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Soil Stabilization using Agricultural Waste

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Abstract: ***The stability and strength of structure depends on Construction design and also on the strength of subgrade soil on which the structure is being erected. Soil should poses adequate strength and stability for a safe and economic Construction work. Construction work on Expansive soils poses a problem for Civil Engineers as such soil shows swelling and shrinking when exposed to changes in the moisture content, thus methods of Soil Stabilization can be adopted. This paper examined the Effects of Agricultural Waste such as Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) as Stabilizer Material for Economic and Environmental Friendly way of Soil Stabilization. The Geotechnical lab tests carried out were Liquid Limit, Plastic Limit, Plasticity Index Water Content and Specific Gravity Test and Standard Proctor Test on soil. Engineering tests like California Bearing Ration (CBR) (unsoaked) was performed with percentage of 8% with and without Stabilizer Material. The results showed significant improvement in CBR with addition of stabilizers. The research concludes Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) are very effective source of soil stabilization.***

Keywords: Black Cotton Soil, Soil Stabilization, Sugarcane Straw Ash, Coconut Husk Ash, California Bearing Ratio, Swelling and Shrinkage.

I. INTRODUCTION

Expensive Soil such as Black Cotton Soil constitute about 1/6 or 16.66% of the total soil present in India. Expansive soils are soils that expand when water is added and shrink when it dries out. For construction of roads and pavements, properties of subgrade soil are as important as its design. Subgrade soil on which foundation is laid out should have high bearing ratio and is able to support the load passed by the foundation. Expansive soils are characterized by low shear strength, low bearing capacity and high swell potential. Such soils are unsuitable for construction on subgrade soil. Black cotton soil usually swells and contracts depending on the amount of water contained in the soil voids. Such soils can form deep cracks in drier seasons and expand dramatically when wet. Such instability affects the strength performance of soil as a construction material. Thus, Soil Stabilization Techniques are adopted to improve Engineering properties of soil. Cement and Lime Stabilization, which is popular method of soil stabilization is not only Expensive but also Harmful for Environment for its Production and usage. Considering the Environmental hazards, efforts for alternate methods of Soil Stabilization are carried out. One such method proposed by the researches were to use waste material with pozzolanic properties. Years of research has gone into identifying agricultural wastes whose ashes produce good pozzolans and which are available in exploitable quantity. M. Singh et.al. [2016], P. M. Reddy et.al. [2016], A. Borah et.al. [2016], M. Singh et.al. [2017], A. Chakraborty et.al. [2018], Researched various locally available agricultural waste materials such as Rice Husk Ash, Groundnut Shell Ash, Sugarcane Bagasse Ash, Sugarcane Straw Ash, Coconut Shell Ash, Corn-cob Ash, Egg Shell Ash, Saw Dust Ash. This study was oriented towards improving the strength of soil by using locally available agricultural waste to reduce the construction cost. In this paper, Effects of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) as Stabilizer. From comparisons of soil sample from before and after addition of stabilizing material show a significant increase in the Bearing strength of soil after addition of stabilizer Materials. The studies conducted focuses to compare the geotechnical properties of the black cotton soil before and after adding the sugarcane straw ash (SCSA) and Coconut Husk Ash (CHA) and to observe the changes seen in the soil consistency, shear strength , CBR values by making use of the locally available agricultural waste and industrial waste as the stabiliser. The studies show the possibility of using Agricultural waste materials like SCSA and CHA in soil stabilization and investigating the chemical and physical properties of stabilizing agents and there suitability by comparing CBR values of CHA and SCSA.

II. LITERATURE REVIEW

Amu, O. O. Ogunniyi et.al. [2011][1] stabilized the soil by collecting Sugarcane ash from the sugarcane industry. This study solves the disposal problem of sugar cane because samples for stabilization was collected from sugarcane industry. The Sugarcane Straw ash contains the fibrous material in which silica is present. The laboratory tests such as CBR, Standard Proctor Test and Atterberg's Limit test was conducted to find the potential of the stabilized material. Tests were conducted with partial replacement of different percentages and it is noticed that % bagasse ash surges the significant chemical, physical and geotechnical properties of the soil. In

the initial study, itis concluded that black cotton soil has low compressibility and bearing capacity. With the addition of ash, the shear strength and bearing capacity strengthened.

J. R. Oluremi, et.al. [2012] [II] conducted experiments to find out the effect of Coconut Husk Ash on the strength properties of the ash after burning at the optimum temperature. Ash materials are burned at an appropriate temperature to extract the fibrous material to achieve the aim. Therefore, under controlled temperature only 8 % ash was occupied. Compressive and flexural strength test was conducted to verify the relative quality and strength development of mortar. The results concluded from the experiment shows that addition of Coconut Straw ash is optimum to synergize the mortar. The reason behind improvement is the optimization of pozzolanic and filler effect. Moreover, the significant improvement was examined due to the presence of Coconut Straw ash.

M. Wubshet et.al. [2014] [III] research determines the geotechnical properties of the soil by adding sugarcane Straw Ash as a stabilizer and experimenting various tests which includes CBR test, moisture content test, specific gravity test etc. The soil used here is the lateritic soil for the experiment. The pozzolan material having Cementous value at a particular temperature. The plasticity index of the soil was reduced for the different samples which exhibits the indication of soil improvement. Moreover, the CBR value was 400% higher than unstabililized samples for A and C and 220 % for sample B. The results of the test strengthen the research which demonstrates that cane ash is an excellent stabilizer for the soils which are rich in iron and aluminum in soils.

A. Chakraborty et.al. [2016] [IV] presents the study on the usage of Sugarcane ash to stabilize the black cotton soil.Soil is taken from the Agricultural Fields where soil possesses weak properties which results into failure of foundations and pavements. The whole process is natural and thus fibrous material is obtained after experimentation. The optimum moisture content and maximum drying density was measured which is good for replacement with 6% Sugarcane Ash.The experiment is conducted using the different proportion of the ash replaced with the soil. The replacements are 0%,3%,6%,9% and 12% of ash. The strength tests are carried out with each blend and results are concluded by IS 2720. The results are based on MDD, OMC, CBR test which proves successful to stabilize the soil.

R. Bade et.al. [2016] [V] researched the effects of Coconut Husk Ash On Expansive Soil. This is because stabilization using admixtures are more advantageous than the mechanical, cement, lime, bituminous and earth reinforcement method. The major reason for stabilization is that black cotton soil contains special mineral which absorbs water. This gives shrinking and contraction to the pavements which is seen in the form of cracks. So, research is conducted to stabilize the expansive soil by adding admixture. The main focus is on the use of the industrial waste. Here, potential of the applied material is checked by the specific gravity, grain size distribution, liquid limit, plastic limit, CBR and standard proctor test. The results showed that adding 8 % of CSA to the soil decrease the water content up to a limit. This research is suitable and gives most effective results on 8 % CSA which is an optimum percentage to enhance the properties of the required soil.

S. Prasanna et.al. [2017] [VI] presents a Case Study on Soil reinforcement using Coconut Straw Ash on Indian Soil. Coconut husk wastes were collected from hotels and household wastes. In this project work, experimental study on the effect of coconut shell ash to increase the strength of the soil was studied. This research is aimed at assessing the impact of coconut shell ash on the stabilization of poor soil. Different tests were conducted on soil sample with varying percentage of Coconut Husk ash. The samples were subjected to different laboratory tests, such as moisture content, specific gravity test, particle size distribution, Atterberg;s limits, bulk density, compaction and direct shear test. They concluded that these materials can thus serve as suitable alternatives to modify and stabilize problematic shale and hence help to reduce construction costs, environmental hazards and ultimately bring about shales with improved geotechnical properties.

T. Suresh Reddy et.al. [2017] [VII] examines the soil very closely which poses threat to the civil engineers. Here, cost effective method sugarcane straw ash is used to stabilize the expansive soil. Stress is more given on to enhance the geotechnical properties by varying curing periods and percentages of admixtures. Already, enough work is done by using Sugarcane ash but here different proportions of straw ash and polypropylene Fibres are taken by testing on different days. Thus, various tests are investigated such as CBR, UCS, Atterberg limits, sieve analysis, proctor and CBR value. The Unconfined compressive strength test was conducted on 3, 5 and 7 day curing period. The results represent that the increase in curing period increases the UCS value. However,8 % addition of admixture gives the maximum CBR value.

R. Ramli et.al. [2018] [VIII] led the testing on the essential properties of the soil by blending Coconut Husk Ash as stabilizer for road works. Diverse test performed reasoned that California Bearing Ratio test, explicit gravity and dampness content. Here the soil utilized is Clayey. The siliceous and aluminous properties having cementeous quality at a specific warm effect. PI of the dirt abatements for various examples which show the dirt improvement. CBR is additionally increments higher percentage regarding the sample. UCS is the fundamental property of the clayey soil. The end is that subsequent to blending Coconut Husk Ash for brilliant outcomes found in expanding the quality of the soil which makes suitable for Road works.

III. MATERIALS USED

1) *Soil:* The soil sample was collected from the locality of Peth (Maharashtra, India). Soil sample was collected from at least 2 feet below the natural ground level. The sample collected should be properly stored in the jute bags for partial elimination of the natural water from the collected soil and should be stored in the dry place. The next process is to air dry the soil sample for the two weeks. The soil after complete air drying must be sieved through 75 micron IS sieve for the further study.
2) *Sugarcane Straw Ash (SCSA):* Collection of Stabilizer Material, Sugarcane Straw Ash (SCSA) was done from Sahyadri Sugar Mill Karad. The next process is to convert the sugarcane straw into sugarcane straw ash(SCSA) The sugar cane straw was collected and dried under sunlight up to 24 hours (thorough drying of the straws should be done so that the straws are burnt easily in the later stages of the study). After complete air drying the sugar cane straw was spread on the ground and was burnt into ashes ,was collected and stored in the polythene bags (The burnt sugarcane straw must be stored in a dry area free from moisture), later on it was sieved through 90µ IS sieve to obtain the fine powdered ash.
3) *Coconut Husk Ash (CHA):* Coconut Husk was collected from the local households of Karad region in Maharashtra. Sample was dried under sunlight up to 24 hours. Thorough drying of the Husks should be done so that the straws are burnt easily in the later stages of the study. After complete air drying the sugar cane straw was spread on the ground and was burnt into ashes and was collected and stored in the polythene bags. The burnt sugarcane straw must be stored in a dry area free from moisture, later on it was sieved through 90µ IS sieve to obtain the fine powdered ash.

IV. METHODOLOGY

Laboratory experiments undertaken as a primary source of data for this study. The experimental studies aimed at investigating the effects of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) on Black Cotton Soil and comparing their CBR values to determine best Stabilizer Material. The tests also involve determination of index properties of expansive soil. The following laboratory tests were performed.

A. Liquid Limit Test.
B. Plastic limit Test.
C. Specific Gravity Test.
D. Water Content Test. (Oven Drying Test)
E. Proctor Test.
F. California Bearing Ratio Test. (CBR)

The experiment was conducted in two stages. During the first phase engineering tests were conducted on the soil sample such as Liquid Limit Test, Plastic Limit Test, Specific Gravity Test, Water Content Test, California Bearing Ratio Test (CBR) and Proctor Test. In the second phase the California Bearing Ratio Test was conducted on soil sample which was blended with 8 percent of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA).

V. RESULTS

A. Geotechnical Properties of Soil

Tests	Parameters	Description
Water Content Test	Water Content (%)	23.37
Specific Gravity Test	Sp Value	2.26
Atterberg's Limit test	Liquid Limit Test	59.59%
	Plastic Limit Test	27.65
	Plasticity Index	22.94

Table 1: Geotechnical Properties of Soil.

The Plasticity of the Soil is the ability of the Soil to mould into many shapes when the soil is wet. This is basically due to the presence of Clay Minerals. So, when the soil is wet it is attracted towards water molecules. So, this plasticity is due to adsorbed water. The Soil has a liquid limit of 50.59 %, Plastic Limit of 27.65 % and Plasticity Index of 22.94 which classifies the Soil as clayey. Such Soils exhibit low bearing strength, high compressibility and high level of volumetric change which causes the soil to loose strength causing soil settlement in sub-grade which leads to cracks in road pavements destabilization of building constructions. Such Soils needs to be stabilized by Stabilizing Methods for further Study. The Specific Gravity of Soil is 2.26 which is not an ideal range for deducing stability of Soil against Loading. The Ideal range of Specific Gravity is 2.6 to 2.80. Thus further proving that the Soil is not ideal for construction. The moisture content is recognised as the fundamental property which influences the behaviour of soils. The measurement of moisture content in both the natural state and under laboratory test conditions provides a basis for soil classification and an indication of engineering properties of cohesive soils. It is probably the single most important test carried out in routine geotechnical engineering work. The Ideal Water Content of Soil for Construction activities should be 10 to 20 percent. The result showed the Water Content of 23.37 which is significantly more than the Standard water content.

B. Standard Proctor Test

Compaction test of soil is carried out using Proctor's test for understanding the compaction characteristics of different soils with change in moisture content. The ability for compacting a soil depends on the water content of the soil. It is a very important test for structural stability on the construction site. Proctor test is used to find two major properties i.e. Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). Standard Proctor test establishes the variation of the unit weight of soil and degree of compaction with the moisture content. It also helps us find out the optimum moisture content for the highest practical density.

Sr. No.	Dry Density Of Soil (g/cm²)	Moisture Content Of Soil (%)
1.	1.58	18.8
2.	1.64	19.4
3.	1.62	22.8
Maximum Dry Density Of Soil (MDD)		1.64
Optimum Moisture Content (OMC)		19.4

Table 2: Observations for Maximum Dry Density and Optimum Moisture Content of Soil.

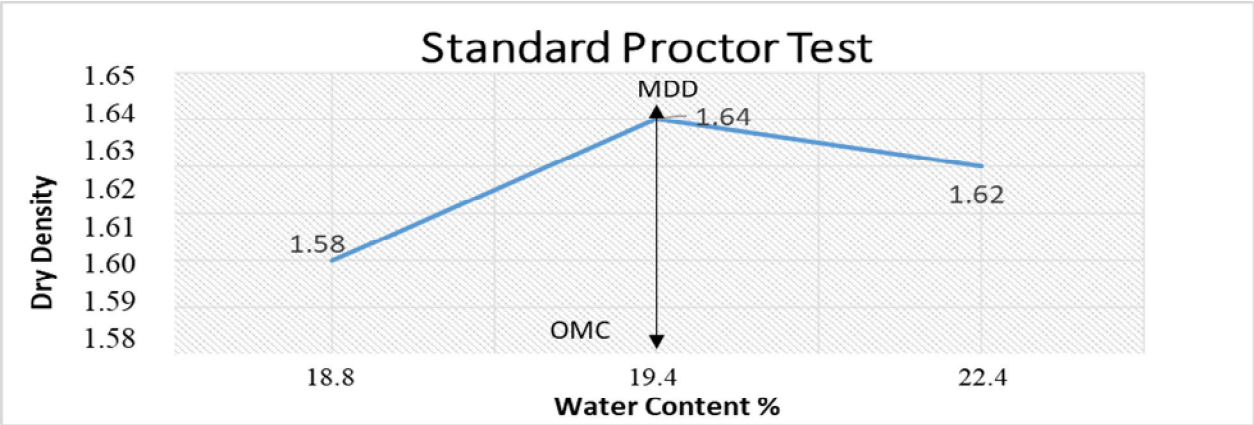

Figure 1: Maximum Dry Density and Optimum Moisture Content.

When we plot the results of the Standard Proctor test, we observe that the unit weight or density rises initially with increasing moisture, reaches a maximum, and then declines quickly. The maximum is called the maximum unit weight of soil and the moisture content corresponding to it the Optimum Moisture Content (OMC). From the Plotted Graph we can determine that the Optimum Water content of Soil is 19.4 % and Maximum Dry Density of Soil is 1.64 kg/cm².

C. California Bearing Ratio Test

The California Bearing Ratio (CBR) test is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. It was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR test may be conducted in remoulded or undisturbed sample. Test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value. The main purpose of the California bearing ratio test is the measurement of a soil resistance penetration before reaching its highest ultimate value of a shearing. California Bearing Ratio test is done for determining the bearing capacity of soil or bitumen pavement. It is also used for determining the subgrade strength value of pavements and roads.

Sr. No	Penetration (mm)	CBR value of Soil	CBR value of Soil with addition of 8% SCSA	CBR value of Soil with addition of 8% CHA
1.	2.5	4.83	10.14	8.73
2.	5.0	4.56	9.71	8.56

Table 3: Comparison of CBR values of Soil after addition of 8 % SCSA and CHA.

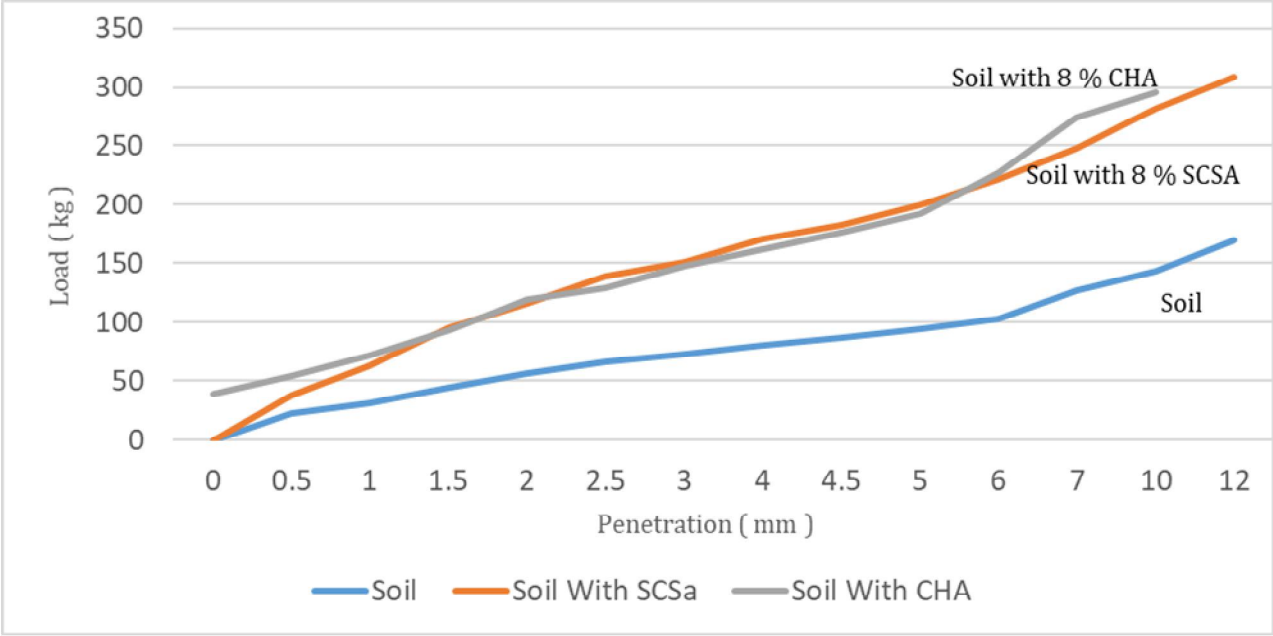

Figure 2: Comparison of CBR values of Soil after addition of 8 % SCSA and CHA.

CBR test were carried on Soil before and after addition of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) at 8 % the total weight of Soil. The CBR value of Soil was 4.83 %. Which after addition of Sugarcane Straw Ash increased from 4.83 % to 10.14 % which shows increment of 5.31 %. After addition of Coconut Husk Ash (CHA), the CBR value increased from 4.83 % to 8.73 % showing increase of 3.9 %. By comparing the results of Soil after addition of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA), the Sugarcane Straw Ash (SCSA) gives 1.41 % more improvement than that of Coconut Husk Ash (CHA). Thus, the test results show significant improvement in CBR values and prove that Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) are excellent Stabilizing Materials with Sugarcane Straw Ash giving the maximum improvement out of the two.

More efforts should be given by the researchers to find various Soil Stabilization Methods, which are not only Effective, Economical but also Environment friendly. These methods must also tackle the problems regarding Waste Management as a further step towards using advancements in Science and Technology for developing new Soil Stabilization Techniques but also means of preservation of Environment.

VI. CONCLUSIONS

A. The Study conducted showed the CBR value increases up to 5.31 % after addition of Sugarcane Straw Ash of 8 % the weight of soil. The Addition of Coconut Husk Ash increased the CBR value up to 3.9 % after addition of 8% of CHA. Thus, showing that Addition of Sugarcane Straw Ash and Coconut Husk Ash increases the bearing capacity of soil.

B. By comparing the CBR values of Soil after addition of Sugarcane Straw Ash and Coconut Husk Ash at 8 % the weight of Soil, the Sugarcane Straw Ash improves the Soil by 1.41 % more than that of the Coconut Husk Ash.

C. From this study, we can conclude that Sugarcane Straw Ash (SCSA) has given better results as Stabilizer Material than Coconut Husk Ash (CHA).

D. The evidence from the study conducted shows that both Sugarcane Straw Ash and Coconut Husk Ash show significant improvement in Bearing Capacity of Soil and are Cheap and Eco-Friendly way of Soil Stabilization.

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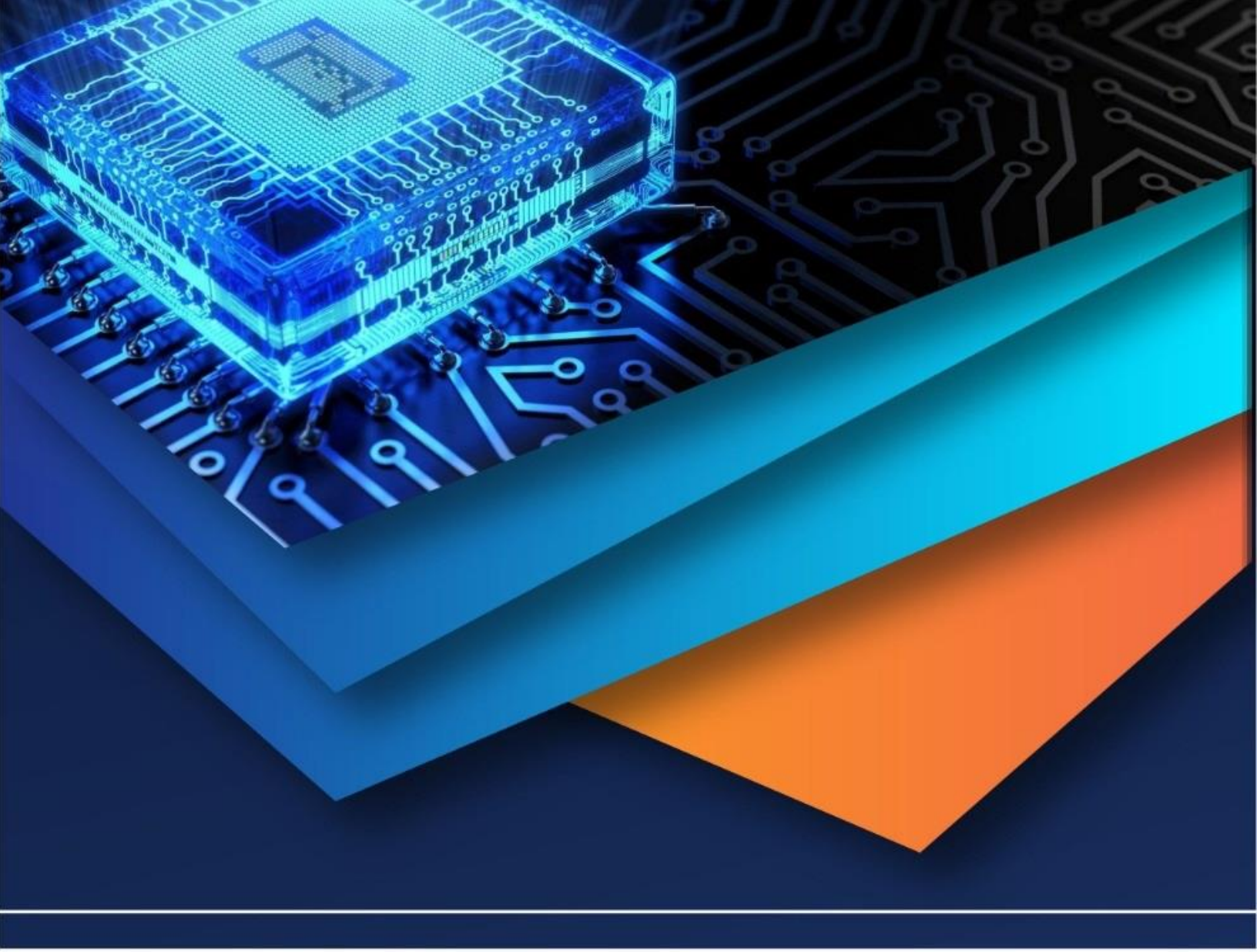

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