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Study of Compaction Characteristics of Black Cotton Soil Reinforced with Natural Coir Fibre

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Abstract: ***Expansive soil covers up to 20% of area of Indian peninsular plateau, an example of expansive soil is black cotton soil. The basic nature of such soil is to swell and shrink with the variation of moisture content .The swelling and shrinkage of soil is due to the presence of a mineral in it called "montmorillonilite", as a result of the action of this mineral on gaining moisture content the soil expands and when the moisture content recedes it shrinks. The structure on such soil therefore becomes unstable due to differential settlement. In this paper we are going to discuss about the variation in properties of black cotton soil on being reinforced with different percentages of natural coir fibre and the changes in its shearing and bearing capacities with it . Coir fibre is a biodegradable material that is expected to have a life of about 20y in normal condition of soil temperature and pressure. However with the variation in environmental condition such as exposure to freezing and thawing , leachate , chemical pollutants etc the average age of a coir fibre may vary from 8 to 10 years. In this paper compaction test has been conducted to study the variation in properties of expansive soil with varying percentage of coir fibre. The percentage increment in the coir fibre starting from 0 at the rate of 1% till 3% is reached with respect weight of soil taken for respective experiment.***
Keywords: Expansive Soil, Soil Stabilization, Fibre Reinforcement, Coir Fibre, Atterberg Limits, Light Compaction Test.

I. INTRODUCTION

Indian subcontinent covers about 3,287,240 sq. Km. of geographical area, having erratically distributed population of nearly 125 million. Due to rapid urbanization the availability of land for construction purposes is decreasing exponentially making it compulsory to opt for weak soil for construction, such soil when used as foundation needs to be stabilised owing to its low bearing and shearing capacities .

There are various methods of stabilising such soils that can be summed up under chemical (synthetic) and natural stabilization .

1) Chemical stabilization includes lime stabilization, use of geofibres, geosynthetics etc.

2) Natural stabilisers include coir fibre /pith, bagasse, jute, oil palm, rice husk, sisal etc.

Natural fibres are abundantly available and cheap. Being good reinforcement material there is a need to concentrate on improving the properties of soil using cost-effective practices World's total coir fibre production is about 250,000 tones. Mainly the coastal region of Kerala State produces 60% of the total world supply of white coir fibre. Sri Lanka produces 36% of the total world brown fibre output. Over 50% of the coir fibre produced annually throughout the world is consumed in the countries of origin, mainly India. Together India and Sri Lanka produces 90% of the 250,000 metric tons of coir which is produced every year.

II. DISSERTATION WORK AND ITS SIGNIFICANCE

This paper is an exhaustive study of variation in compaction characteristics of soil with percentage inclusion of coir fibre with respect to its weight.

This paper gives result of various test conducted on expansive soil of two sites:

Site A: Village: Katsira, District: Korba, Chhattisgarh.

Site B: Village: Godgiri, District: Durg, Chhattisgarh.

Compaction Test has been performed for soil with and without reinforcement with varying percentages of coir fibre.

This paper will compare the changes in properties of soil of these two sites and suggest the optimum content of fibre to be included to stabilise the soil to improve its performance for construction of pavement.

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III. OBJECTIVES OF THE STUDY

To study the compaction characteristics of expansive soil of two commercially important districts of Chhattisgarh (Durg and Korba) by performing Light Compaction Test on expansive soil of two selected underdeveloped sites (Godgiri and Katsira village).

IV. LITRATURE REVIEW

A. Vivi Angrainni et.al ,(2016)[1], studied the properties of marine clay treated with coir fibre and lime. He concluded that the shear strength and durability of natural soil has been enhanced with the use of these two materials and also there has been increase in frictional and cohesive characteristics of soil.

B. Amit Tiwari and H. K. Mahiyar(2014)[5], they performed various tests like CBR and Direct Shear Test on soil reinforced with coconut coir fibre, crushed glasses and fly ash and concluded that optimum combination is 20% FA + 5% CG +1 % CCF With soil which reduces the weight of soil to $1/10^{th}$ of its original. It was also observed that the value of CBR gets increased to up to 3.5 times the original soil without reinforcement.

C. N.Farzadnia, H. Jahangirian et al,(2016)[8], they performed various tests on modified treated coir fibre and found that compressive strength of soil increased by 64%, whereas the indirect tensile strength by 122% and the flexural strength by 56% with respect to soil reinforced with unmodified untreated fibres.

V. MATERIALS REQUIRED

A. Coir fibre

It is a biodegradable naturally occurring fibre extracted from coconut shell, it can be either tailor made to desired length and chemically processed or used as it is to reinforce the soil. For the study the coir fibre has been purchased from local market in Korba district of Chhattisgarh.



Figure 1 Unprocessed Coconut Coir Fibre

B. Expansive Soil

Expansive soil is a range of soil the volumetric properties of which will change with the change in the moisture condition viz with the increase in the moisture content its volume expands and with decrease in the moisture content it shrinks. The soil in this study has been selected from two commercially important districts of Chhattisgarh:

1) Site A: Village Katsira, Korba.
2) Site B: Village Godgiri, Durg.

VI. METHODOLOGY

A. Collection of soil from site A and B.
B. Calculation of physical and chemical properties.
C. Performing light compaction test.
D. Result analysis.
E. Discussion & Conclusion.
F. Recommendation.

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VII. RESULTS

Various tests were conducted to calculate the engineering properties of soil with and without coir reinforcement and the result has been tablulated below.

Table 1: Engineering Properties

S.No	Properties	Site A	Site B
1.	Specific Gravity	2.48	2.16
2.	Grain size analysis		
	Gravel %	Nill	0.8%
	Sand %	15%	19.20%
	Silt and clay %	85%	80%
3.	Consistency limits		
	Liquid limit	54%	55.6%
	Plastic limit	28.20%	31.25%
	Shrinkage limit	25.80%	34.35%
4.	IS classification	CH or OH	CH or OH
5.	Activity of soil	Highly Active	Highly Active

Table 2: Chemical Properties of coir fibre

S. No	Properties	Evaluated values	Standard values from coir board
1.	Cellulose	43.54%	43.44%
2.	Lignin	45.77%	45.84%
3.	Hemicelluloses	0.25%.	0.28%
4.	Pectin	4.00%	3.30%
5.	Water solubles	4.25%	5.25%
6.	Ash	2.22%	2.22%

Table 3: Physical Properties of coir fibre

S. No	Properties	Evaluated values	Standard values from coir board
1.	Specific gravity	1.4g/cc	1.4g/cc
2.	Cut length	150-200mm	NA
3.	Tensile strength	60mpa	50-70mpa
4.	Diameter	16mic	NA
5.	Breaking elongation	30%	30%

A. Standard Proctor Compaction Test Results

The Light Proctor Compaction Test of soil was determined as per "IS 2720: part 7-1980 methods of test for soils: Determination of water content – dry density relation using light compaction was performed on soils of two sites, by varying the percentage inclusion of coir fibre form 0% to 3%.

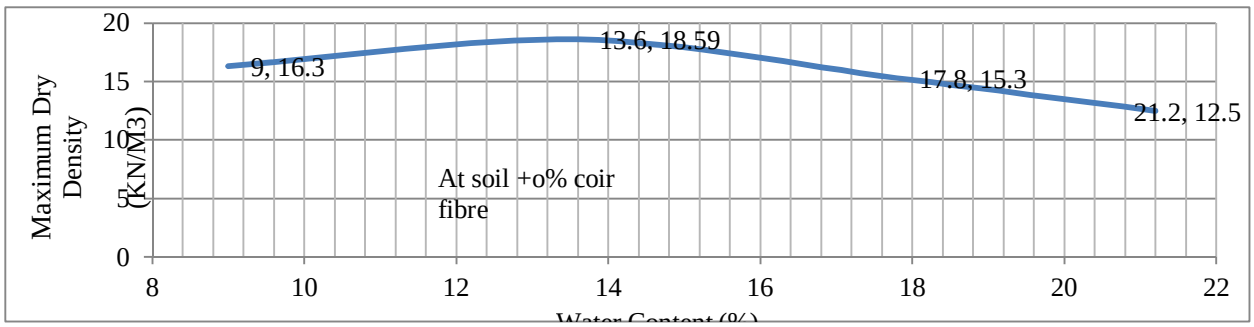


Figure 2 Compaction Curve At 0% Coir Fibre For Site A

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From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 2% coir fibre is 26.4% and 19.1 KN/m^3 respectively.

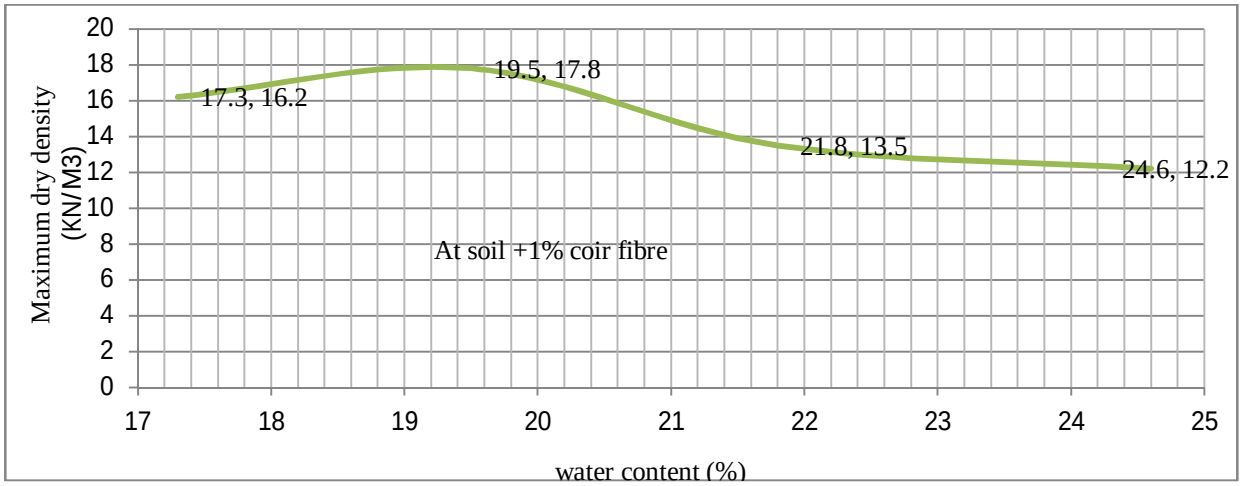


Figure 3 Compaction Curve At 1 % for Site A

From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 1% coir fibre is 18.8% and 16.50 KN/m^3 respectively.

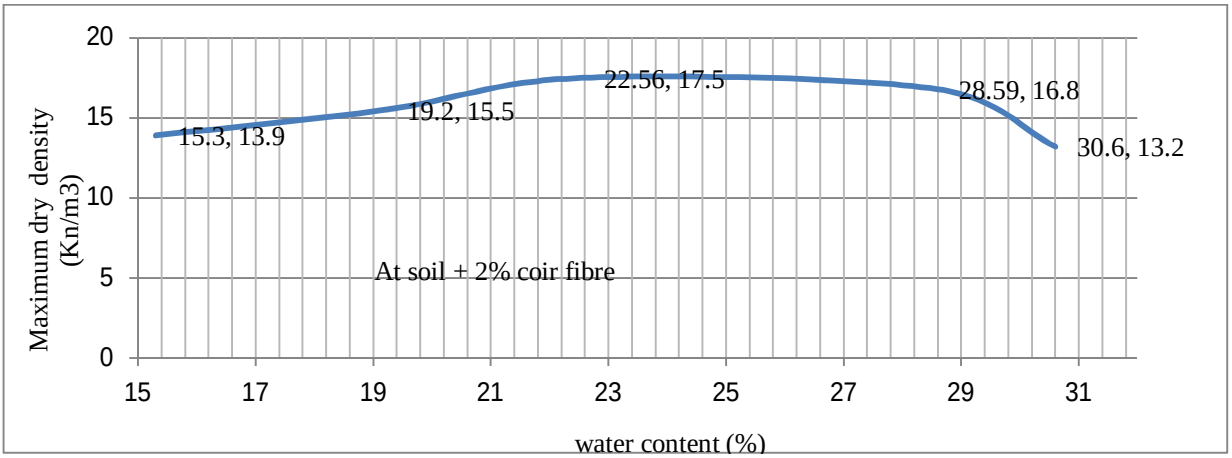


Figure 4 Compaction Curve at 2% coir fibre for site A

From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 2% coir fibre is 22.56% and 17.5 KN/m^3 respectively.

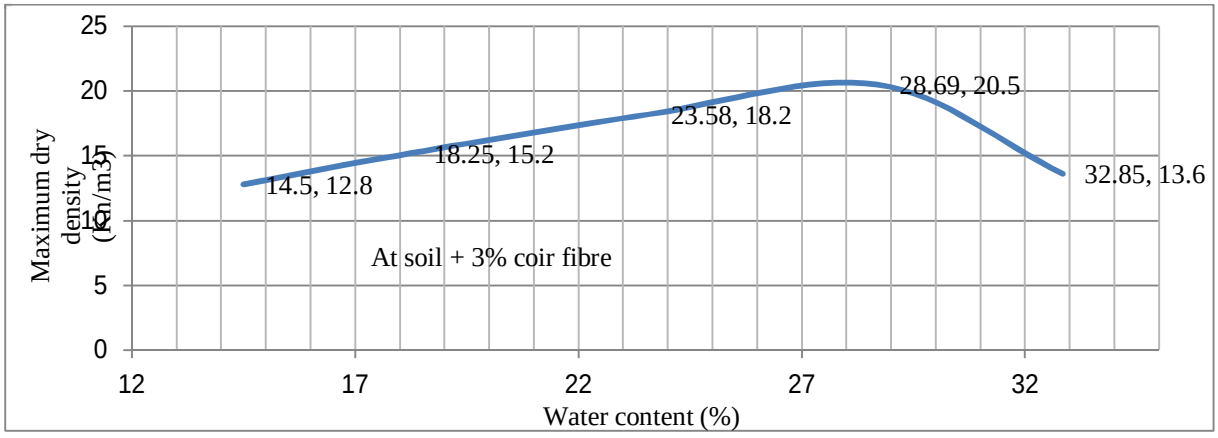


Figure 5 Compaction Curve at 3% Coir Fibre for site A

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From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 3% coir fibre is 28.69% and 20.5 KN/m^3 respectively.

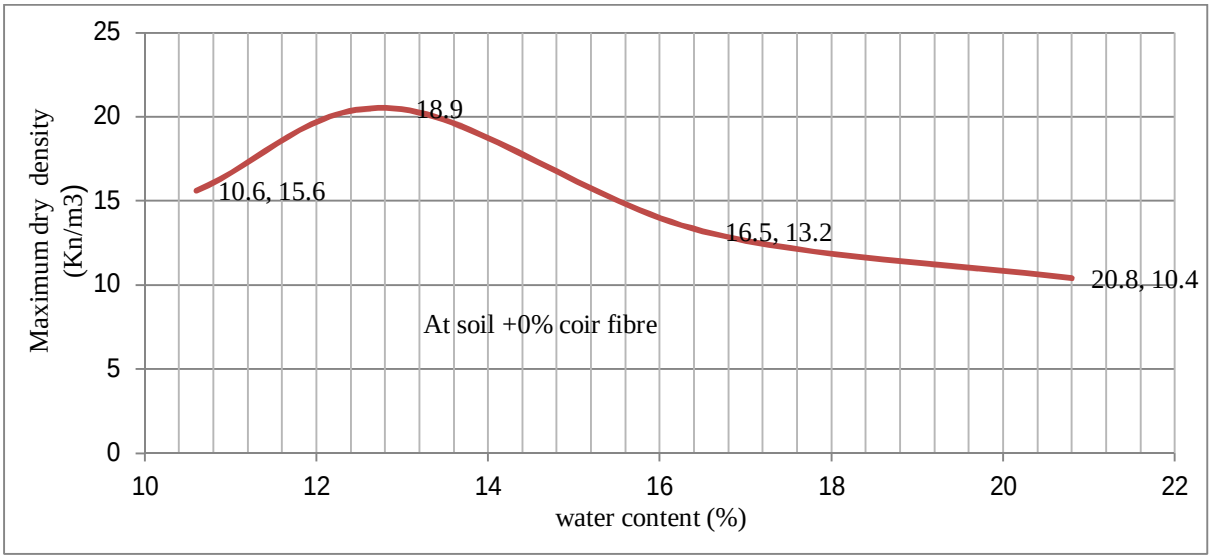


Figure 6 Compaction Curve at 0% Coir Fibre For Site B

From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 0% coir fibre is 12.9% and 18.9 KN/m^3 respectively.

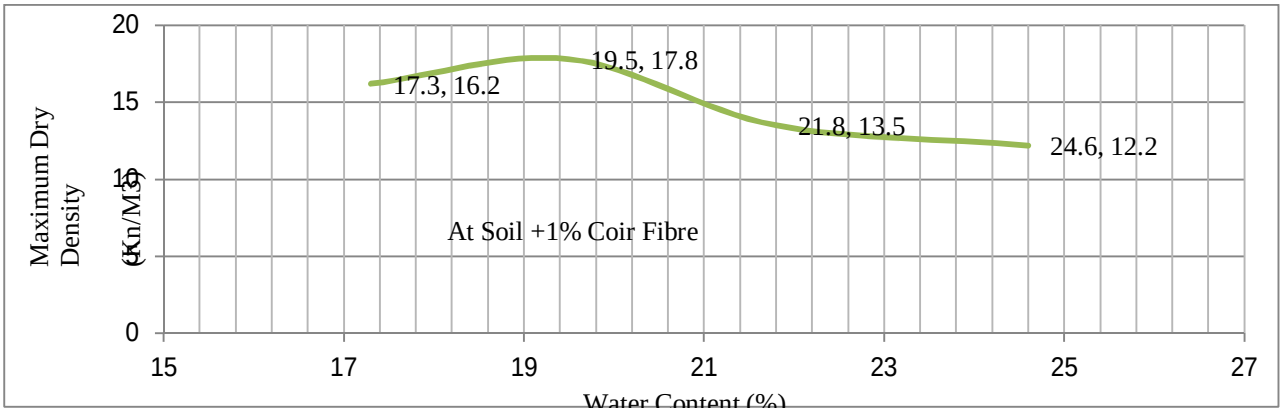


Figure 6 Compaction Curve at 1% Coir Fibre For Site B

From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 1% coir fibre is 19.5% and 17.8 KN/m^3 respectively.

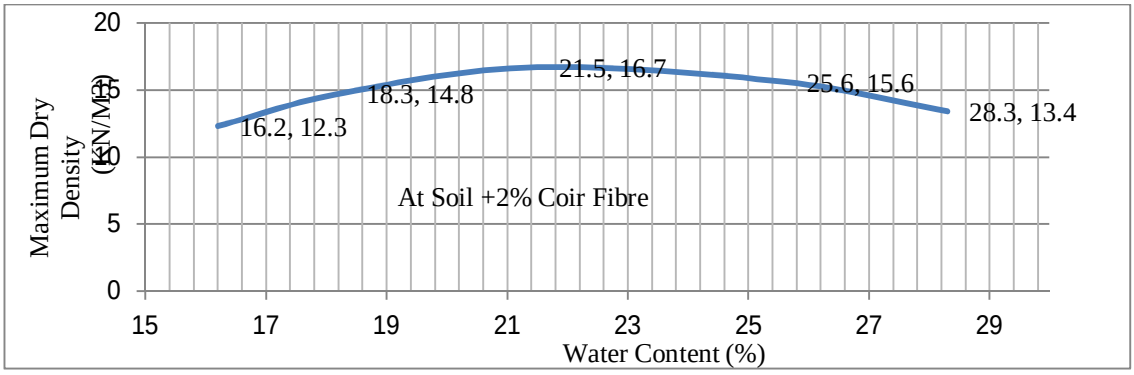


Figure 7 Compaction Curve at 2% Coir Fibre For Site B

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From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 2% coir fibre is 21.5% and 16.7 KN/m^3 respectively.

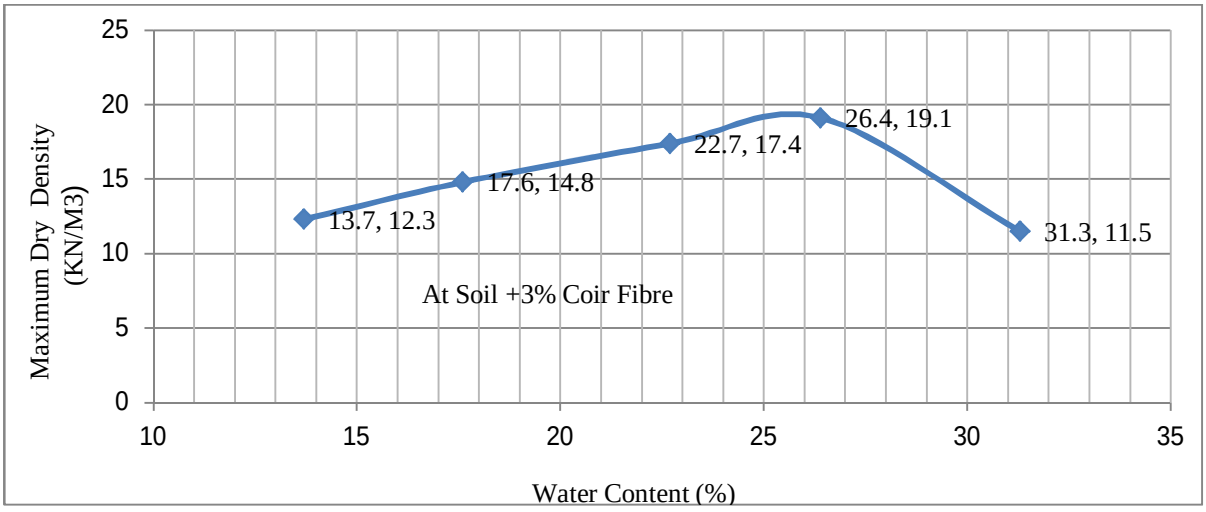


Figure 8 Compaction Curve At 3% Coir Fibre For Site B

From graph above we can conclude that the optimum moisture content and maximum dry density of soil at 2% coir fibre is 26.4% and 19.1 KN/m^3 respectively.

Table 4 Comparison of OMC and MDD of Site A and Site B

SNO.	MIXTURE	SITE A		SITE B	
		OMC (%)	MDD(KN/m^3)	OMC (%)	MDD(KN/m^3)
1	Soil +0% Coir fibre	13.6	18.59	12.9	18.9
2	Soil +1% Coir fibre	18.8	16.5	19.5	17.8
3	Soil +2% Coir fibre	22.56	17.5	21.5	16.7
4	Soil +3% Coir fibre	28.69	20.5	26.4	19.1

VIII. DISCUSSION

From Table 4 for site A, we can perform comparative analysis of the test result, we can see that with inclusion of coir fibre the OMC of the expansive soil has increased from 13.6% (at 0% coir inclusion) to 28.69% (at 3 % coir inclusion), the increase being 1.1 times the coir without fibre inclusion.

Similarly, for site B, on comparing the OMC results it has increased from 12.9% (at 0% coir fibre inclusion) to 26.4%(at 3% coir fibre inclusion), the % increase being 1.04 times the coir without fibre inclusion.

Now, if we compare the results for MDD for site A, it has increased from 18.59 KN/m^3 (at 0% coir fibre inclusion) to 20.5 KN/m^3(at 3% coir fibre inclusion) and in the same way for site B, it has increased from 18.9 KN/m^3(at 0% coir fibre inclusion) to 19.1 KN/m^3(at 3% coir fibre inclusion).

IX. CONCLUSION

For site A and B at 3% of coir fibre inclusion, we can see that the soil exhibits properties that will be highly beneficial for the stability of sub grade if used for the pavement.

From above experimental analysis we can conclude that soil of both the sites have similar properties and therefore it can be reinforced with same optimum percentage of coir fibre.

X. RECOMMENDATIONS

By performing the above experimental study we can say that stabilization of expansive soil is of prime importance in the preparation of sub grade for pavement, these two areas of commercially important districts of Chhattisgarh and require connection to the town via road transport therefore with this study we can recommend that if we keep the percentage inclusion of coir fibre in between 2%-3% , the performance of soil will be enhanced as it will increase the bearing capacity of soil.

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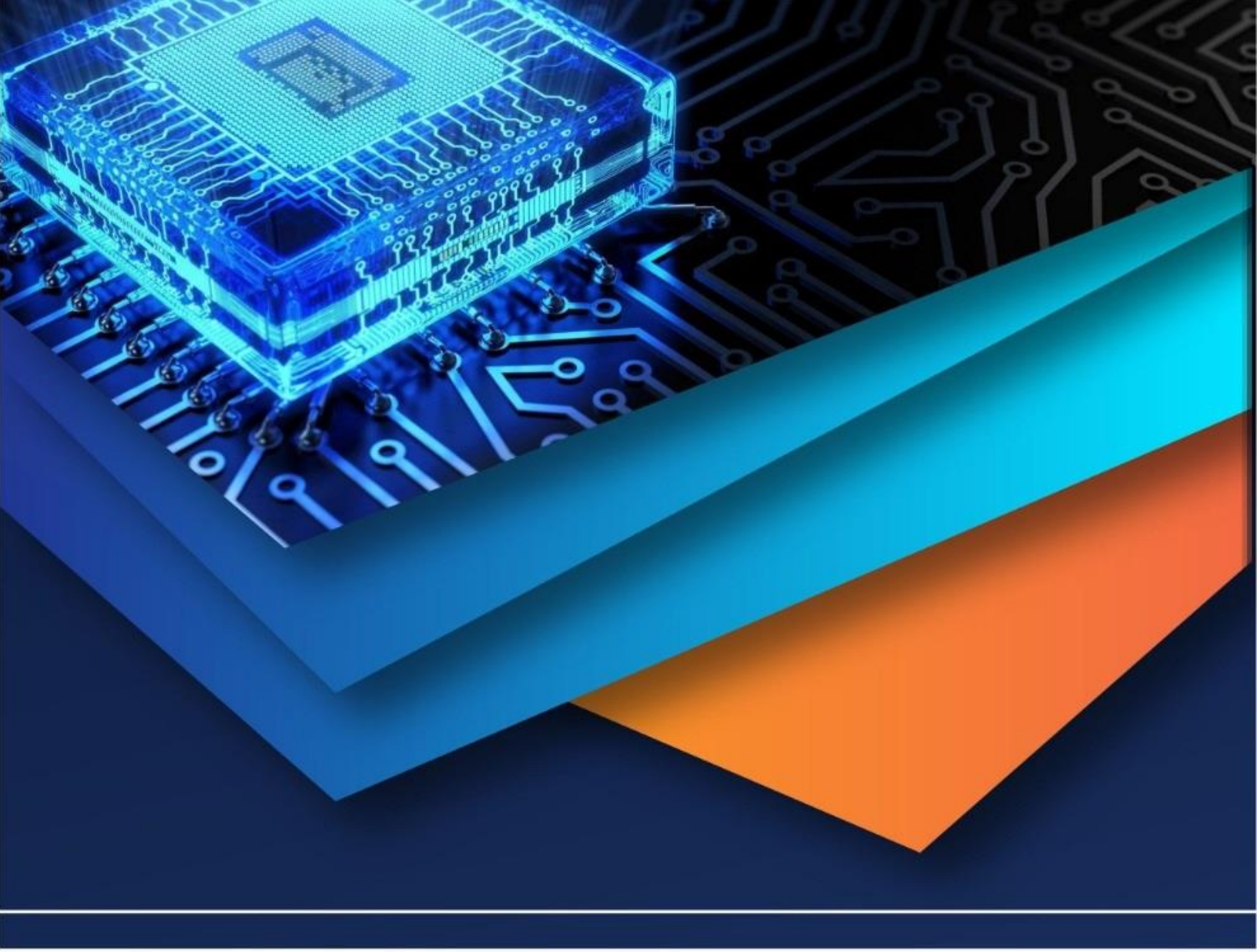
XI. ACKNOWLEDGEMENT

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