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Improving Soil Properties by Using Coir

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Abstract: ***Construction on these soils is found to be expensive because of their low bearing strength. Soil having poor bearing need stabilization to make it suitable for construction purpose. In this study coir (extracted from coconut) is used as natural fiber for stabilization of soil. Stabilization using natural fiber is a cost-effective and eco-friendly approach to improve properties of soil. The study is carried out to evaluate the effects of coir fiber on properties of soil. Coconut coir in the soil were varied from 0, 0.5, 1.0, 1.5, and 2.0% and various soil properties were studied.***
Keywords: California Bearing Ratio, Coconut Coir, Compaction Test, Core Cutter, Red Clay Soil, Stabilization

I. INTRODUCTION

Due to rapid urbanization and industrialization, there has been gradual increase in the use of land for various constructional activities. This has resulted in the scarcity of the suitable land (soil) for construction. soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable. However, the term stabilization is generally restricted to processes which alter the soil material itself for improvement of its properties. Several materials have been used as stabilizers which include lime, coconut husk ash, rice husk, bagasse fibers, chemical additives, coir fibers, and etc. soil stabilization increase the bearing capacity of soil.Stabilization using natural fiber is a cost-effective and eco-friendly approach to improve properties of soil. chemical-based or synthetic fibers harm our environment so; the use of natural fiber is an initiative to maintain balance in nature. The study of stabilizing or reinforcing soil with coir fiber helps to predict an idea of its workability and the durability. The workability of soil depends on load bearing capacity and shear strength. Soil gradation is also important to keep in mind while working with soils. The soils may be classified as well-graded which is stable as it has less number of voids or uniformly graded which is partially stable but has more voids. Here, in this study, soil stabilization has been done with the help of randomly distributed coir fibers obtained from outer shell of coconut (waste material). The objective of this study is to focus on improvement of the soil parameters. coir extracted consists of rotting the husk in water and removing the organic material binding the fiber diameter is 0.5mm. The coir is cut into pieces of 3cm to 5cm, as those percentage remains 0, 0.5, 1, 2, 3%. laboratory soil tests have been carry out on the stabilized soil samples like; California Bearing Ratio (CBR), Optimum Moisture Content (OMC), Maximum Dry Density (MDD), and Safe Bearing Capacity (SBC).

II. LITERATURE REVIEW

A. Nikita Chauhan, Dr. R.P. Arora, [2019], "Performance of Clayey Soil Stabilized with Coir Fiber- A Review":

Clayey soils are not suitable for construction due to their undesirable characteristics such as poor grading, low strength, and tendency to shrink and swell so soil stabilization is done to improve the engineering properties of the soil. This study deals with the utilization of Coir Fibre for soil stability. This study concluded that the C.B.R. value of soil reinforced with coir fibers is increased. Therefore addition of coir fiber is helpful in increasing CBR value and hence, thickness of pavement reduces in high rainfall area. If fly ash and coir fibre used for soil stabilization it will overcome the environmental hazard caused by coir fibre. For improvement of ground it wills cheapest method.

B. Anitha.S, Sangeetha. G, Sujatha. M, Banu. K [2018], "Stabilization of red clay soil by using coconut coir fiber

In this journal it is mentioned that the addition of coconut coir and lime into the black cotton soil changes the compaction parameters of soil. The OMC increases with increasing in the percentage of fiber coir. CBR, UCC values also increases with increasing coir fiber. The addition of 0.75% of coir fiber increases the UCC values. In this paper five samples are taken and percentage of coir is added (0%, 0.25%, 0.50%, 0.75%, 1%).

C. Pooja Upathyay and Yatendra Singh [2017], "Soil stabilization using coconut coir fiber"

In this thesis they have studied the effect of coir fiber on shear strength of soil by carrying out direct shear test and unconfined compression test on two different samples. It was observed that fiber reinforcement of 0.5%, 1.0% and 1.5% the increase in cohesion was found to be 10%, 4.8% and 3.73% respectively and increase in the angle of internal friction was found to be 0.8%, 0.31% and 0.47% respectively.

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Overall they concluded that reinforcing soil with fibers can be considered as good ground improvement technique especially in engineering projects on weak soils where it can act as a substitute to deep/raft reducing the cost of project.

III. MATERIALS

A. Clayey Soil

Clay is one of the main construction material in the manufacture of brick. Clay is the finely grained natural rock or soil material that combines one or more clay minerals with possible traces of quartz, metal oxides and organic matter. Soil is the most cost effective construction material. Soil is the major and most typically used material within the field of civil engineering.

B. Coconut Coir

Coir or coconut fiber, is a natural fiber extracted from the outer husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Coir fibers are found between the hard, internal shell and the outer coat of a coconut.

IV. EXPERIMENTAL PROCEDURE

Soil sample location: Chaitanya engineering college, kommadi, visakhapatnam, Coconut coir: brought from local retailer.

Table 1: Proportion of Soil Samples

Sample No.	Identification of Soil Samples	% Clayey Soil	% Coconut Coir
1.	RCS0.0 cc	100%	0.0%
2.	RCS0.5 cc	99.5%	0.5%
3.	RCS1.0 cc	99.0%	1.0%
4.	RCS1.5 cc	98.5%	1.5%
5.	RCS2.0 cc	98.0%	2.0%

The experiments conducted are:

A. Specific Gravity Test on Soil

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water. It is measured by the help of a pycnometer.

$$\text{Specific Gravity } G = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

Where

W_1- Weight of bottle in gms, W_2- Weight of bottle + Dry soil in gms

W_3- Weight of bottle + Soil + Water, W_4- Weight of bottle + Water

B. Liquid Limit Test on Soil

The liquid limit (LL) is conceptually defined as the water content at which the behavior of a clayey soil changes from plastic to liquid. A graph plotted between number of blows, N on a logarithmic scale and water content, w on the natural scale. From the graph the liquid limit was determined by reading the water content corresponding to 25 blows on the flow curve.

C. Plastic Limit Test on Soil

Plastic limit (PL) is the moisture content at which a fine-grained soil cannot be remolded without cracking**.** The plastic limit test requires repeated rolling of a soil sample into a thread until it reaches a point where it crumbles. This is determined by rolling out soil till its diameter reaches approximately 3 mm and measuring water content for the soil which crumbles on reaching this diameter.

D. Particle Size Distribution by Sieve Analysis

Grain size analysis or sieve analysis is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.

E. Field Dry Density-Core Cutter

A cylindrical core cutter is a seamless steel tube. For determination of the dry density of the soil, the cutter is pressed into the soil mass so that it is filled with the soil without disturbing the core contents. The cutter filled with the soil is lifted up. The mass of the soil in the cutter is determined. By using core cutter method, bulk density of soil can be quickly calculated and by determining the moisture content of the soil the dry density of the fill can be calculated and hence the voids percentage.

F. IS Light Weight Compaction Test

The objective of the IS light compaction test is to determine the relation between the water content and the dry density of compacted soil and to determine the MDD and OMC from this test. The compaction energy used to compact the soil corresponds to that of standard Proctor test. A graph is plotted between % water content and dry density the curve obtained is called compaction curve. The water content corresponding to the maximum dry density is called optimum moisture content (OMC).

G. IS Heavy Weight Compaction Test

Heavy compaction test of soil is carried out using modified proctor test to understand the compaction characteristics of different types of soils with change in moisture content (water content). The Proctor compaction test (or heavy compaction test) is a laboratory test which is used for experimentally determining the optimal moisture content (O.M.C.) of soil at which the given type of soil specimen will become most dense and achieve its maximum dry density.

H. California Bearing Ratio Test

California bearing ratio is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm/min. CBR value of a soil is an index which is related to its strength, modulus of sub grade reaction, modulus of resilience and plasticity index. The index is highly dependent on the condition of material at the time of testing. CBR test performed on remoulded specimens who may be compacted either statically or dynamically.

V. TEST RESULTS

Table 2: Liquid Limit values of soil samples with varying percentages of coconut coir fiber

Soil Sample	Liquid Limit
$RCS_{0.0\ cc}$ (0% Coir)	28.438%
$RCS_{0.5\ cc}$ (0.5% Coir)	33.394%
$RCS_{1.0\ cc}$ (1.0% Coir)	36.739%
$RCS_{1.5\ cc}$ (1.5% Coir)	40.158%
$RCS_{2.0\ cc}$ (2.0% Coir)	29.05%

Chart 1: Liquid Limit values of soil samples with varying percentages of coconut coir fiber

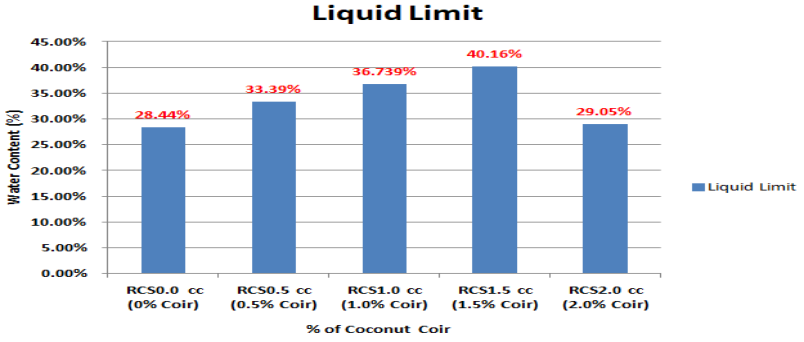


Table 3: Plastic Limit values of soil samples with varying percentages of coconut coir fiber

Soil Sample	Plastic Limit
$RCS_{0.0\ cc}$ (0% Coir)	22.58%
$RCS_{0.5\ cc}$ (0.5% Coir)	25.51%
$RCS_{1.0\ cc}$ (1.0% Coir)	27.66%
$RCS_{1.5\ cc}$ (1.5% Coir)	29.13%
$RCS_{2.0\ cc}$ (2.0% Coir)	27.38%

Chart 2: Plastic Limit values of soil samples with varying percentages of coconut coir fiber

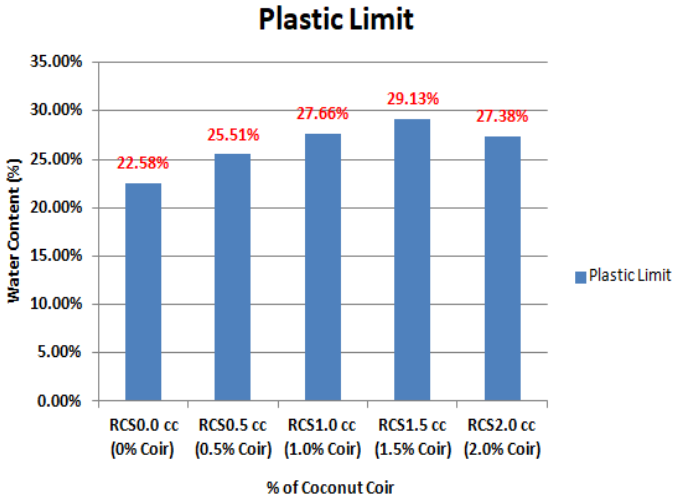


Table 4: IS Light Weight Compaction Test values of soil samples with varying percentages of coconut coir fiber

Soil Sample	Maximum Dry Density (MDD) gm/cc
$RCS_{0.0\ cc}$ (0% Coir)	1.873
$RCS_{0.5\ cc}$ (0.5% Coir)	1.90
$RCS_{1.0\ cc}$ (1.0% Coir)	1.94
$RCS_{1.5\ cc}$ (1.5% Coir)	1.96
$RCS_{2.0\ cc}$ (2.0% Coir)	1.885

Chart 3: IS Light Weight Compaction Test values of soil samples with varying percentages of coconut coir fiber

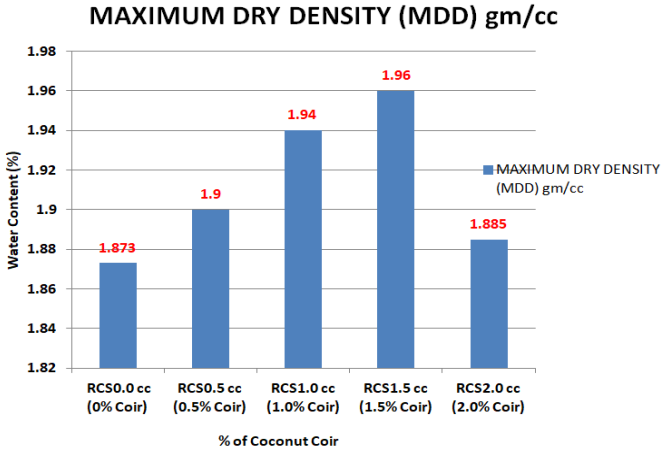


Table 5: IS Heavy Weight Compaction Test values of soil samples with varying percentages of coconut coir fiber

Soil Sample	(MDD) gm/cc
$RCS_{0.0\ cc}$ (0% Coir)	2.102
$RCS_{0.5\ cc}$ (0.5% Coir)	2.289
$RCS_{1.0\ cc}$ (1.0% Coir)	2.381
$RCS_{1.5\ cc}$ (1.5% Coir)	2.423
$RCS_{2.0\ cc}$ (2.0% Coir)	2.216

Chart 4: IS Heavy Weight Compaction Test values of soil samples with varying percentages of coconut coir fiber

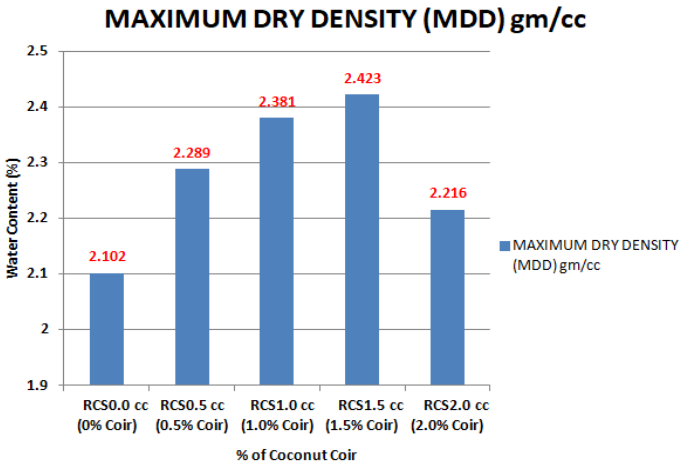
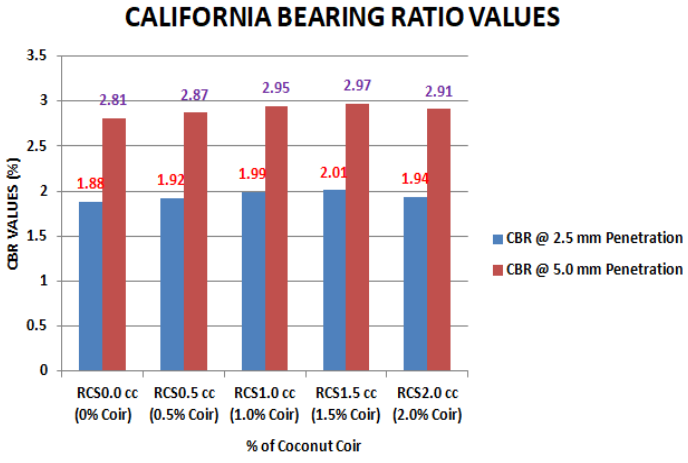


Table 6: California Bearing Ratio test values of soil samples with varying percentages of coconut coir fiber

Soil Sample	CBR @ 2.5 mm Penetration(%)	CBR @ 5.0 mm Penetration(%)
$RCS_{0.0\ cc}$ (0% Coir)	1.88	2.81
$RCS_{0.5\ cc}$ (0.5% Coir)	1.92	2.87
$RCS_{1.0\ cc}$ (1.0% Coir)	1.99	2.95
$RCS_{1.5\ cc}$ (1.5% Coir)	2.01	2.97
$RCS_{2.0\ cc}$ (2.0% Coir)	1.94	2.91

Chart 5: California Bearing Ratio Test values of soil samples with varying percentages of coconut coir fiber



VI. CONCLUSIONS

On the basis of present experimental study, the following conclusions are drawn:

A. Based on Liquid Limit test on soil sample, with fiber reinforcement of 0%, 0.5%, 1.0%, 1.5%, the increase in liquid limit value was found to be 28.438%, 33.394%, 36.739%, 40.158%. But beyond 1.5% the liquid limit value decreases to 29.05% at 2% fiber content. (illustrated in Chart-1).

B. Based on Plastic Limit test on soil sample, with fiber reinforcement of 0%, 0.5%, 1.0%, 1.5%, the increase in plastic limit value was found to be 22.58%, 25.51%, 27.66%, 29.13%. But beyond 1.5% the plastic limit value decreases to 27.38% at 2% fiber content. (illustrated in Chart-2).

C. Based on IS Light Weight Compaction test on soil sample, with fiber reinforcement of 0%, 0.5%, 1.0%, 1.5%, the increase in maximum dry density value was found to be 1.873gm/cc, 1.90 gm/cc, 1.94gm/cc, 1.96gm/cc. But beyond 1.5% the maximum dry density value decreases to 1.885gm/cc at 2% fiber content. (illustrated in Chart-3).

D. Based on IS Heavy Weight Compaction test on soil sample, with fiber reinforcement of 0%, 0.5%, 1.0%, 1.5%, the increase in maximum dry density value was found to be 2.102 gm/cc, 2.289 gm/cc, 2.381 gm/cc, 2.423 gm/cc. But beyond 1.5% the maximum dry density value decreases to 2.216 gm/cc at 2% fiber content. (illustrated in Chart-4).

E. Based on California Bearing Ratio test on soil sample, with fiber reinforcement of 0%, 0.5%, 1.0%, 1.5%, the increase CBR value @ 2.5mm penetration was found to be 1.88%, 1.92%, 1.99%, 2.01% and CBR value @ 5.0 mm penetration was found to be 2.81%, 2.87%, 2.95%, 2.97% . But beyond 1.5% the CBR value @ 2.5mm penetration was found to be decreases to 1.94%, CBR value @ 5.0 mm penetration was found to be decreases to 2.91% at 2% fiber content. (illustrated in Chart-5).

F. Overall it can be concluded that fiber reinforced soil can be considered to be good ground improvement technique specially in engineering projects on weak soils and the optimum % of coir replacement was found to be 1.5%.

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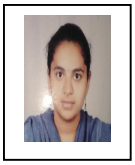
BIOGRAPHIES

Anusuri Uma Maheswari, working as an Assistant Professor & HOD in Dept. of Civil Engineering, Chaitanya Engineering College, kommadi. Obtained B.tech and M.tech from G.V.P. College of Engg.



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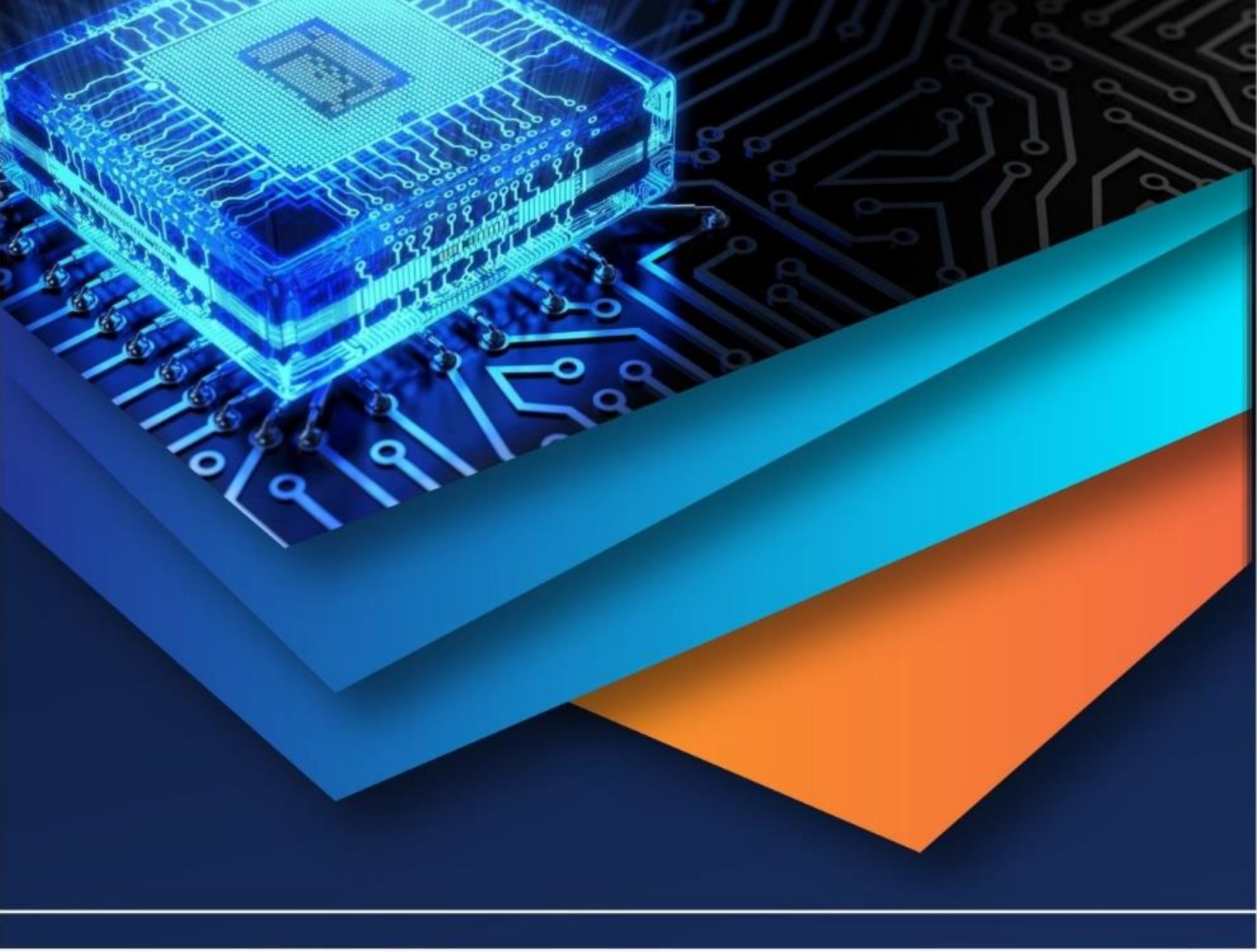

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