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Development of Methods and Techniques for Soil Stabilization Using Fly Ash and Plastic-Waste

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Abstract: In this study, it was tried to stabilize the soil by using fly ash and plastic waste. Because these two materials are becoming a big problem for the environment. If we use these materials for construction, it will be a win-win situation. Additionally, some areas have large enough soil with high enough shrinkage to indirectly produce most of the montmorillonite creating unsuitable conditions for construction, so construction must first be made of solid soil to prevent settlement, which will cause serious damage. building and cause damage. situation. Liming is a popular method of chemical stabilization as it reduces the activity of montmorillonite, and compaction is a popular stabilization method. In this article, we use fly ash and plastic waste, which are environmentally friendly, inexpensive, and easy to use. Here we run different tests. Try to find ways to use fly ash and plastic waste.
Keywords: Black Cotton Soil, Plastic waste, and fly ash

I. INTRODUCTION

Soil stabilization is the process of improving and stabilizing the properties of the soil. It is used to improve shear performance and reduce soil imperfections such as permeability and consolidation. These machines are mainly used in the construction of highways and airports. Compaction and pre-consolidation are often used to improve existing soils. On the other hand, ground stabilization is not only done to soften the ground and reduce the soft ground cost.

In addition to examining the composition of the soil mass, the chemical transformation of the material in the soil is also an important part of the process. Soil improvement is sometimes used to make urban and suburban roads more permeable.

Fly ash is a burning product in power plants and must be buried. But many governments encourage the reuse of some waste materials for sustainable construction.

Since plastic is not a vital material, it cannot degrade. Strategies used to promote the recycling of plastic waste have an impact on the environment. Bacteria are at risk of plastic leaching due to the acidic soil environment. Therefore, the new system should remove the plastic. Plastic has many properties such as strength, brittleness and corrosion resistance. Antibiotic, line failure, abrasion resistance, insulation and heat resistance.

We can use plastic waste to strengthen the soil as a way to deal with plastic waste. In this new technology, plastic is used as a soil stabilizer to reduce pollution and improve soil quality. Strategies used to promote the recycling of plastic waste have an impact on the environment. Bacteria are at risk of plastic leaching due to the acidic soil environment. Therefore, the new system should remove the plastic. Plastic has many properties such as strength, brittleness and corrosion resistance. Antibiotic, line failure, abrasion resistance, insulation and heat resistance.

We can use plastic waste to strengthen the soil as a way to deal with plastic waste. In this new technology, plastic is used as a soil stabilizer to reduce pollution and improve soil quality.

II. MATERIALS

A. Soil Sample

Soil samples collected for testing from the Khadawasla dam site were analyzed for their electrical and mechanical properties. Only expanding soil, locally referred to as black cotton soil, was used in this experiment. Black cotton soil is an inorganic clay with plasticity and medium to high compressibility.

It is an important soil type in India. The structure and color of black cotton montmorillonite is black or dark gray. Land geotechnical and road engineers have problems because their soil, which is mostly clay and has strong swelling and shrinkage strength, is just cotton soil.

TABLE I. Properties of soil

Sr. No	Properties	Values
1	Specific Gravity	2.62
2	Liquid Limit(%)	29.5
3	Plastic Limit(%)	20.2

B. *Fly Ash*

Fly ash has a good gelling effect, but in the presence of moisture it reacts chemically and forms gelling compounds. The resulting gelling compound increases the strength and compressibility of the soil. It is a cloudy gray fine powder. It is mostly made of silica, which is formed when finely ground coal is burned in boilers to generate electricity. At the MIDC power station in Pune, fly ash is collected from local cement companies.

TABLE II. Properties of Fly Ash

Sr.No	Minerals	Percentage
1.	siO2	48.38
2.	Fe2O3	7.27
3.	Al2O3	27.62
4.	CaO	10.54
5.	MgO	2.59
6.	SO3	3.17
7.	P2O5	0.22

C. *Plastic Waste*

Plastic is a non-biodegradable waste. Therefore, the disposal of environmentally damaging plastic waste has become a major problem. Therefore, the use of plastic waste to stabilize and help reduce pollution is less dangerous, economical, and beneficial for embankments.

Today, the increasing use of plastic in consumer goods has led to an increase in the amount of plastic materials left in the city, which are used and thrown away a short time ago and eventually turn into waste products. Therefore, there is a growing need to develop alternative ways of using plastic bags to extend the life of plastic materials and thus prevent environmental damage.

Plastics are widely used, plastics have good properties such as molding into anything easily, good insulation and not rust, which helps to increase the effect. Plastic is obtained after proper washing of waste plastic bags (milk and dairy products, pet bottles, chocolate packaging, polyethylene bags).

TABLE III. Properties of Plastic Wastes

Sr.No.	Description	Valve
1	Colour	Clean
2	Unit Weight	0.92
3	Compressive Strength	Poor
4	Ultimate tensile strength	57
5	Modulus of Elasticity	115-455
6	Water Absorption	0.02

III. METHODS

A. *Sieve Analysis*

A set of sieves has been used of sieves to remove dirt. Covers are usually made of spun brass, phosphor bronze, or stainless steel.

Fig.1. Sieve Shaker

According to IS: 1498-1970, sieves are classified according to the square aperture size in millimeters or microns. The sieves are available in sizes from 80 mm to 75 microns.

B. Liquid limit

The height of the water at which the soil turns from liquid to plastic is called the liquid limit. The compressibility index used in sedimentation analysis can be determined using the liquid limit test. Clay is almost liquid at the liquid limit, but has low shear strength. At this level, shear strength is the smallest value that can be measured in the laboratory.

C. Plastic limit

The water concentration at which the soil no longer behaves like plastic is called the plastic limit. It began to crumble when covered with earth with a diameter of 3 mm. At this humidity, the ground loses its elasticity and becomes semi-solid.

D. Direct Shear Test

This test is performed to determine the cohesion and internal friction of soil samples.

E. UCS Test

The undetermined Compression Test is a functional test by which we can obtain the Unverified Compressive Strength (UCS) of concrete samples. This test is often associated with saturated and cohesive soils and is generally not recommended. Because the material does not support the lateral volume of the soil. UCS refers to or represents the true maximum uniaxial compression force that the structure can withstand without deformation (failure).

Fig.2. Normal Soil Specimen Undergoing UCS Test

F. Standard Proctor Compression Test

The Compression Test is used to determine the amount of compression and water on the surface. This test establishes a relationship between the amount of water in a sample and its density. Calculate the moisture content of the maximum drying temperature using this relationship test.

G. Bearing Capacity of Soil

The soil's bearing carrying capacity is influenced by soil properties like cohesion, in-situ density soil, voids ratio, and angle of internal friction. Because compacted & dense soil has more unit weight correspondingly more bearing capacity. If the loading is moderate and the bearing capacity is sufficient to take load then a shallow foundation is used. If the soil strata are weak and the intensity of loading is high then a deep foundation like a pile, well, or pier foundation is preferred. So, for the construction of any civil engineering structure bearing capacity plays an important role. Instead of changing the design of the foundation we can change the bearing capacity of soil. And if we use waste material like fly ash and plastic waste for improving bearing capacity then there is a win-win situation. As we are improving bearing capacity as well as saving the environment. We have used the following instruments to determine bearing capacity, which consists of the following

1) Frame

has steel materials that meet the requirements of IS 1730:1989 (Steel plates, Plates, strips, and flats for Dimensions for structural and general engineering purposes).

Fig.3 Framed Setup

2) Loading frame and mechanism

The loading mechanism has a cylindrical loading unit with an S-shaped washer on it. Check the ground load. The load cell is supported by a 30cmx30cmx5cm M25-level concrete carrier plate. This is the loading system.

Use stainless steel rollers. S-beam load cells are named because of their shape. The name "S-Beam Load Cell" comes from its S-shaped shape. It has the S model. S-Beam load cells can produce output in tension or compression.

Tank levels, hoppers and truck scales are examples of applications. The cell is a sensor that converts energy into an electrical signal. Although there are many types of load cells, strain gauge load cells are the most common. This is the most common type. Although the truth is only in a few laboratories, equipment that is in balance is in use, electronic equipment is used. Take over the heavy shopping/jobs.

3) Display unit

A display unit is a visual device that displays information. It gives information about the loads and deflections caused by the loads applied to the ground. The wire is connected to the beam and the deflection meter makes the connection.

When the load is applied manually to the load unit, the device detects the load, converts it into a digital signal, and displays it in the display unit of the digital meter.

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Fig.5 Digital Deflection Meter

4) Manual Loading bar

For manual loading, use a stainless-steel bar of approximately Fe500 quality. Apply the loads to the floor, using three to four sticks with a diameter of about 10 mm at a time. Therefore, stainless steel is used where the strength and corrosion resistance of the steel is required. Um, additives reduce acidity while increasing corrosion resistance and preventing the pitting of chloride.

Fig.6. Steel Rod

5) L.V.D.T.

This L.V.D.T (Linear Variable Differential Transformer) is used to determine ground compatibility through the load. As the ground load increases, the settlement of the ground and this deflection L.V.D.T. should be measured with

Internally, the hotel has a spring-like structure. Checkers are also used to determine if an agreement has been reached. A wire from L.VDT is connected to the display unit showing the ground reading. Maximum measurable deviation from 0 to 50 mm.

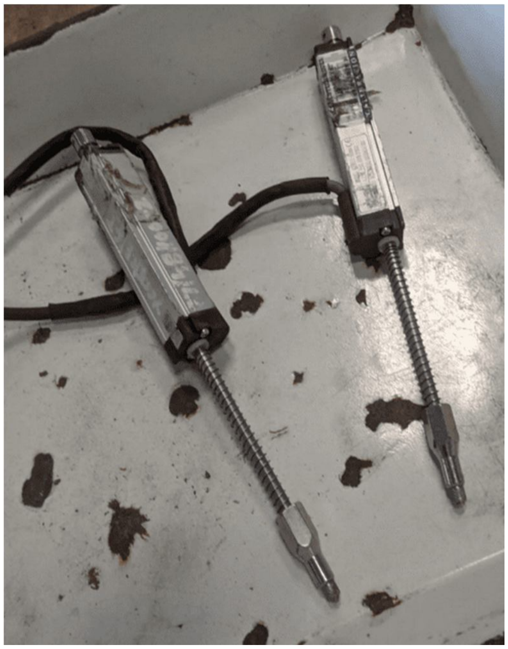


Fig.7 L.V.D.T Instrument

6) Steel Plate

A flat surface is required to transfer the weight of the load to the ground, this can be done with a steel plate or concrete steel plate in our project.

IV. RESULT AND DISCUSSION

The following test is performed to find out the basic properties of soil

A. Sieve Analysis

Sieve analysis is performed in the laboratory and the following observation is obtained. It is observed that soil is well graded and clay particles are predominant.

TABLE IV. Sieve Analysis Table

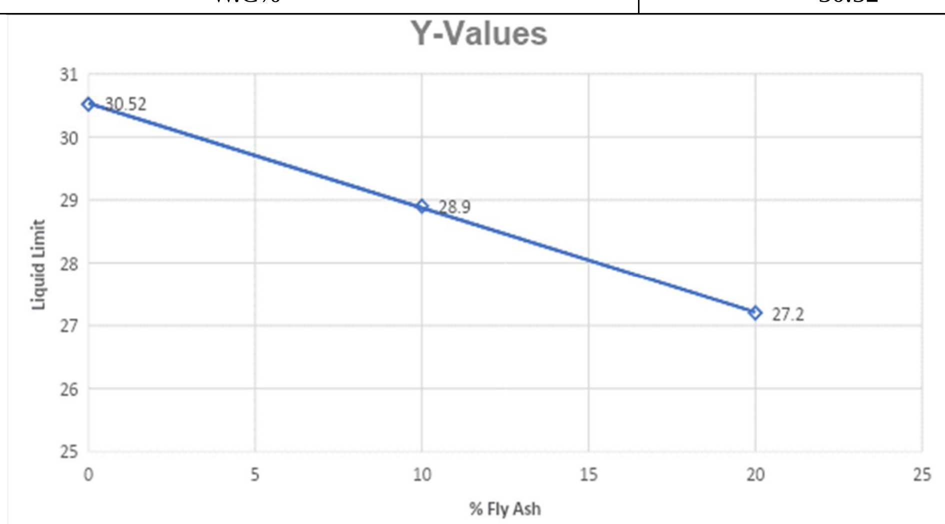
Sieves size (mm)	Mass retained (gms)	Soil mass preserved on a Cumulative basis in(gms)	% of soil preserved in total	Percentage of finer
4.75	219	21.9	21.9	78.1
2.0	40.2	40.2	62.1	37.9
0.85	282.5	28.25	90.35	9.65
0.425	76.5	7.65	98	2
0.15	11.5	1.15	99.15	0.85
0.07	3.0	0.3	99.45	0.55
PAN	5.5	0.55	100	0

B. Liquid Limit

The liquid limit is calculated for soil having different fly ash content. The following graph is drawn with liquid limit versus fly ash percentage. As fly ash percentage increases the liquid limit decreases.

TABLE V. Liquid Limit Table

No.of blows	25
Container no.	82
Wt of Container Wo	24.28
Weight of container+wet soil W1	40.41
Weight of container+Dry soil W2	36.43
W.C%	30.52



Graph 1 Variation of liquid Limit v/s Fly ash (%)

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C. Plastic Limit

The Plastic limit is calculated for soil having different fly ash content. The following graph is drawn with Plastic limit verses fly ash percentage. As fly ash percentage increases the Plastic limit decreases.

TABLE VI. Plastic Limit Table

Container no.	3
Weight of container Wo	26.10
Weight of container +Wet soil W1	32.29
Weight of container +Dry soil W2	31.20
W.C%	21.37

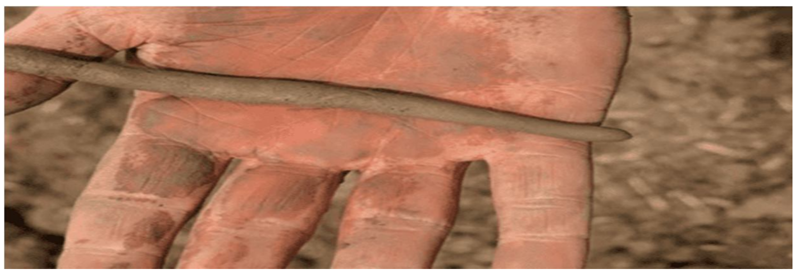
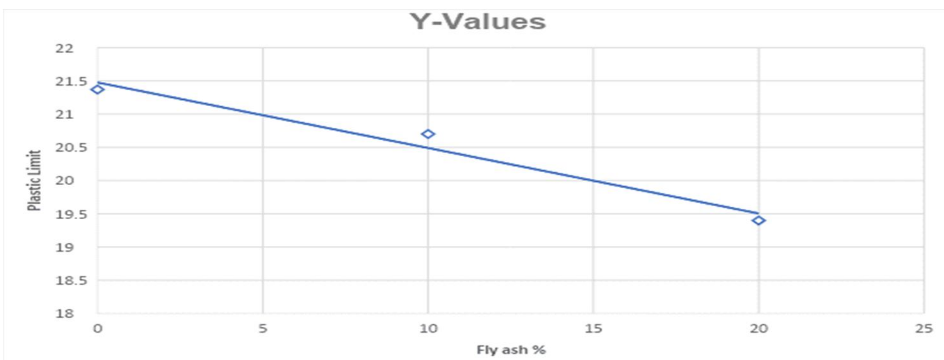


Fig.8 Plastic limit Soil Thread



Graph 2 Variation of Plastic Limt v/s fly Ash (%)

D. Direct Shear Test

TABLE VII. Normal soil+24% W. C

Load On Hanger(W) KG	2.832 kg	4.248 kg	5.664 kg
Normal Load on Soil Sample (N)Kg (W+W1)x 5+W2	18.655 kg	25.735 kg	32.815 Kg
Normal Stress	0.518 Kg/cm^2	0.715 Kg/cm^2	0.912 Kg/cm^2
Proving Ring at Failure(D)	8 x 11 = 88	8 x 13 =104	8 x 15 = 120
Shear 00force at Failure	19.36 kg	22.88 kg	26.4 Kg
Shear resistance	0.537 Kg/cm^2	0.635 Kg/cm^2	0.733 Kg/cm^2
Angle of shearing resistance	46.031^o	41.608^o	38.789^o

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E. UCS Test

TABLE VIII. For WC 15%

Sr.No	Description of material	Unconfined compressive strength(Kg/m^2)
1	Normal Soil	142
2	Mix Soil with 30% ash+ 1% Plastic	156

TABLE IX.For WC25%

Sr.No	Description of material	Unconfined compressive strength(Kg/m^2)
1	Normal Soil	155
2	Mix Soil with 30% ash+ 1% Plastic	189

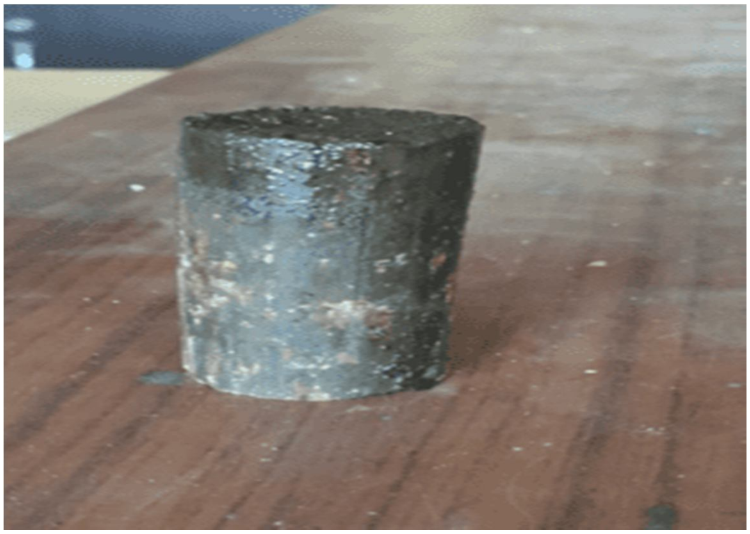

Figure 9 UCS specimen of Normal Soil

Table X. Normal Soil + Fly Ash + 25% W.C

Load On Hanger(W) KG	2.832 kg	4.248 kg	5.664 kg
Normal Load on Soil Sample (N)Kg (W+W1)x 5+W2	18.655 kg	25.735 kg	32.815 Kg
Normal Stress	0.518 Kg/cm^2	0.715 Kg/cm^2	0.912 Kg/cm^2
Proving Ring at Failure(D)	8 x 5 = 40	8 x6 =48	8 x 7 = 56
Shear force at Failure	8.8 kg	10.56 kg	12.32 Kg
Shear resistance at Failure	0.244 Kg/cm^2	0.293 Kg/cm^2	0.342 Kg/cm^2
Angle of shearing resistance	25.222^o	22.283^o	20.556^o

Figure 10 UCS specimen of Mix

F. *Standard Proctor Compaction Test*

Table XI. Improvement in MDD and OMC

Plastic dimension (mm)	Percent added	MDD (KN/m3)	OMC (%)
0	0	12.81	42
5x7.5	2	12.362	28.7
10x15	2	11.49	33.8
15x20	2	12.01	34.2

Sr.No	Observation	Sample 1	Sample 2	Sample 3
1	Mass of empty core cutter (W1	4036 gm	4036gm	4036gm
2	Mass of core cutter + soil (W2)	5348 gm	5859 gm	5091 gm
3	Density $\gamma = \frac{W2-W1}{v}$	1.312	1.813	1.055
4	Dry density $\gamma d = \frac{\gamma}{1-w}$	1.098	1.279	1.246

G. *Bearing Capacity of Soil*

Table XII. Bearing capacity of soil

Sample No	1	2	3	4	5	6	8	9	10	11	12	12	14	15	16
% of fly ash by weight	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42
% of plastic waste by weight	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bearing Capacity kN/m2	49.8	58.1	66.2	72.1	81.9	85.3	91.3	95.6	102.3	99.1	97	95.3	94.1	93.2	91.1

In the loading frame, we have filled soil in a box of size .5 x 0. 5 x 0.5 in three layers. Each layer is compacted to 60 Nmblows required to achieve maximum dry density at optimum moisture content. Then bearing capacity of the soil is calculated in the loading frame as per stander procedure. The test is reputed for the different combinations of fly ash and plastic waste. The different combinations are mentioned in Table 12 and the bearing capacity of each combination is calculated. It is observed that maximum bearing capacity is achieved for flay ash at 24 % and plastic waste at 8 %. There may be some more perpetual combinations to achieve the same.

V. CONCLUSION

1) The inclusion of fly ash and plastic to expensive soil increases bearing capacity of soil. The combination of 24 % of fly ash and 8% of plastic waste gives maximum bearing capacity.
2) The Atterberg limit is slightly influenced by the incorporation of fly ash (which is freely available). The liquid limit is reduced by roughly 25% when 15% fly ash ash is added. According to our observations, when 30 percent fly ash is applied, the liquid limit reduces by roughly 46 percent.
3) At 25% water content, the compressive strength increases by 22.88 percent.
4) Based on the aforementioned, waste material, and test results, it can be determined that raising soil shear strength while decreasing permeability improves soil stability. Compressive strength has also increased as a result of the use of fly ash and plastic.
5) It's also worth noting that when the amount of fly ash in the mixture grew, the ideal moisture content increased as well. f. Smaller strip size and content have seen a significant increase in UCS.

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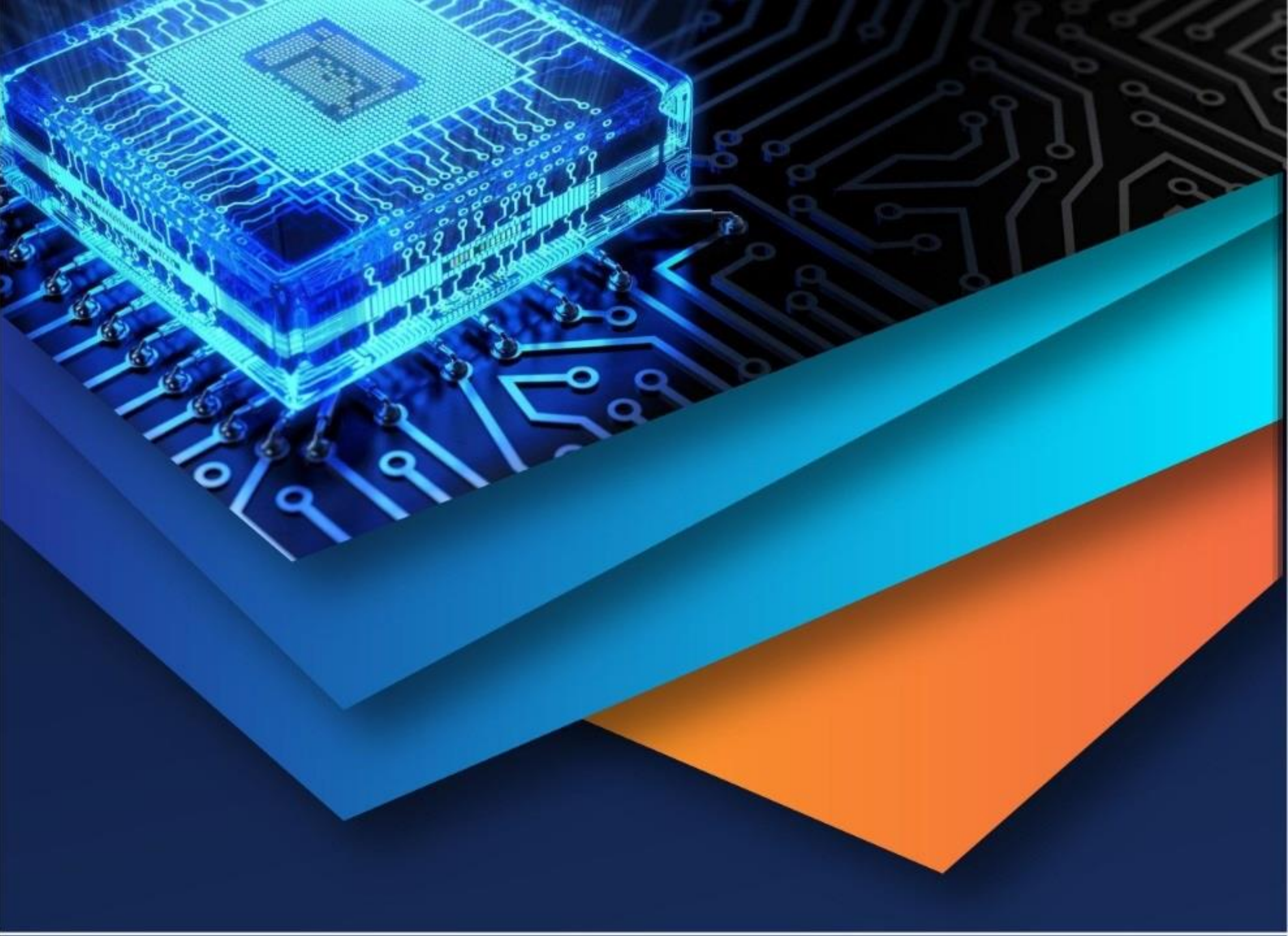

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