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An Investigational Evaluation on Soil Stabilization by Using Bio-Enzymes

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Abstract: The conventional methods are time consuming and are not economically feasible. Hence there is a need to find the other possible ways to satisfy the performance as well as economical criteria. These enzymes have been demonstrated to be very effective and economical. Another advantage of the bio enzyme is that these are environment friendly. The efficiency of bio enzyme depends upon the amount of quantity, type of soil and curing time span. In our country vast areas consist of black cotton soils. As the conventional soil stabilizers like gravel, sand and others are exhausting and becoming costly day by day at a very rapid pace, it becomes necessary to look towards for alternative eco-friendly stabilizers as their substitute. Recently many Bio-enzymes have emerged as cost effective stabilizers for soil stabilization. Some such type of bio-enzyme, like Terazyme, bagasse ash, lime etc. has been used in the present work. Recently many Bio-enzymes have emerged as value influential stabilizers for soil stabilization. One such Bio-enzyme, Terrazyme, has been used withinside the gift paintings to take a look at its impact at the Unconfined Compressive electricity of the Black Cotton soil. It has been located that Terrazyme dealt with Black Cotton soil suggests vast boom in Unconfined Compressive electricity with longer curing period
Keywords: Bio-enzyme, Stabilization, Black Cotton Soil, Bagasse ash, Lime, Liquid Limit, Plastic Limit, CBR test.

I. INTRODUCTION

Black cotton is one of the expansive soil available in India. Black cotton soil is anexpansive soil that generally available in the tropical zones. Their appearance varies from black colour to brown color. In our country black cotton soil occupies nearly 20% of the available land. Expansive soil major share generally found in central part and some places in south India. Expansive soils known by black cotton soil are obtainable in the Deccan plateau fields (Deccan Trap) including Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh and in some parts of Odisha, in the Indian sub-continent. Black cotton soil available in the valley of river Tapti, Narmada, Godavari and Krishna. The west side of Deccan plateau and in upper portion of Krishna and Godavari basin. In this area the black cotton soil depth is very narrow. These soils formed by the residual action of basalt or trap rocks. The other reason behind formation of these soils is weathering of igneous rocks, after volcanic eruption by the cooling action of lava. These soil shows high plasticity nature. The major clay mineral is montmorillonite. Because of montmorillonite group mineral these clays exhibit more swelling and shrinkage characteristic. The main problem with this type of minerals is instability of earth material. Expansive soils are hard when they lose water content, and another day if they capture water, they become soft in nature.
In Maharashtra region the expansive soils are acknowledged by name “Black Cotton” soil. These soils possess decrepit properties due to presence of clay minerals known as “Montmorillonite”. Typical behavior of soil results into failure of structure in form of settlements cracks etc.

A. Terrazyme, A Bio-Enzymatic Soil Stabilizer

TerraZyme is a natural, non-toxic, non-corrosive and non- inflammable liquid, produced via way of means of formulating vegetable extracts. Organic enzymes are available in liquid shape. They are flawlessly soluble in water, brown in shadeation with scent of molasses. Their aroma has no effect. Neither gloves nor mask are required at some stage in handling. TerraZyme is specifically formulated to adjust the engineering houses of soil. They require dilution in water earlier than utility. TerraZyme while delivered to water and blended with soil alters the engineering houses relying upon the form of the soil and dosage of enzyme. These enzymes are liquid additives, which act at the soil to lessen the voids among soil debris and decrease absorbed water withinside the soil for max compaction. The enzymes react with the natural rely (humid rely) withinside the soil to shape cementitious material. This decreases the swelling capability of the soil debris and decreases permeability. The utility of TerraZyme complements climate resistance and will increase load bearing capability of soils.

These functions are in particular glaring in fine-grained soils including clay wherein the components impacts the swelling and shrinking behavior. The response is at micron degree and the presence of finely divided humid rely and clay-sized debris is important. Presence of clay is important because the bonds fashioned bind this length of debris. The components has the capacity to extrade the matrix of the soil so that when compaction the soil loses its capacity to reabsorb water and the mechanical blessings of compaction aren't misplaced even after water is reapplied to the compacted soil. Once the enzyme reacts with the soil, the extrade is everlasting and the product is bio-degradable.

II. LITERATU REREVIEW

Rajni S. Chandran, Padmakumar G.P (2009) lime is an unparalleled aid in the modification and stabilization of soil beneath road and similar construction projects. Use of lime can substantially increase the stability, impermeability, and load bearing capacity of the sub grade. Black cotton soil can be stabilized by the addition of small percentages, by weight of lime thereby enhancing main of the engineering properties of the soil and thus produces an improved construction material. The strength developed is obviously influenced by the quantity of cementations gel produced. consequently on the amount of lime consumed and curing period. Dry lime used for stabilization cause dust allergy and is corrosive to human skin and so lime solution was used in the study. The soil used in the study is clay from Thonnakal in Trivandrum district, in which kaolinite mineral is predominant. The lime solution with different concentrations were added to the soil samples for stabilization and cured with water for 7, 14, 21, 28 and 35 days. Results showed that optimum concentration of lime solution that gives the highest soil strength is the optimum concentration of lime solution for soil stabilization.

From the test results, it was also found that the imconfmed compressive strength increased up to a curing period of 28 days and thereafter there are no appreciable effects.

Shukla et al. (2003) used Bio-Enzymes to stabilize 5 unique varieties of soil starting from low clay content material to very excessive clay content material, engineering houses and energy traits have been decided and it turned into located that there may be little to excessive development in bodily houses. Little development might be because of soil constituent, which has low reactivity with Bio-Enzymes. There turned into development in CBR and unconfined compression energy of soils like silty soil to sandy soil. An growth of sixty five to 252% in UCS fee turned into determined after four weeks of curing. Pavement layout thickness additionally reduces to twenty-five to forty percent. Moreover, in case of shortage of granular material, best stabilized floor with skinny bituminous surfacing can satisfy the pavement layout requirement. Sharma (2006) has performed laboratory research on use of bio-enzyme stabilization of 3 varieties of soils specifically clay of excessive plasticity (CH), clay of low plasticity (CL) and silt of low plasticity (ML). It turned into located that the CH soil had a growth in CBR fee with discount in saturation moisture from forty to 21 four weeks of stabilization. Also, it turned into located that there has been 100% growth in unconfined compression energy.

Shankar et al. (2009) studied the impact of various dosages of Bio-Enzymes on Lateritic soil of Dakshin a Kannada (district of India), having liquid restrict and Plasticity Index greater than 25% and 6% respectively. Tests have been performed on lateritic soil through including unique chances of sand as well. They concluded that there may be medium development in bodily houses of lateritic soil. Therefore, it turned into cautioned that impact of Bio-Enzyme on soil must be tested in laboratory earlier than real discipline application. Higher dosage (200ml/2m3 of soil) produced 300% growth in CBR, 450% in unconfined compressive energy and permeability turned into decreased through 4 weeks of curing. It turned into additionally determined that enzyme isn't powerful for brotherly love much less soil.

Venkatasubramanian et al. (2011) performed exams on 3 soils with various houses and unique dosages of Bio-Enzyme. Three soils had liquid limits of 28, 30 and 46% and plasticity index of 6, five and 6%. Increase in unconfined compressive energy after four weeks of curing turned into said as 246 to 404%.

Akiije, et.al (2015) The contrast of A-6(10) laterite soil stabilized with Power max cement and hydrated lime one after the other in possibilities of 6%, 8%, 10%, 12% and 14%. It additionally taken into consideration the stabilized substances suitability in courting to their power and permeability traits as subbase and basecourse substances in dual carriageway pavement layout and creation primarily based totally upon endorsed exercise of AASHTO category system. Heuristic algorithms for reasoning and choice making done concerned issues for fundamental and physio-chemical homes of the laterite soil, Power max cement and hydrated lime to optimally arrive at layout goal features and serviceability necessities of the stabilized pavement substances. Strength and permeability traits of herbal A-6(10) laterite soil and at its most of 14mixture stabilization with Power max cement and hydrated lime one after the other have been different.

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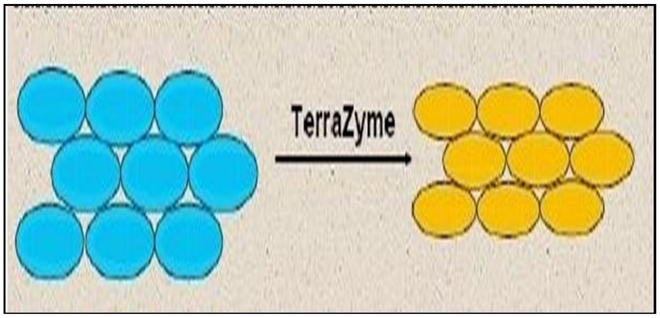
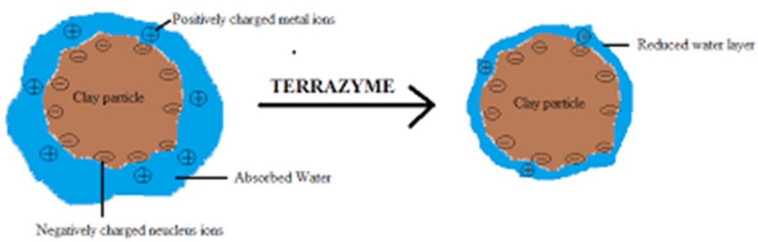
III. METHODOLOGY

In clay water mixture positively charged ions (cat-ions) are present around the clay particles, creating a film of water around the clay particle that remains attached or adsorbed on the clay surface.

The adsorbed water or double layer gives clay particles their plasticity. In some cases, the clay can swell and the size of double layer increases, but it can be reduced by drying. Therefore, to truly improve the soil properties, it is necessary to permanently reduce the thickness of double layer. Cat-ion exchange processes can accomplish this. By utilizing fermentation processes specific micro-organisms can produce stabilizing enzyme in large quantity. These soil-stabilizing enzymes catalyze the reactions between the clay and the organic cat-ions and accelerate the cat-ionic exchange without becoming part of the end product.





TerraZyme replaces adsorbed water with natural cations, as a result neutralizing the terrible price on a clay particle. The natural cations additionally lessen the thickness of the electric double layer. This lets in TerraZyme dealt with soils to be compacted extra tightly together.

TerraZyme resists being replaced by water, thus reducing the tendency of some clay to swell. TerraZyme promotes the development of cementatious compounds using the following, general reaction:

$$\mathbf{H_2O + Clay \xrightarrow{\textit{Terrazyme}} Calcium\ Silicate\ Hydrates}$$

A. Test Are Performed As Follows

1) Determination of chemical composition of sugar cane bagasse ash
2) Soil Classification
3) X-ray analysis method of Black Cotton soil
4) Grading test
5) Moisture Content
6) Specific Gravity
7) Specific Gravity
8) Atterberg Limits
9) Liquid Limit
10) Plastic Limit
11) Plasticity Index
12) Maximum Dry Density
13) Optimum Moisture Content
14) California Bearing Ratio

IV. MATERIALS AND TESTS

A. Chemical Analysis of SCBA

The chemical analysis indicated that the ash contained mainly silica, calcium, magnesium and aluminium with other minor elements Table 4.1. The combined percent composition of SiO_2, Al_2CO_3 and Fe_2O_3 of the ash is more than 70% hence exhibits pozzolanicity property.

Table 4.1: Chemical analysis of Bagasse Ash

Description	Abbreviation	Ash (%)
Silica	SiO_2	66.23
Iron	Fe_2O_3	3.09
Calcium	CaO	2.81
Magnesium	MgO	1.54
Sodium	Na_2O	0.26
Potassium	K_2O	6.44
Loss of Ignition	.	16.36
Alumina	Al_2O_3	1.90
Titanium	TiO_2	0.07
Manganese	MnO	0.60

B. Black Cotton Soil

Results of the study on physical properties on neat sample of soil is given in Table 4.2 and indicated that the sample belonged to black cotton soil. Most of the properties required to be improved to meet engineering standard.

Table 4.2 Properties of black cotton soil

PROPERTY	QUANTITY
Colour	Grayish black
Percentage passing No. 200 sieve, %	99.5
Liquid limit, %	67
Plastic limit, %	32
Plasticity index, %	35
AASHTO soil classification	A.7.5
Free swell, %	0.7.5
Specific gravity	2.65
Maximum dry density, kg/m^3	1240
Optimum moisture content, %	26.4
Soaked CBR value, %	11

The chemical analysis of black cotton according to (Ramesh et al.) is shown in Table 4.2. The main components are silica (SiO_2) 52.85% and alumina (Al_2O_3) 12.24%, loss of ignition is 16.18%.

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Table 4.3: Chemical analysis of black cotton Black Cotton

Description	(%)
Silica	52.85
Iron	8.04
Calcium	6.01
Magnesium	0.48
Sodium	0.26
Loss of Ignition	16.18
Alumina	12.24
Titanium	0.24

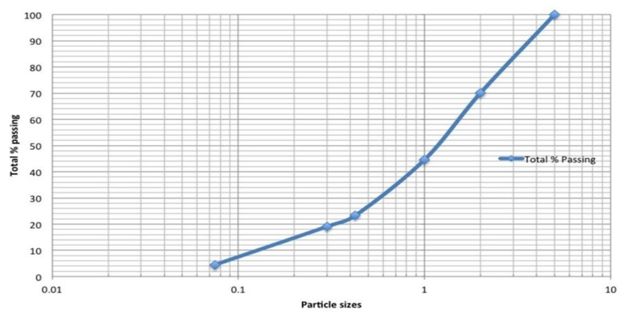

Figure 4.2: Grading curve analysis

Plasticity Index – Lime : Ash

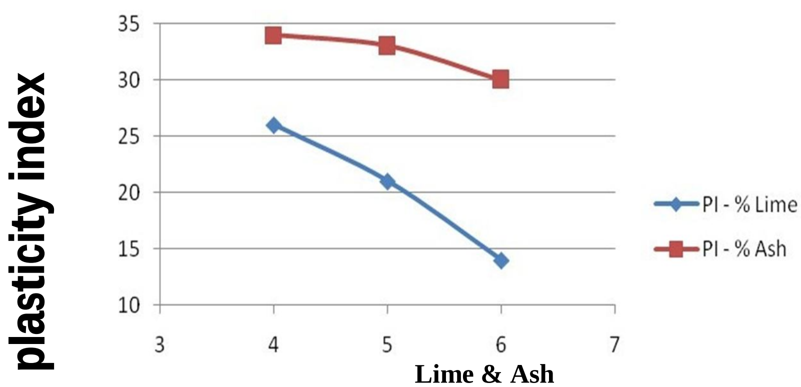

Figure 4.3: Variation of plasticity index with addition of different bagasse ashcontents

MDD and OMC for neat

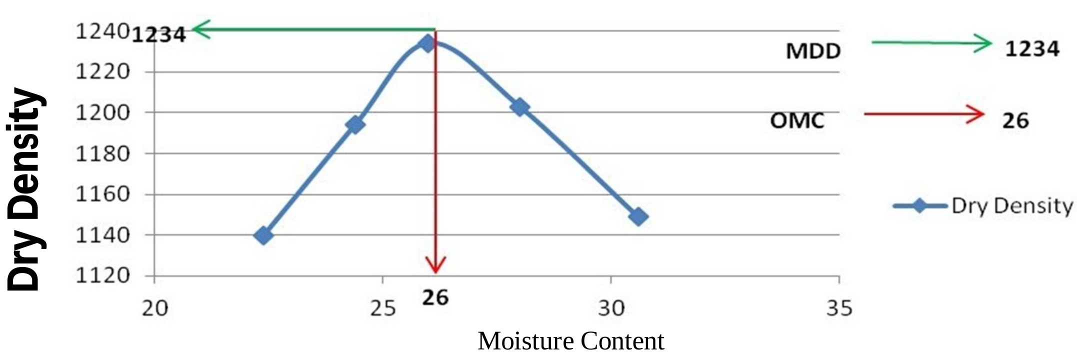

Figure 4.4 Maximum Dry Density and Optimum Moisture Content for neat sample

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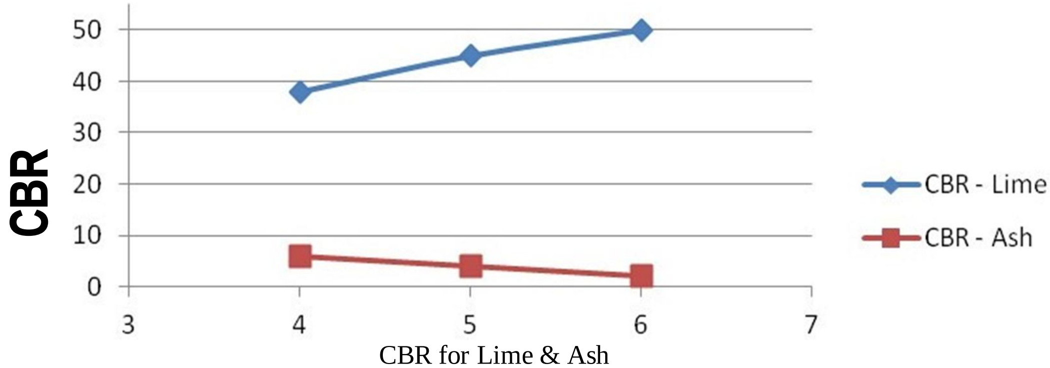
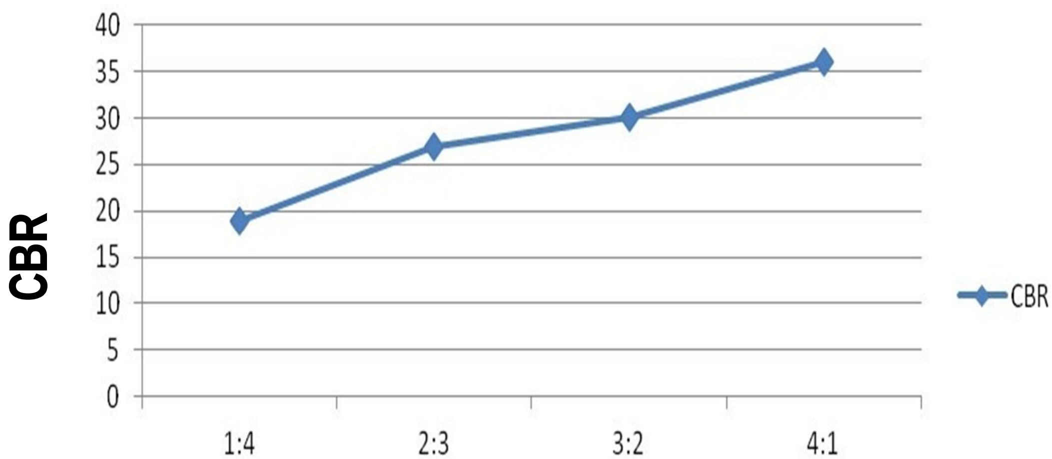


Lime & Ash

Figure 4.5: CBR of Lime and Bagasse Ash



Lime : Ash

Figure 4.7: CBR for ratio of lime to ash (%)

V. DETERMINATION THE PI OF ASH & LIME RATIO

Table 4.4: Determination of PI of 4% lime

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	C1	C2	C3	C4	C5	C6	C7
Sample + wet soil g	37.8	39.7	41.9	43.6	45.8	20.1	20.2
Sample + dry soil g	31.5	32.6	34.1	34.9	36.2	19.8	19.9
Sample g	18.9	19.0	19.7	19.5	19.8	18.8	18.8
Water g	6.3	7.1	7.8	8.7	9.6	0.3	0.3
Dry soil g.	12.6	13.6	14.4	15.4	16.4	1.0	1.1
Moisture content %	50.0	52.2	54.0	56.6	58.5	29.6	28.4

Table 4.5: DETERMINATION OF PI 5% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	F1	F2	F3	F4	F5	F6	F7
Sample + wet soil g	54.1	52.5	58.3	58.5	62.8	22.7	23.6
Sample + dry soil g	43.9	42.8	46.9	46.0	49.4	22.1	22.8
Sample g	19.6	20.4	21.8	19.8	22.4	19.6	19.8
Water g	10.2	9.7	11.4	12.5	13.3	0.6	0.8
Dry soil g	24..3	22.4	25.1	26.2	27.0	2.5	3.0
Moisture content %	49.1	43.3	45.5	47.9	49.7	24.2	26.4

Table 4.6: DETERMINATION OF PI 6% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	K1	K2	K3	K4	K5	K6	K7
Sample + wet soil g	57.5	60.6	64.6	67.7	69.3	23.2	23.0
Sample + dry soil g	48.2	50.1	51.9	53.8	54.2	22.5	22.4
Sample g	22.1	21.8	19.9	20.4	22.4	19.8	20.4
Water g	9.3	10.5	12.7	13.9	15.1	0.7	0.6
Dry soil g	26.1	26.3	32.0	33.4	34.8	2.7	2.1
Moisture content %	35.6	37.1	39.6	41.7	43.3	25.4	28.6

VI. CONCLUSION

The following conclusions can be drawn from the results of the investigation carriedout within the scope of the study.
The chemical analysis of bagasse ash indicated that the main element were silica (66.23%), potassium (6.44%) iron (3.09%), their combined percent composition is 75.76 % which is above 70 % specified by (ASTM 2012) standards for pozzolanic reaction.
The plasticity index reduced with increased in content of bagasse ash and lime but the increment for bagasse ash was insignificant compare with the set standard by Road design manual part III. Bagasse ash alone cannot be used for expansive Black Cotton soil stabilization.

California bearing ratio increased for lime samples but reduced for bagasse ash samples and this was attributed to negligible amount of calcium present in bagasse ash. Similarly bagasse ash has negative impact on the strength of expansive Black Cotton soil hence cannot be used as standalone stabilizer. When bagasse ash partially replaced lime, plasticity index reduced and California bearing ratio increased as the ratio varies. At the ratio of 4:1 (lime:ash) the results obtained conformed with the standard set Road design manual part III of CBR 36 %, PI 20% , linear shrinkage of 9.0 and negligible swelling thus can be used for expansive Black Cotton stabilization

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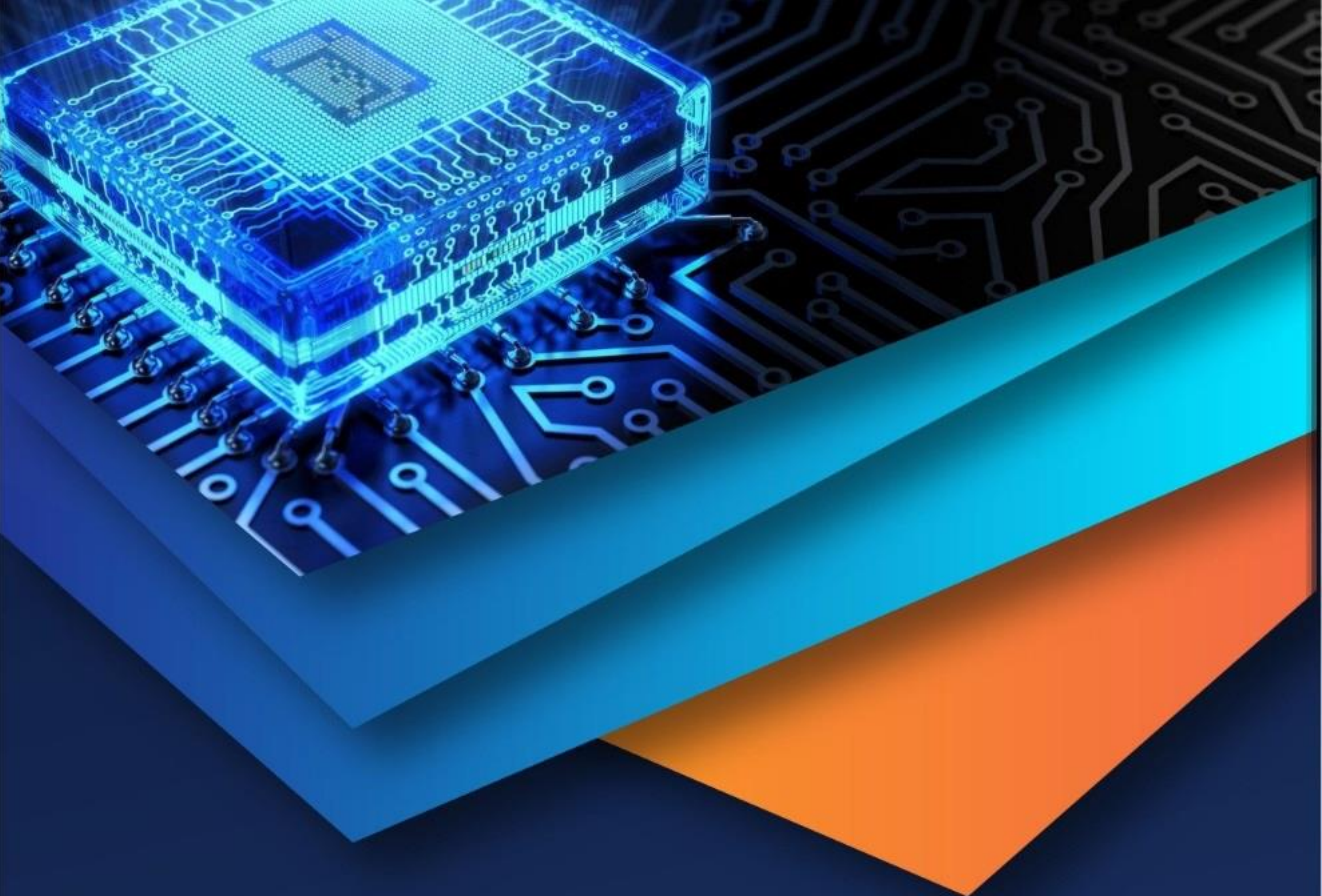

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