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Experimental Study of Coir Fiber & Rice Husk Ash on Geotechnical Properties of Expansive Soil

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Abstract: ***The problem with expansive soils has been recorded all over the world. In monsoon they imbibe alternative swelling and shrinkage, lightly loaded civil engineering structures like residential buildings, pavements and canal linings are severely damaged. It is, therefore, necessary to mitigate the problems posed by expansive soils and prevent cracking of structures.***
This paper describes the use of Coir Fiber and Rice Husk Ash for soil stabilization. Standard proctor test, California bearing ratio test and unconfined compression strength test were carried out. The fraction of Coir Fiber is used in this paper is 2, 2.5, 3 and 3.5 along with fixed value of Rice Husk ash 15%. The different percentage were determined which showed considerable enhancement in the strength of treated soil. The maximum value of C.B.R. is at 3% Coir Fiber and 15% Rice Husk Ash additional increase in ratio of Coir Fiber the C.B.R. value decreases. The maximum value of U.C.S. is also at 3% Coir Fiber and Rice Husk Ash 15%. Experiment results show Coir Fiber and Rice Husk Ash enhances the strength properties of soil along with use of economical materials and also solves the environment problem.
Keywords: Expansive Soil, Rice Husk Ash, Coir Fiber, Soil Stabilization

I. INTRODUCTION

Soil stabilization is the process of making some improvement in the engineering properties of the given soil and thus making in more stable. It is required when the soil available for construction is not suitable for the purpose intended.The main goal in soil stabilization is to enhance the strength properties and reduce the settlement. Soil stabilization is an efficient and unfailing technique for enhancing soil strength and firmness. The material which is use to mix with soil for stabilization of soil is known as the soil stabilizer. It is illustrious that the mechanism of soil stabilization by rice husk ash and coir-fiber is a worthy method of ground improvement, which leads to increase in UCS, CBR value of given expansive soil, hence it increases the stability of structures, i.e. subgrade and foundation

II. LITERATURE REVIEW

Dasaka et al. (2011) reinforced the soil with the coir fiber at various fiber content and found that with the fiber length of 15 mm, unconfined compressive strength increases with the increase in the fiber content and the soil shows a ductile behavior with the addition of the fiber. It was found that peak compressive strength increased up to the fiber content of 1.5% and after that, the compressive strength does not increase considerably. From the study, it can be stated that with the increase in the fiber content the failure would take place slowly and samples behave like ductile material and well-defined failure surface could not be seen due to increased ductile behavior.

Dutta et al. (2012) studied the effect of inclusion of coir fiber (15 mm in length) in the unconfined compressive strength of the soil. Dry fiber, sodium hydroxide and carbon tetrachloride treated coir fibers were taken for the study. The specimen for the unconfined compressive tests were prepared from unreinforced and reinforced dry/treated fiber with the fiber content of 0.4%, 0.8% and 1.6%.

Maliakal et al. (2013) studied the effect of randomly distributed coir fiber on the shear strength of clay, for this series of consolidated undrained test were performed with varying fiber content having an aspect ratio of 50, 100 and 150 and fiber content of 0.5, 1 and 2% was taken for study. For all percentages of coir fiber. maximum improvement in strength was obtained at the fiber content of 2% and improvement in strength was 1.7 times in comparison to the unreinforced soil. For the aspect ratio, the maximum improvement was reported at the aspect ratio of 150 and the length of fiber at this aspect ratio was 36 mm.

Ms. Aparna Roy (2014) 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.

Qasim et al. (2015) 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.

Das et al. (2016) studied about the shear strength parameters of the unreinforced and reinforced soil with coir fiber. The coir fiber was added to the value of 1%, 2% and 3% by weight of soil. It was observed that the application of coir fiber on sand result in an increase in the shear strength parameters. The main cause for the improved shear strength is that in the absence of reinforcement the soil shows brittle failure but after the reinforcement, the soil starts showing the ductile failure as the friction has now been developed between the soil and the reinforced material

Murali et al. (2017) 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.

A. Objectives Of The Study

1) To investigate the optimal use of Coir Fiber & Rice Husk Ash in Expansive Soil.
2) To determine the OMC & MDD of untreated soil sample with CF & RHA.
3) To determine the CBR value of untreated soil sample with CF & RHA.
4) To determine the UCS value of untreated soil sample with CF & RHA.

III. MATERIALS & METHODOLOGY

A. Soil

350kg sample of soil used in the mix was collected from the fields of **BUMORA (KATHUA DISTRICT), J&K**. It will be combined with soil and fiber in different proportions for further analysis.

The soil collected from the site was pulverized to break the lumps with wooden hammer and then dried in air under covered area.

Property of Soil Sample	Value
Specific gravity	2.57
Liquid Limit LL (%)	36.5
Plastic Limit PL (%)	21.7
Plasticity Index PI (%)	14.8
Optimum Moisture Content (%)	13.80
Maximum Dry Density (g/cc)	18.21KN/m^3
CBR	3.2%
UCS	85.87 kN/m^2
Indian soil classification	CI

Properties of Soil Sample

B. Coir Fiber

These fibers are biodegradable and environmentally friendly. It has the greatest tearing strength among all-natural fibers and retains this property in wet conditions. Therefore, coconut fiber is selected as the reinforcement material for this study. Coir used for the study was cut into 30 mm length.Coir fiber will be purchased from Anand mattress manufacturing company GANGYAL (JAMMU DISTRICT), J&K.

Chemical properties	Composition
Lignin	45.84 %
Cellulose	43.44 %
Hemi-Cellulose	00.25 %
Pectin’s and related compounds	03.00 %
Water soluble	05.25 %
Ash	02.22 %

Chemical Properties of Coir Fiber

Physical properties	Value
Length in inches	6-8
Density (g/cc)	1.40
Tenacity (g/Tex)	10.0
Breaking elongation %	30
Diameter in mm	0.1 to 1.5
Rigidity of modulus (dyne/cm²)	1.8924
Swelling in water (Diameter)	5%
Moisture at 65% RH	10.50

Physical Properties of Coir Fiber

C. Rice Husk Ash

Rice Husk Ash (RHA), basically a waste material, is produce by rice -mill industry while processing rice from paddy. Rice husk will be obtained from milling industry RS PURA (JAMMU DISTRICT), J&K.

S.No.	**Particulars**	**Proportion**
1	Silicon dioxide	86.94 %
2	Aluminium oxide	0.2 %
3	Iron oxide	0.1 %
4	Calcium oxide	0.3-2.2 %
5	Magnesium oxide	0.2-0.6 %
6	Sodium oxide	0.1-0.8 %
7	Potassium oxide	2.15-2.30 %

Properties of Rice Husk Ash

D. Water

Potable water was used throughout the study.

E. Experimental Program

The expansive soil will be mixing with four different content of coir fibers and rice husk ash in order to prepare various samples. Following 13 types of different samples has been made with different proportion of Rise Husk Ash and Coir Fiber as shown in Table Below. Here, S = Soil, RHA = Rice Husk ASH & CF = Coir Fiber

S.NO.	DESIGNATION (S:RHA:CF)
1.	100:0:0
2.	99.5:0:0.5
3.	99:0:1
4.	98.5:0:1.5
5.	98:0:2
6.	95:5:0
7.	90:10:0
8.	85:15:0
9.	80:20:0
10.	83:15:2
11.	82.5:15:2.5
12.	82:15:3
13.	81.5:15:3.5

IV. LABORATORY TESTS

After the soil was oven dried, following basic tests were performed on it:

1) Atterberg's limit analysis (IS: 2720 Part V-1985)
2) Specific Gravity Test (Pycnometer test) (IS: 2720 Part III-Section I/II-1980)
3) Standard proctor test (IS: 2720 Part VII-1980)
4) California bearing ratio test (IS: 2720 Part XVI-1987)
5) Unconfined compressisve strength test (IS: 2720 Part X-1991)

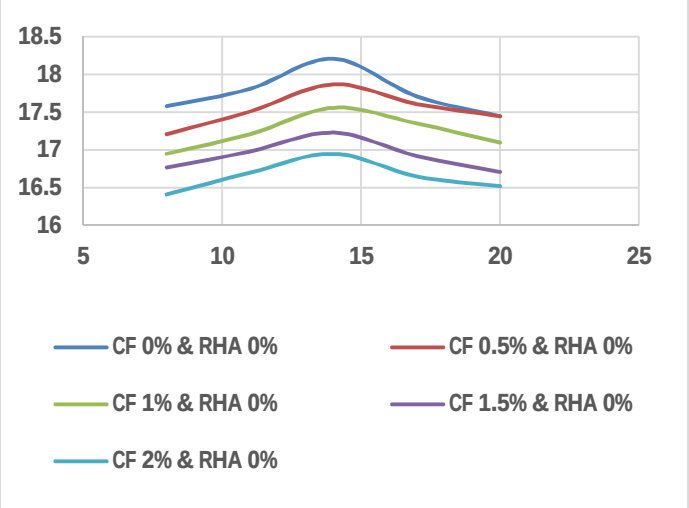
A. Standard Proctor's Compaction Test

The optimum water content (OMC) and maximum dry density (MDD) will be ontained by conducting Standard Proctor's Test as per IS:2720 (Part 7) – 1980. The relation between moisture content and dry density is obtained from compaction test.

1) Soil: Coir Fiber Mix

Results of MDD and OMC of SOIL: COIR FIBER Mix

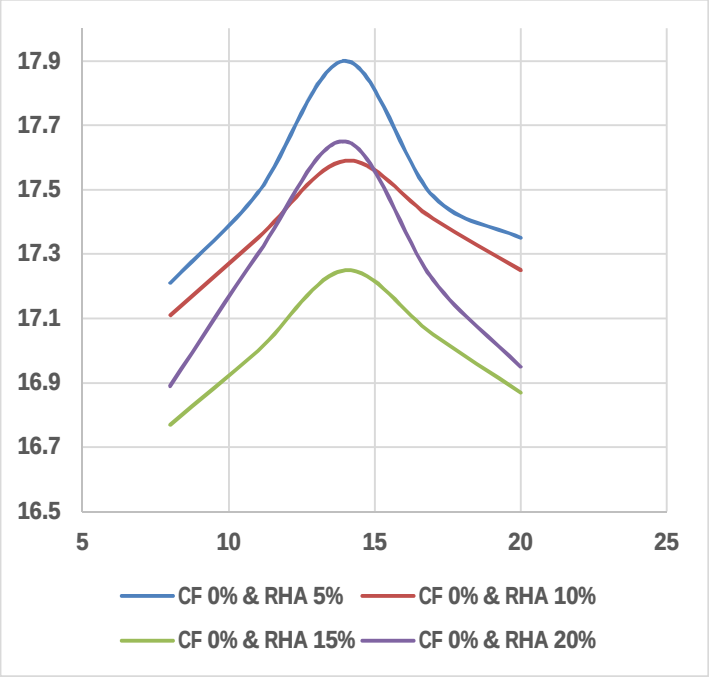
SOIL:COIR FIBER	MDD (kN/m^3)	OMC (%)
100:0	18.21	13.80
99.5:0.5	17.87	14.02
99:1	17.56	14.31
98.5:1.5	17.23	14.66
98:2	16.95	14.80



2) Soil: Rice HUSK ASH

Results of MDD and OMC of SOIL : RICE HUSK ASH Mix

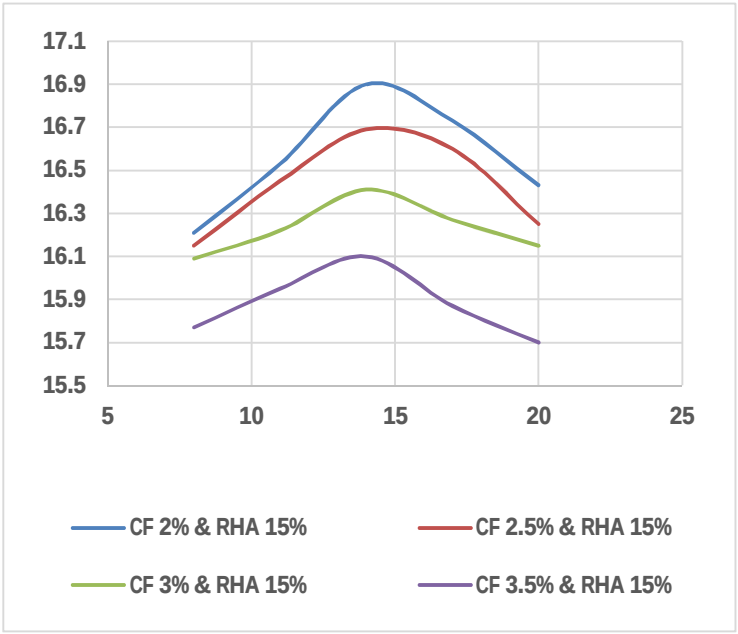
SOIL:RICE HUSK ASH	MDD (kN/m^3)	OMC (%)
95:5	17.90	14.20
90:10	17.59	14.49
85:15	17.25	14.80
80:20	17.65	14.31



3) Soil: Rice HUSK ASH : COIR FIBER Mix

Results of MDD and OMC of SOIL: RICE HUSK ASH: COIR FIBER Mix

SOIL:RHA:CF	MDD (kN/m^3)	OMC (%)
83:15:2	16.90	14.85
82.5:15:2.5	16.69	14.94
82:15:3	16.41	15.10
81.5:15:3.5	16.10	15.25



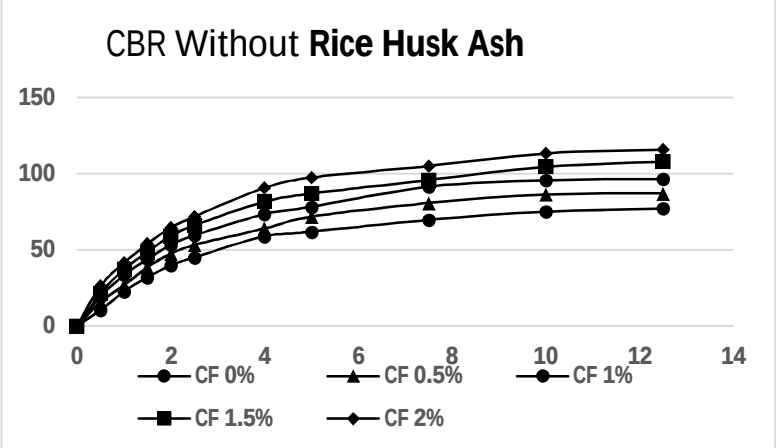
B. California Bearing Ratio Test

California bearing ratio test is done to determine the bearing capacity of the soil. CBR test is done to determine the bearing capacity of the soil. In this paper CBR test is done for the expansive soil and coir fiber mixture, soil and rice husk ash mixture and mixture of soil, coir fiber and rice husk ash mixture and values are tabulated.

1) Soil: COIR FIBER Mix

Results of CBR test of SOIL:COIR FIBER Mix

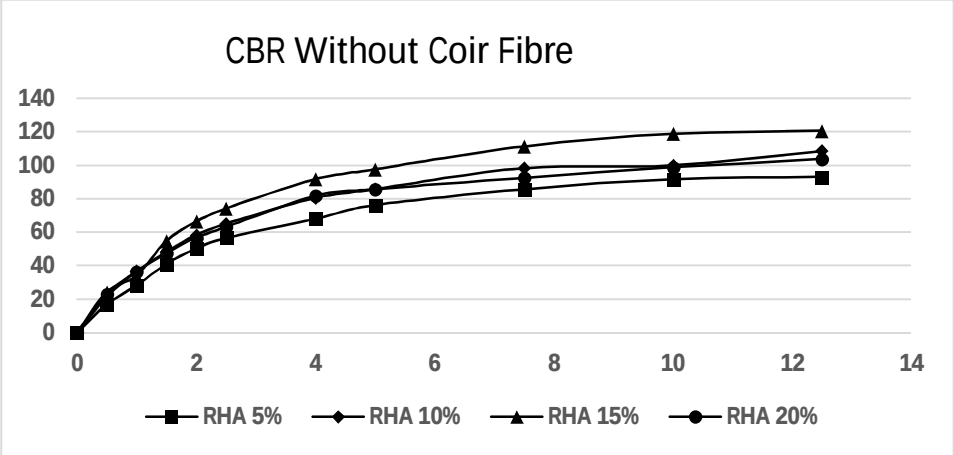
SOIL:COIR FIBER	CBR [%]
100:0	3.2
99.5:0.5	3.8
99:1	4.3
98.5:1.5	4.8
98:2	5.2



2) Soil: RICE HUSK ASH

Results off CBR test of SOIL:RICE HUSK ASH

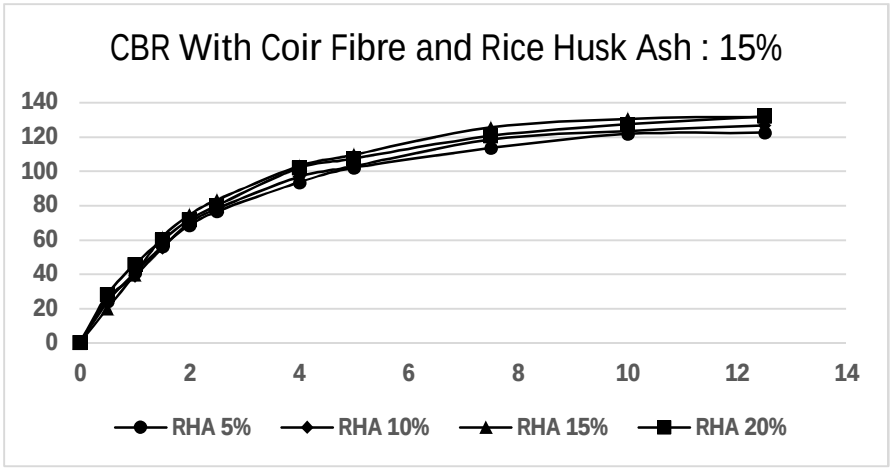
SOIL:RICE HUSK ASH	CBR [%]
95:5	4.1
90:10	4.7
85:15	5.4
80:20	4.6



3) Soil: RICE HUSK ASH: COIR FIBER MIX

Results of CBR tests of SOIL: RICE HUSK ASH:COIR FIBER Mix

SOIL:RHA:CF	CBR [%]
83:15:2	5.5
82.5:15:2.5	5.7
82:15:3	6.0
81.5:15:3.5	5.8



C. Unconfined Compression Test

This experiment is used to determine the unconfined compressive strength of the soil sample which in turn to calculate the unconsolidated, undrained shear strength of unconfined soil. The unconfined compressive strength (qu) is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive load.

1) Soil: COIR FIBER Mix

Results of UCS test of SOIL:COIR FIBER Mix

SOIL:COIR FIBER	Curing period (days)	UCS (kN/m^2)
100:0	7	85.87
99.5:0.5	7	115.85
99:1	7	136.03
98.5:1.5	7	156.48
98:2	7	178.37

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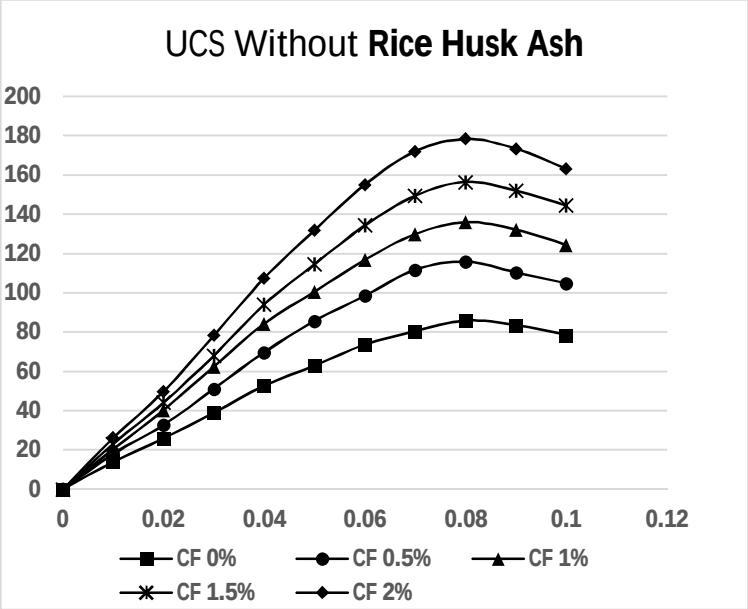
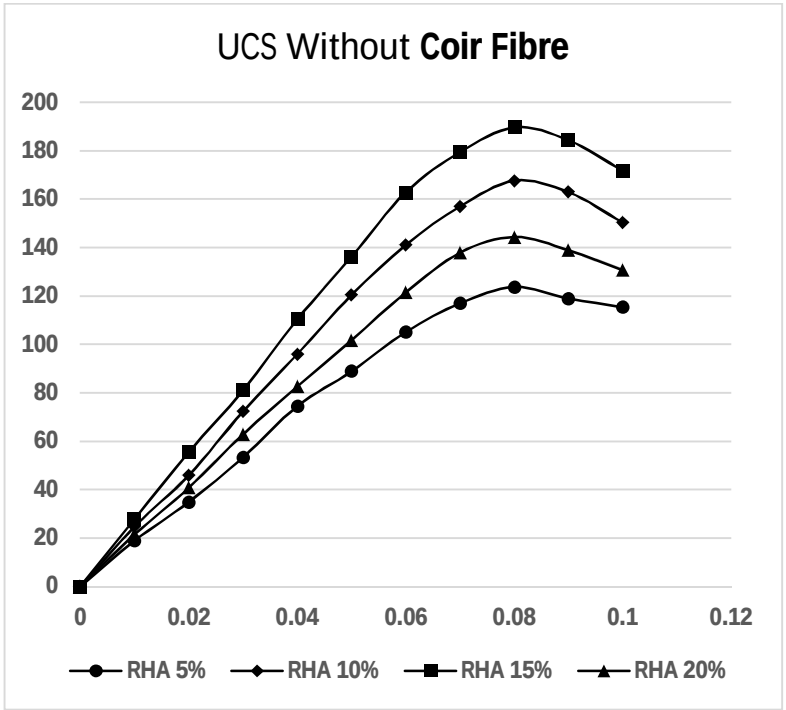


2) Soil: RICE HUSK ASH

Results of UGS test of SOIL:RICE HUSK ASH

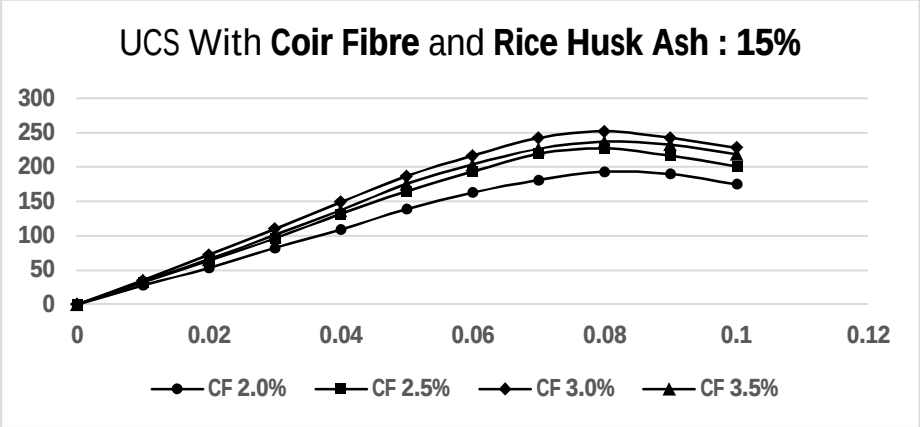
SOIL: RICE HUSK ASH	Curing period (days)	UCS (kN/m^2)
95:5	7	123.67
90:10	7	167.57
85:15	7	189.64
80:20	7	144.34



3) Soil: RICE HUSK ASH: COIR FIBER MIX

Results of UCS Test of SOIL:RICE HUSK ASH:COIR FIBER Mix

SOIL:RHA:CF	Curing period (days)	UCS (kN/m^2)
83:15:2	7	193.27
82.5:15:2.5	7	227.15
82:15:3	7	252.04
81.5:15:3.5	7	237.01



V. CONCLUSION

A. Standard Proctor Test

1) An increase of OMC from 14.02 to 14.80% and decrease of M.D.D. from 17.87 to 16.95% when the percentages of Coir Fiber are used as 0.5, 1, 1.5 and 2% respectively.

2) There is an also increase of OMC from 14.20 to 14.31% and decrease of MDD from 17.90 to 17.65% when the percentages of Rice Husk Ash are used as 5, 10, 15 and 20% respectively.

3) There is an also increase of OMC from 14.85 to 15.25% and decrease of MDD from 16.90 to 16.10% when the percentages of Coir Fiber vary from 2, 2.5, 3, and 3.5% and Rice Husk Ash is fixed at 15%.

B. California Bearing Ratio Test

1) An increase of CBR value was observed 3.8 to 5.2% when the percentages of coir fiber are used as 0.5, 1, 1.5 and 2% respectively.

2) There is an also increase of CBR value was observed when Rice Husk Ash is added to soil. This increase at the 15% of Rice Husk Ash after that CBR value decreased. The optimum value of Rice Husk Ash was found at 15%.

3) With the Rice Husk Ash kept constant at 15% CBR value increases with an addition of Coir Fiber at different ratios i.e. 2, 2.5, 3% after that it decreases.

C. Unconfined Compression Test

1) The UCS value of virgin soil is 85.87 kN/m^2 it increases to 178.87 kN/m^2 with an addition of Coir Fiber at different ratios i.e. 0.5, 1, 1.5% and 2%respectively.

2) The UCS value of virgin soil enhances fundamentally with expansion of Rice Husk Ash constant. The UCS value increment from 85.87 kN/m^2 to 189.64 kN/m^2 with expansion of Rice Husk Ash upto 15% in the wake of curing time 7days. UCS value decreases with more expansion of Rice Husk Ash.

3) The UCS value of virgin soil also improves considerably with Rice Husk Ash kept constant 15% and Coir Fiber at different ratios i.e. 2, 2.5, 3% after that it decreases.

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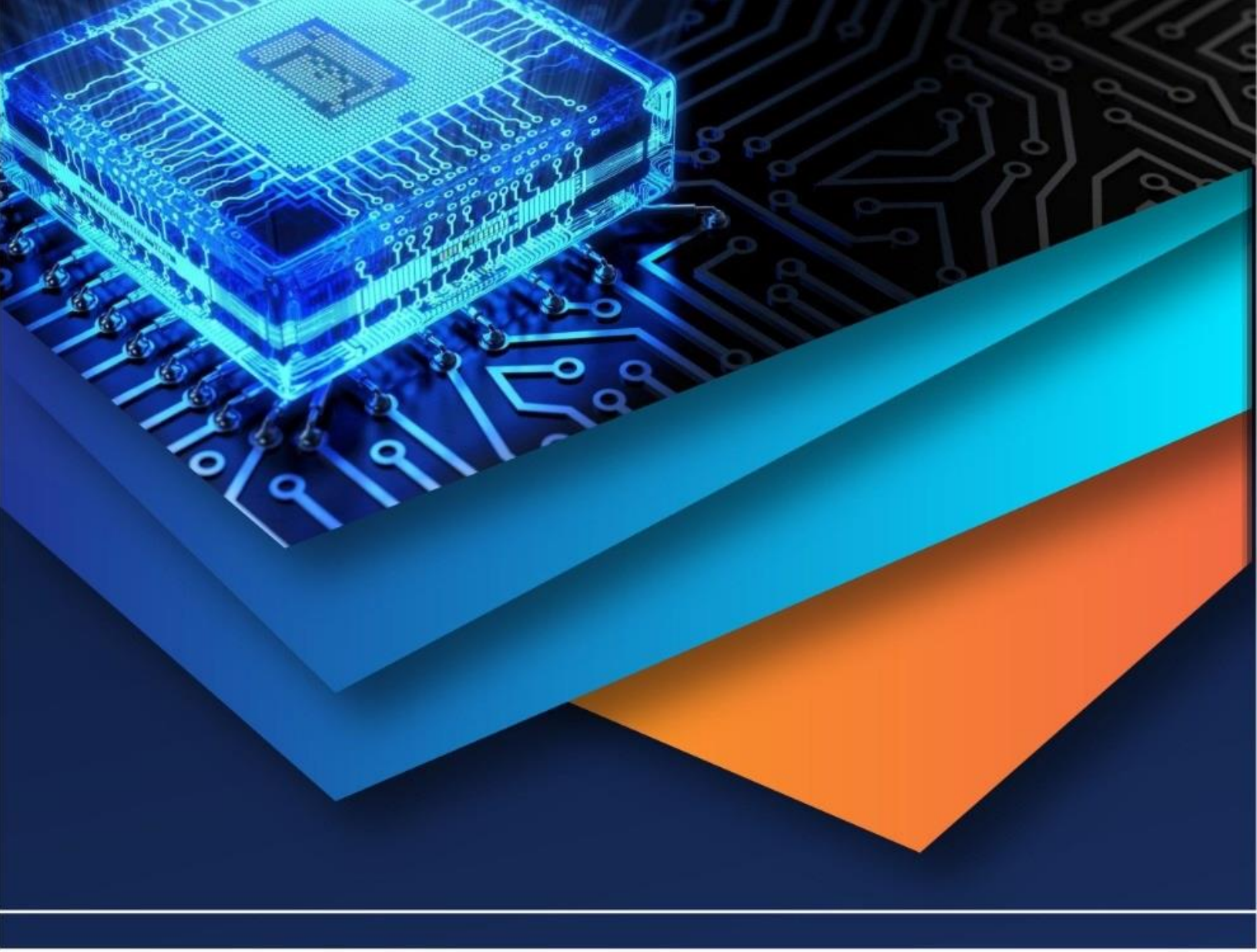

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