspect Ratio 10 in Optimum Soil-Lime-RHA mixture

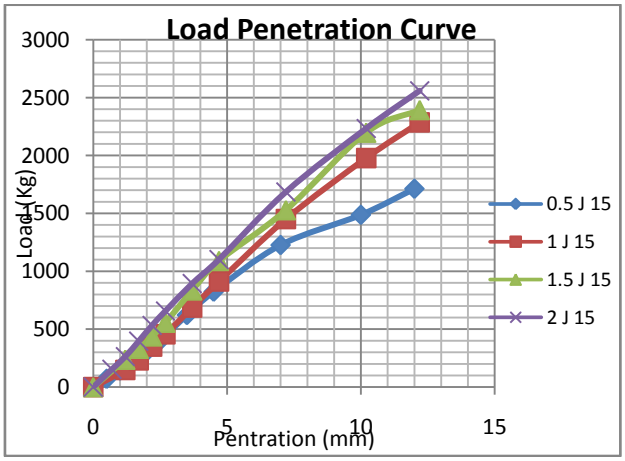

Fig.20 Load Penetration Curve for Various % Jute of Aspect Ratio 15 in Optimum Soil-Lime-RHA Mixture

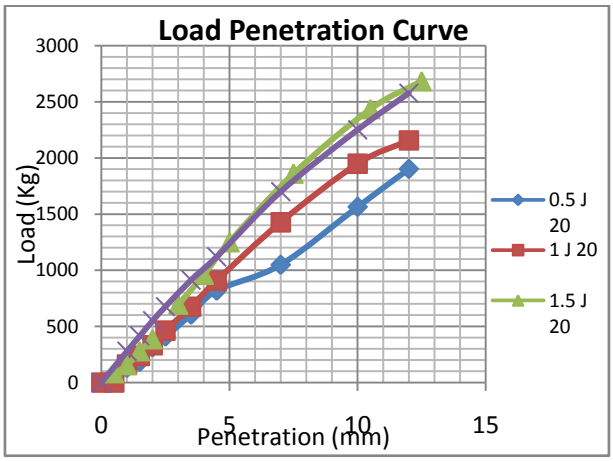

Fig.21 Load Penetration Curve for various % Jute of Aspect Ratio 20 in Optimum Soil-Lime-RHA Mixture

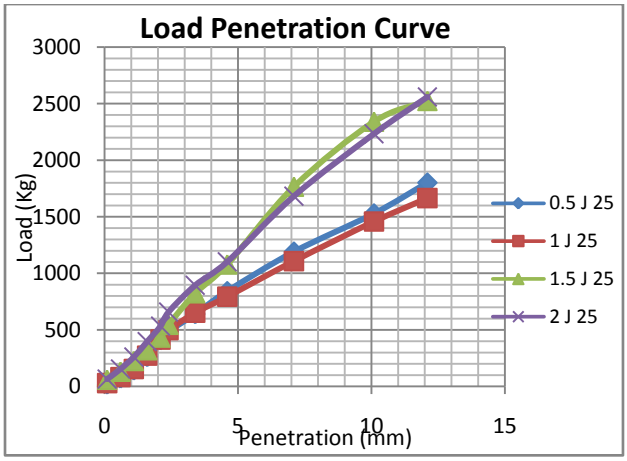

Fig.22 Load Penetration Curve for Various % Jute of Aspect Ratio 25 in Optimum Soil-Lime-RHA Mixture

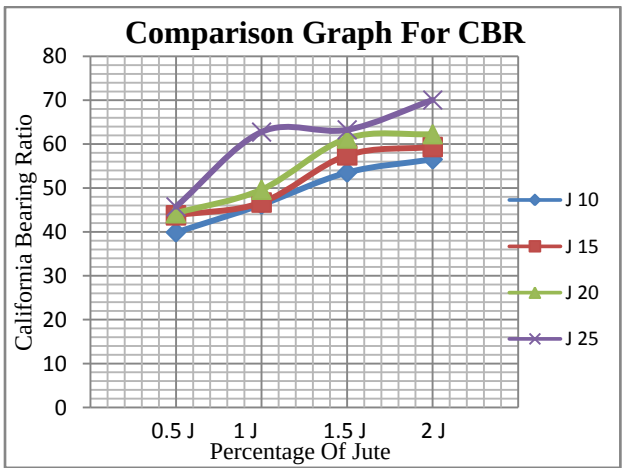

Fig.23 Load Penetration Curve for Various % and Aspect Ratio of Jute in Optimum Soil-Lime-RHA Mixture

E. Effect of Lime and Jute on Maximum Dry Density and Optimum Moisture Content of Clayey Soil

Table VII OMC and MDD for 2% Jute of Various Aspect Ratio in Soil-Lime Mixture

COMBINATIONS	OMC (%)	MDD (g/cc)
L6, 2 jute of aspect ratio 10	20	1.744
L6, 2 jute of aspect ratio 15	19.4	1.706
L6, 2 jute of aspect ratio 20	17.4	1.63
L6, 2 jute of aspect ratio 25	17	1.592

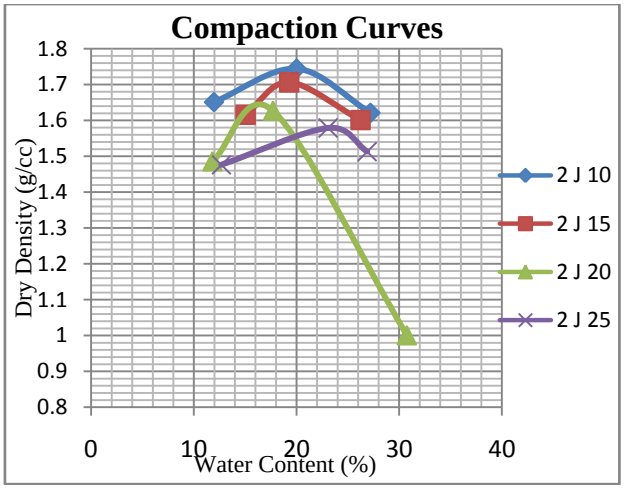

Fig.24 Compaction Curve for 2% Jute of Various Aspect Ratios in Soil-Lime Mixture

F. Effect of Lime and Jute on Unconfined Compressive Strength of Clayey Soil

Table VIII UCS for 2% Jute of various Aspect Ratio in Soil-Lime mixture

Combinations	UCS
L6, 2 jute of aspect ratio 10	0.028
L6, 2 jute of aspect ratio 15	0.029
L6, 2 jute of aspect ratio 20	0.036
L6, 2 jute of aspect ratio 25	0.0373

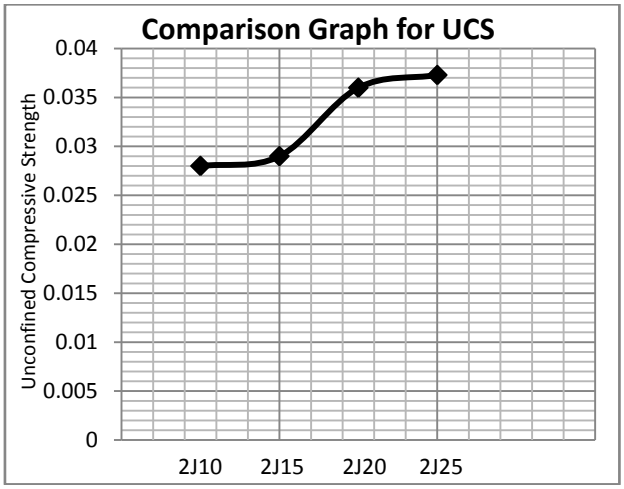

Fig.25 UCS for 2% and Various Aspect Ratio of Jute in Soil-Lime Mixture

G. Effect of Lime and Jute on California Bearing Ratio of clayey soil

Table IX CBR for 2% Jute of Various Aspect Ratio in Soil-Lime mixture

COMBINATIONS	CBR (%)
L6, 2 jute of aspect ratio 10	31.09
L6, 2 jute of aspect ratio 15	31.63
L6, 2 jute of aspect ratio 20	31.97
L6, 2 jute of aspect ratio 25	36.50

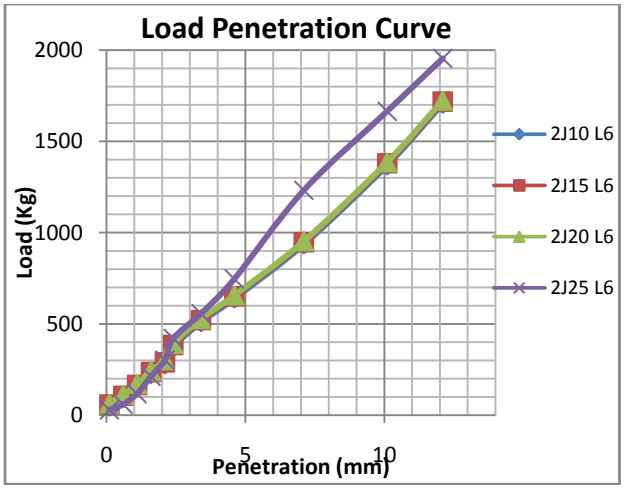

Fig.26 Load Penetration Curve for 2% Jute of Various Aspect Ratios in Soil-Lime Mixture

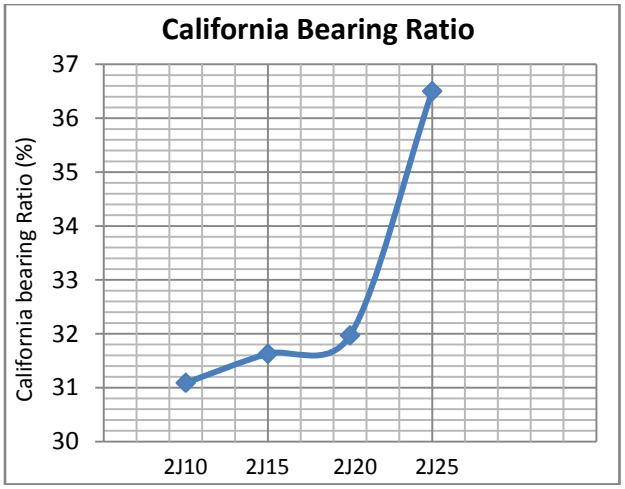

Fig.27 Load Penetration Curve for 2% Jute of Various Aspect Ratios in Soil-Lime Mixture

VI. CONCLUSIONS

The various samples of soils were collected from paddy field.

- The natural water content of soil samples was obtained as 53.39% by oven drying method.
- The specific gravity of the soil sample was found to be 2.69.
- The liquid limit, plastic limit and Shrinkage limit was found to be 41%, 21.635% and 27.3% respectively.
- Using the Indian Standard Classification System (ISCS), the soil was classified as CI (Inorganic Clay of Intermediate compressibility).
- The optimum moisture content for the clayey soil sample is 14.7%.
- The California Bearing Ratio Test was done and its value is 20.92%.
- The addition of various percentages of Lime and RHA into the soil progressively decreases the OMC and increases MDD.
- The combination of 6% Lime and 6% RHA was obtained as optimum.
- Addition of various percentages and aspect ratio of jute in Optimum Soil-Lime-RHA Mixture progressively increases OMC, decreases MDD, increases UCS and increases CBR.
- Among various combinations of jute, 2% jute of aspect ratio 25 proves to be more effective as compared to lower percentages because when the length of the jute fiber increases, more and more soil particles will get bonded together precisely increased length of jute fiber increases the reinforcement among the soil and jute fiber.

ACKNOWLEDGEMENT

Every success stands as a testimony not only to the hardship but also to hearts behind it. Likewise, the present project work has been undertaken and completed with direct and indirect help from many people and we would like to acknowledge the same.

First and foremost we take immense pleasure in thanking the Management and respected principal, Dr.Priestly Shan, for providing us with the wider facilities.

We express our sincere thanks to Dr. Surendran A, Head of the Department of Civil Engineering for giving us opportunity to present this project and for timely suggestions.

We wish to express my deep sense of gratitude to the project coordinators Mr. Muhammed Shareef k, Asst. Professor & Mr. Mahesh K.M, Asst. Professor, in Department of Civil Engineering, who coordinated in right path.

Words are inadequate in offering our thanks to Mr. Vishnu T.C, Asst. Professor, Department of Civil Engineering, for his encouragement and guidance in carrying out the project.

Needless to mention that the teaching and non-teaching faculty members had been a source of inspiration and timely support in the conduct of our project. We would also like to express our heartfelt thanks to our beloved parents for their blessings, our friends / classmates for their help and wishes for the successful completion of this project.

Above all we would like to thank the Almighty God for the blessings that helped us to complete this venture smoothly.

ABBREVIATIONS

SYMBOL	DESCRIPTION
L2R2	2% Lime & 2% Rice Husk Ash
L4R4	4% Lime & 4% Rice Husk Ash
L6R6	6% Lime & 6% Rice Husk Ash
0.5J10	0.5 jute of aspect ratio 10
1J10	1 jute of aspect ratio 10
1.5J10	1.5 jute of aspect ratio 10
2J10	2 jute of aspect ratio 10
0.5J15	0.5 jute of aspect ratio 15
1J15	1 jute of aspect ratio 15
1.5J15	1.5 jute of aspect ratio 15
2J15	2 jute of aspect ratio 15
0.5J20	0.5 jute of aspect ratio 20

1J20	1 jute of aspect ratio 20
1.5J20	1.5 jute of aspect ratio 20
2J20	2 jute of aspect ratio 20
0.5J25	0.5 jute of aspect ratio 25
1J25	1 jute of aspect ratio 25
1.5J25	1.5 jute of aspect ratio 25
2J25	2 jute of aspect ratio 25
ISCS	Indian Standard Classification System

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