Feasibility of Soil Stabilization using Rice Husk Ash and Coir Fibre

Abarajithan. G, Rishab Kumar. P, Srikanth. R
Bachelor of Engineering Students,
Department of Civil Engineering
Misrimal Navajee Munoth Jain Engineering College
Chennai – 600 097, Tamil Nadu, India

Barathidason. P
Assistant Professor,
Department of Civil Engineering
Misrimal Navajee Munoth Jain Engineering College
Chennai – 600 097, Tamil Nadu, India

***Abstract*— Soil stability is an important criteria in the field of construction. For soil which lacks sufficient stability, various stabilization techniques can be adopted. Stabilization can increase the shear strength of soil and control the shrink-swell properties of soil, thus improving the load bearing capacity of the sub-grade to support pavements and foundations. A vast diversity of stabilization techniques exist. The focus of this report is to study the feasibility of stabilizing soil by using rice husk ash and coir fiber, thus re-using waste materials and providing an economical and ecofriendly method of soil stabilization.**

Keywords*— Soil stabilization, Rice Husk Ash, Coir Fibre, Index properties, Optimum Moisture Content, Unconfined Compressive Strength, Bearing capacity

I. INTRODUCTION

A. General

Soil is a significant component in the construction scenario. The longevity of a structure is directly dependent on the soil upon which it rests, therefore, it is necessary to ensure that the soil over which any structure is constructed, is firm or stable enough. Soil stabilization is a set of methods devised to improve the stability of soil. Various stabilization techniques prevail in the construction field utilizing diverse materials of varying properties.

This study, particularly aims at testing the viability of utilizing waste materials such as Rice Husk Ash and Coir Fibre which are eco-friendly as well as economical, for soil stabilization.

B. Soil Stabilization

Soil stabilization is a physical, chemical, biological or combined method of altering the properties of a particular soil type to meet an engineering purpose. The prime objective of soil stabilization is to improve on-site materials to create a solid and strong sub-base and base courses. Originally, soil stabilization was done by utilizing the binding properties of clay soils, cement-based products such as soil cement, or utilizing the soil compaction technique and lime. Some of the renewable technologies are: enzymes, surfactants, biopolymers, synthetic polymers, co-polymer based products, cross-linking styrene acrylic polymers, tree resins, ionic stabilizers, fibre reinforcement, calcium chloride, calcite, sodium chloride, magnesium chloride and more.

However, recent technology has increased the number of traditional additives used for soil stabilization purposes. Traditionally and widely accepted types of soil stabilization techniques use products such as bitumen emulsions. However, bitumen is not environmentally friendly and becomes brittle when it dries out. Portland cement has been used as an alternative to bitumen, in soil stabilization. This can often be expensive and not a "green" alternative. In recent times, green alternatives such as natural fibres have been used for soil stabilization and various other eco-friendly and economical methods are being devised.

C. Soil

Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. It also serves as a base over which every structure is constructed. Like holding the roots of vegetation firmly, the soil is required to hold the foundation of a building firm enough, such that the building will sustain without any type of failure for a long period of time. Soil with strong cohesive properties prove to be stable and can withstand heavy structures. However, soil with weak mechanical properties cannot withstand structures and may lead to failure of the structure at a later stage. Stabilization methods can be employed to improve the mechanical properties of that particular soil.

D. Rice Husk Ash

Rice Husk are the hard protective coverings of grains of rice. In addition, it can be put to use as building material, fertilizer, insulation material, or fuel. It contains large amount of iron oxide, opaline, lignin and silica. Rice Husk is separated from the rice grain by a process known as winnowing. It is used as fuels in kilns and furnaces in certain industries such as rice mills, bakeries, etc. and as a result of complete incineration, Rice Husk Ash can be obtained. Rice Husk Ash is chemically stable and its physical properties are similar to that of natural sand. The high angularity and friction angle of Rice Husk Ash contribute to excellent stability and load bearing capacity. This ash is a potential source of amorphous reactive silica. Silica is the basic component of sand, which is used with cement for plastering and concreting. Most of the ash is used in the production of Portland cement.

Fig 1: Rice Husk Ash and Coir Fibre

E. Coir Fibre

Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Coir has a neutral pH level which does not affect the chemical composition of the soil. The fibrous property of coir helps in improving the structural integrity of soil when mixed in required proportions. However, the disadvantage of utilizing coir fibre for soil stabilization is that it decomposes after a particular period and is not beneficial for a lifetime. But the lifetime of Coir Fibre can be prolonged to some extent by chemical treatment. When used in lower concentration, the effect of decomposition of coir fibre will be less pronounced. Apart from being structurally beneficial, coir also helps in facilitating improved vegetation by retaining moisture and by providing sufficient aeration to the plants. Coir Fibre with fixed *aspect ratio can be used throughout, as reinforcement. Nevertheless, a fixed aspect ratio was not adopted for the Coir Fibre in this study.

II. LITERATURE REVIEW

A. Soil Stabilization using Rice Husk Ash and Cement (2014)

Ms. Aparna Roy has presented a study which gives details about soil which is stabilized with different percentages of Rice Husk Ash and a small amount of cement. The results obtained show that the increase in RHA content increases the Optimum Moisture Content but decreases the Maximum Dry Density. Also, the CBR value and Unconfined Compressive Strength of soil are considerably improved with the Rice Husk Ash content.

B. CBR variation in soil reinforced with natural fibres (2015)

Mr. Dharmendra has put forth a comparative study on locally available soil, reinforced with Jute and Coir fibre. The Jute and Coir fibres were reinforced in different percentage in the soil samples. Both the soaked and unsoaked CBR values are measured and compared for both the fibres. Test result indicates that CBR value of soil increases with the increase in fibre content to some extent, and further addition of fibre results in decreased strength due to excess organic matter content.

C. Effect of Rice Husk Ash on Soil Stabilization (2014)

Qasim et al. have reviewed the stabilization of soil using sustainable methods. They concluded that Rice Husk Ash, with the presence of humidity, reacts with chemicals and improves strength and compressibility nature of soil.

*Aspect ratio – The ratio of length to width of the Coir Fibre Strands.

D. Review on Stabilization of Soil Using Coir Fibre (2015)

Dr. Sharma et al. concluded that randomly distributed fibre reinforced soil have recently attracted increasing attention in geotechnical engineering. The main aim of this paper, therefore, is to review the, benefits, properties and applications of coir fibre in soil reinforcement through reference to published scientific data.

E. Soil stabilization with rice husk ash and waste coir material (2017)

Murali et al. Studied the usability and effectiveness of Rice Husk Ash and Waste Coir material reinforcement for deep foundation or raft foundation, as a cost effective approach and to evaluate the effects of Rice Husk Ash and Waste Coir material on the shear strength of unsaturated soil samples by carrying out Direct Shear Tests and Unconfined Compression Strength Tests.

III. EXPERIMENTAL INVESTIGATION

1. Specific gravity:

Specific gravity is the ratio of the density of any substance to the density of a reference substance, (example: water) for the same given volume. The scope of specific gravity test is to calculate certain soil properties such as density, void ratio and degree of saturation.

2. Grain size distribution:

Grain size analysis is used in the engineering classification of soils. Information obtained from the grain size analysis can also be used to predict the permeability of soil.

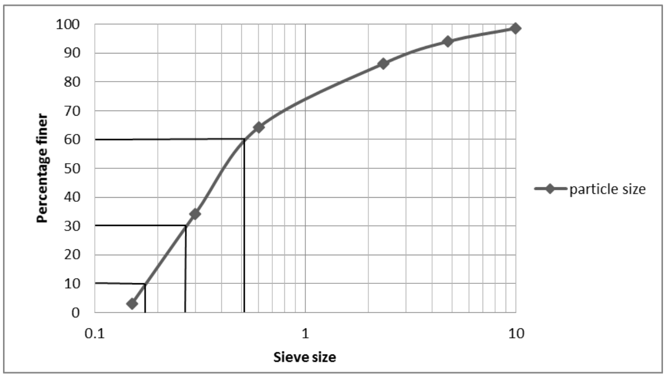


Fig 2: Particle Size Distribution Chart

From the graph D_{10}, D_{30}, D_{60} values are determined and the corresponding values of C_u and C_c are determined.

$C_u = 2.89 < 6$ and $C_c = 0.838 < 1$, the soil sample is classified under the group symbol SP (Poorly graded sand). And further, because the Gravel content = 6% < 15%, the soil is classified to be poorly graded sand with clay or can generally be referred to as silty clay as per IS: 1498 – 1970 [1].

3. Liquid limit:

The liquid limit of soil is the water content at which the soil behaves practically like a liquid, but possess minimal shear strength.

The Liquid Limit of the test soil sample was found to be W_L= 28% [2]

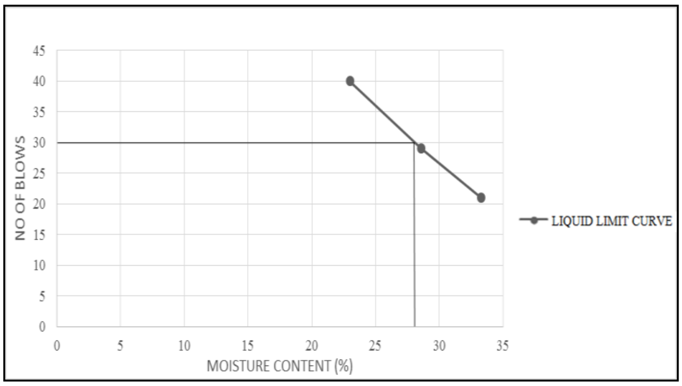


Fig 3: Liquid Limit Flow Curve

4. Plastic limit:

The moisture content expressed in percentage, at which the soil has the least plasticity is known as plastic limit. Just after plastic limit, the soil displays the properties of a semi solid.

The Plastic Limit of the test soil sample was found to be W_P= 17.8% and Plasticity Index, I_P= 10.2 [2]

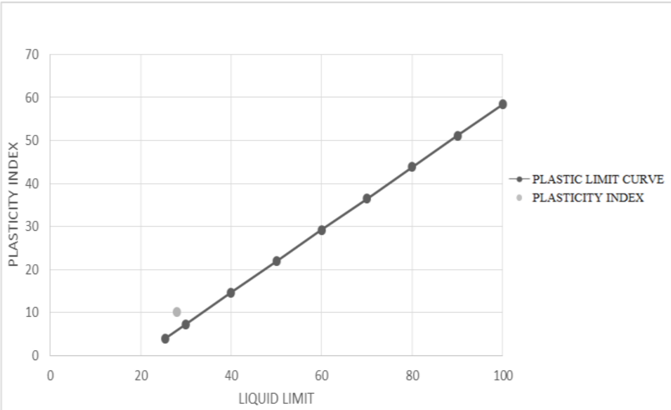


Fig 4: Plasticity Chart

Comparing the plasticity chart obtained, with the standard plasticity chart from IS: 1498 – 1970, it is inferred that the soil can be classified under the group CL or Low plasticity Clay [1].

Table 1: Summary of Index properties of Soil Sample

S. No	Description	Values
1.	Specific Gravity (G)	2.350
2.	Liquid Limit, W_L (%)	28
3.	Plasticity Index, I_P	10.2
4.	Plastic Limit, W_P (%)	17.8
5.	Uniformity coefficient (C_u)	2.89
6.	Coefficient of curvature (C_c)	0.838
7.	Particle size distribution: Gravel content (%) Sand content (%)	 6 94

5. Optimum Moisture Content:

The Optimum Moisture Content of soil is the water content at which the maximum dry unit weight can be achieved after a given compaction effort. A max dry unit weight would have no voids in the soil. Optimum Moisture Content can be determined by means of the Standard Proctor test as per IS: 2720 (Part 7) – 1980 [3]. The results of this test are useful in proceeding with the stability testing of the soil sample after adding Rice Husk Ash and Coir Fibre.

Table 2: Optimum Moisture Content and corresponding Maximum Dry Density of soil

Soil Sample	OMC (%)	MDD (gm/cc)
Unreinforced Soil Sample	9.6	0.690
6% Rice Husk Ash and 2% Coir Fibre	11	0.788
7% Rice Husk Ash and 1.5% Coir Fibre	5	0.857
8% Rice Husk Ash and 1% Coir Fibre	9	0.90

6. Unconfined Compression Test

The unconfined compression test is by far the most popular method of soil shear testing since it is fast and cheap. The method is used primarily for saturated, cohesive soils recovered from thin-walled sampling tubes. The maximum load per unit area of the extruded soil sample is known as Unconfined Compression Strength, q_u [4].

Table 3: Unconfined Compressive Strength Test Result

Soil Sample	Unconfined compressive strength, q_u (KN/m^2)	Unconfined cohesion & shear strength, C_u (KN/m^2)
Unreinforced Soil Sample	372.65	186.33
6% Rice Husk Ash and 2% Coir Fibre	284.39	142.20
7% Rice Husk Ash and 1.5% Coir Fibre	353.04	176.52
8% Rice Husk Ash and 1% Coir Fibre	392.27	196.14

7. California Bearing Ratio Test

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 a required extent, for the corresponding penetration of a standard material. Tests are carried out on natural or compacted soil under soaked or un-soaked conditions and the results so obtained are compared with the standard test to gain insight of its strength [5].

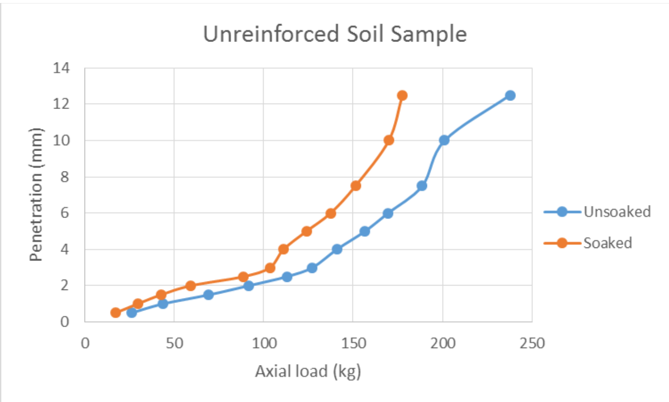
Table 4: Standard Load used in CBR test

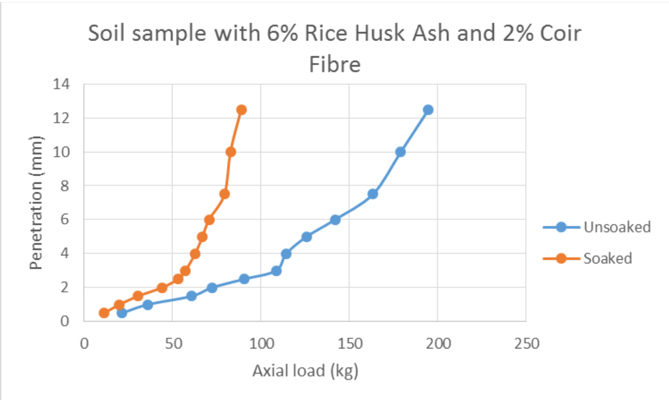
Penetration depth (mm)	Unit standard load (kg/cm^2)	Total standard load (kg)
2.5	70	1370
5.0	105	2055
7.5	134	2630
10.0	162	3180
12.5	183	3600

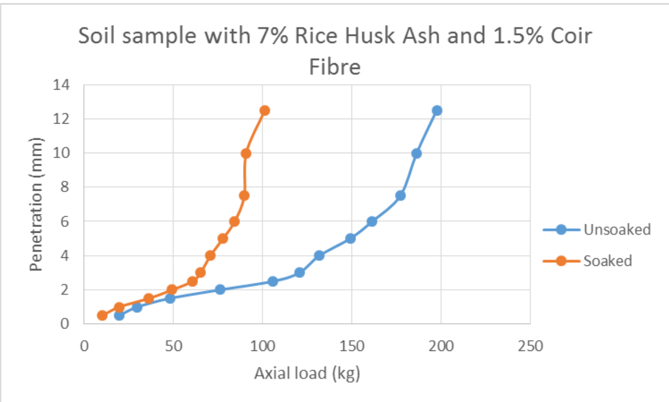
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

Table 5: CBR values of Soil Sample for standard penetration

Soil Sample	Unsoaked		Soaked	
	2.5 mm	5 mm	2.5 mm	5 mm
Unreinforced soil	8.24	7.62	6.47	6.03
6% Rice Husk Ash and 2% Coir Fibre	6.59	6.11	3.87	3.25
7% Rice Husk Ash and 1.5% Coir Fibre	7.73	7.26	4.43	3.79
8% Rice Husk Ash and 1% Coir Fibre	9.38	8.66	6.98	6.55







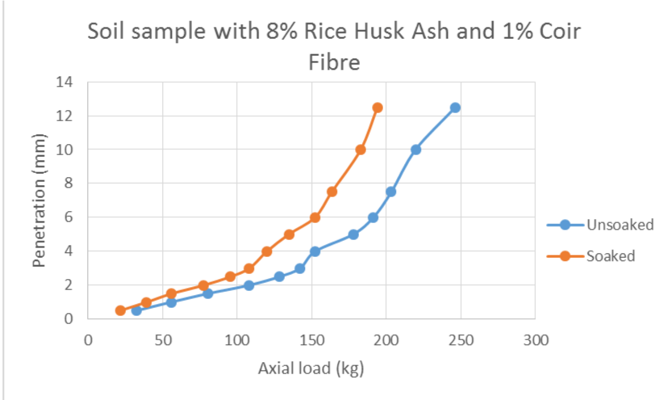


Fig 5: Variation of Axial load for different penetration values.

IV. CONCLUSION

Eco-friendly and Economic materials like Rice Husk Ash and Coir Fibre, made a significant impact on the stability properties of soil, when added to the soil sample in required quantities. From the experimental results, it is evident that Coir Fibre and Rice Husk Ash, in required proportions have increased the value of both the bearing capacity and unconfined compressive strength of the soil.

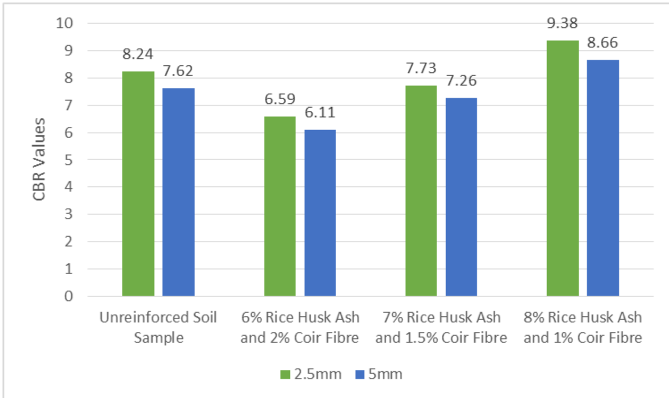


Fig 6: CBR variation for Unsoaked Soil Sample

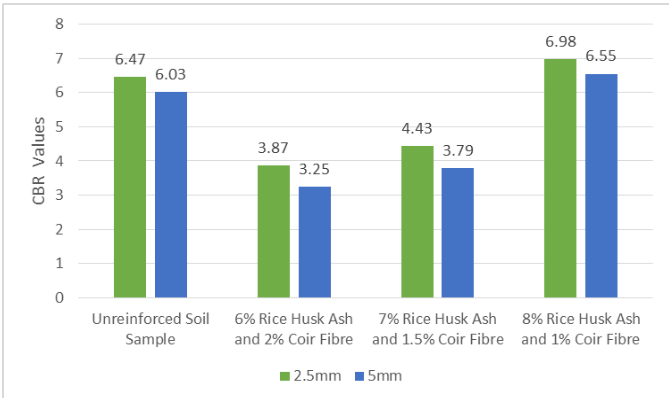


Fig 7: CBR variation for Soaked Soil Sample

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

Based on the results, the CBR value increases on increasing the Rice Husk Ash percentage and decreasing the Coir Fibre percentage for both Soaked and Unsoaked Soil Samples. The maximum bearing capacity of the soil is attained with **8%** Rice Husk Ash and **1%** Coir Fibre than the other ratio of reinforcements both in soaked and unsoaked conditions.

Therefore, based on the results obtained from the CBR test and the literature review, it is clear that the bearing capacity of the soil will definitely increase when a higher percentage of Rice Husk Ash and a lower percentage of Coir Fibre are added to the soil.

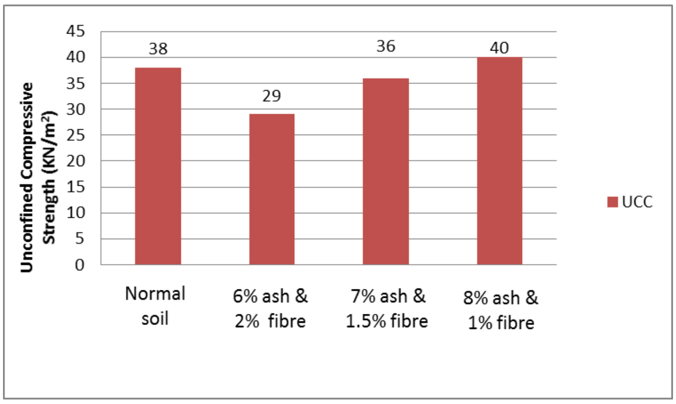


Fig 8: Variation of Unconfined Compressive Strength

Based on the results obtained from the Unconfined Compression test, the compressive strength of the soil increases with the increase in Rice Husk Ash and decrease in Coir Fibre as reinforcements.

From the above graph it is evident that compressive strength of the soil is higher with **8%** Rice Husk Ash and **1%** Coir Fibre than the other reinforcement ratios. Thus, based on the results, the compressive strength of soil will certainly increase when a higher percentage of Rice Husk Ash and a lower percentage of Coir Fibre are added to the soil.

Finally, it can be concluded that the stability of the soil is increased marginally with increase in the percentage of Rice Husk Ash and decrease in the percentage of Coir Fibre.

REFERENCES

[1] IS 1498 : 1970 – Classification and identification of soils for general engineering purposes (First revision)
[2] IS 2720 (Part 5) : 1985 – Determination of liquid and plastic limit (Second revision)
[3] IS 2720 (Part 7) : 1980 – Determination of water content – dry density relation using light compaction (Second revision)
[4] IS 2720 (Part 10) : 1991 - Determination of Unconfined Compressive Strength (second revision)
[5] IS 2720 (Part 16) : 1987 - Laboratory determination of CBR (Second revision)