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Utilization of Waste Generted by Thermal Powerplant (Coal Bottom Ash) in a Building Consturction Material

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Abstract: Due to Utilizing natural resources and greenhouse gas emissions, the manufacturing of concrete has a substantial negative impact on the environment. Concrete manufacturing can have a positive environmental impact if Products made from industrial waste are part place of concrete or aggregates slag, silica fume, fly ash, and other industrial Waste materials are examples of waste materials that can be used in the making of concrete. The amount of garbage dumped in landfills and the carbon footprint connected with cement manufacture can both be decreased by using industrial waste during the making of concrete. However, qualities of the final concrete, such as setting, can also be impacted by the utilization of industrial waste in manufacturing. Before adding a specific waste material to concrete mixtures, careful thought must be given to how it will affect the concrete's qualities.

I. INTRODUCTION

A. Background Of Present Work

One of the most often utilized building materials worldwide is concrete. However, due to the usage of natural resources like sand, water, and cement, as well as the release of greenhouse gases during production, the making of concrete is linked to a substantial environmental impact. Researchers have been investigating using industrial waste materials as cement alternatives in some cases or aggregates to lessen the environmental impact of the manufacture of concrete. slag, silica fume, fly ash, and other waste material from industrial techniques are examples of these materials. The M25 concrete range's mixed design is produced in accordance with Indian Standard Code:10262-1982. A common partial replacement for cement is coal bottom ash. Even while adding coal bottom ash to concrete has several benefits, doing so significantly reduces the material's initial strength because it delays the thermal power plants' coal bottom ash flow, which results in coarse particles. To replace the CBA and produce the required concrete mix, the coarse particles are processed utilizing a ball mix grinder. the smoothest possible finish. We replaced 10% and 15% of the material in this project, respectively.

Therefore, the goal of this research is to assess concrete's strength and performance when it contains ground CBA that has been replaced some of the cement without the use of a super plasticizer. Before adding CBA to the concrete mix in this study's initial step, its physical and chemical qualities were assessed. The two types of concrete are then contrasted in terms of strength and durability.

II. LITERATURE REVIEW

1) Reviewing the role of coal bottom ash as an alternative of cement" by Navdeep Singh, Shehnazdeep, Anjani Bhardwaj

Coal bottom ash (CBA) is a coal industry by-product that is mostly produced by coal-fired thermal power plants. The use of CBA in concrete manufacturing offers a cost-effective and environmentally friendly disposal option. At the same time, its use conserves natural resources and promotes long-term sustainability. The use of CBA in place of Portland Cement (PC) in the manufacture of concrete is the subject of this review article. CBA's smaller particle size increases surface area, while its use as a partial substitute for PC feedback improves concrete's strength, durability, and microstructural characteristics. Until yet, there have been few research on the application of CBA in which various properties of concrete have been examined. Since the current region requires greater attention, most investigations have recommended using CBA as a partial substitute for PC, while just a few have advised against it. The current study examines the fresh, mechanical, and durability qualities, as well as the micro structural characteristics o concrete prepared using CBA. CBA has tremendous potential to be employed as a structure grade concrete replacement, according to the literature.

2) *Utilization of coal bottom ash in recycled concrete aggregates based self-compacting concrete blended with meta-kaolin" by Navdeep Singh, Mithulraj M, Shubham Arya*

The contemporary period's most pressing needs are the conservation of natural resources and the recycling of concrete industry waste. Alternative materials have been used extensively in the concrete manufacturing process for several decades. The purpose of this study is to determine the overall feasibility of Self Compacting Concrete (SCC) made with Coal Bottom Ash (CBA) and Recycled Coarse Concrete Aggregates (RCA) in place of Normal Fine Aggregates (NFA) and Normal Coarse Aggregates (NCA). Experimentally, the performance of SCC made from coal industry by-products [Coal bottom ash (FA), CBA) and building industry wastes (RCA) was assessed. SCC produced with varying concentrations of RCA and CBA was evaluated for various mechanical (compressive and tensile) and long-term (chloride permeability, capillary suction, accelerated carbonation, electrical resistivity, ultrasonic pulse velocity) properties. The analysis concludes that incorporating a consistent amount of CBA (10%) with varied content of RCA (up to 50%) has been proven to be beneficial for use in the construction sector, as enhanced/equivalent performance was reached when compared to control SCC With increased RCA concentration, there was significant heterogeneity in the outcomes of trials done on SCC mixtures. Metakaolin (MK) was designed to capture the observed loss in the behaviour of SCC generated with greater alternative levels (> 50% RCA) and CBA. The results demonstrated that include MK (along with other by-products) in SCC preparations results in comparable/par performance up to full alternative levels (100 percent) of NCA with RCA.

3) *"Study the Effect of Coal Bottom Ash and Limestone Dust as Partial Replacement of Sand and Cement" by Mahapara Abbas, Ravi Kumar, Dinesh Kumar*

The per capita use of cement has increased dramatically as a result of the massive growth in population. As a result, carbon dioxide levels have risen exponentially, causing severe pollution in the environment. Researchers throughout the world have taken the necessary steps to develop alternatives to cement in order to rescue the environment from escalating pollution. Coal bottom ash (CBA), a by-product of coal-fired thermal power plants, is utilised as a partial replacement for sand in this paper, while waste limestone dust [WLSD] is used as a partial replacement for cement in concrete. These two are the waste materials and their utilization in concrete proves economical as the cost of concrete will be less and dumping cost of these two materials is a problem of discussion therefore, the replacements are done at 0%, (10%, 5%), (20% 5%), (30%,5%), (40%, 5%),(60%, 5%), (80%, 5%) of sand and cement respectively at fixed water cement [W/C] ratio (0.45) and fixed slump ranges with mix (1:1.2.2.5). The result showed that at fixed W/C ratio the strength (compressive strength, Compressive strength, split tensile strength) and durability increased initially at small percentages of (10%, 5%), (20% 5%). (30%,5%) and later when the percentage of replacement is increased as (40%, 5%),(60%, 5%). and (80%, 5%) the strength and durability decreased.

III. MATERIALS USED

A. Cement

In this experimental work, UltraTech Ordinary Portland Cement (OPC) 53 grade was used. The cement was fresh and without any lumps.

B. Fine Aggregate

Natural river sand was used in experimental work without any organic impurities

C. Bottom Ash

Bottom ash used in this work was collected from Koradi super thermal power plant Nagpur.

Fig -1 Koradi Super Thermal Power Plant Nagpur

Table -1 Constituents of Bottom Ash

S. No	Name of Constituents	In % (mass/vol)
1.	Silica (Sio2)	48.71
2.	Aluminium Oxide (Al2O3)	29.23
3.	Titanium Oxide (TiO2)	1.88
4.	Iron Oxide (Fe2O3)	4.29
5.	Calcium Oxide (Cao)	7.44
6.	Magnesium Oxide (MgO)	1.70
7.	Sodium Oxide (Na2O)	1.16
8.	Potassium Oxide (K2O)	0.55
9.	Sulphur Trioxide (SO3)	3.96
10.	Phosphorous Oxide (P2O5)	0.22

D. Superplasticizer

The superplasticizer used in this work was Naphthalene Formaldehyde based superplasticizer. The admixture used was naphthalene-based, which improved the strength and workability. It was collected from the Vidarbha RMC Plant in Butibori.

Fig 2- Vidarbha RMC Plant in Butibori

Naphthalene formaldehyde-based superplasticizer is a chemical added to concrete and mortar to make them easier to mix and pour without adding extra water. It spreads out the cement particles, which helps the mixture flow better and reduces friction. This type of superplasticizer is helpful in making strong and long-lasting concrete, especially in precast structures. It allows the use of less water, which increases the strength. It is commonly used because it saves cost, works well with different cements, and greatly reduces water use.

E. Mix Proportion

In this study, the mortar was prepared using a mix ratio of 1:4, meaning one part cement to four parts fine aggregate.

Bottom ash was used to replace the fine aggregate in different amounts to study its effects on the mortar's properties. The replacement levels were 0%, 10%, 15%, 20%, and 25% by weight of the fine aggregate.

Each mix was tested to observe changes in workability, strength, and durability. By comparing these mixes, the aim was to find out the most suitable percentage of bottom ash that can be used without reducing the quality of the mortar. This approach also supports sustainability by reducing the use of natural sand and promoting the use of industrial waste.

Mortar ratio: 1:4 (cement: fine aggregate)

Bottom ash replaced fine aggregate at - 0 %, 10%, 15%, 20%, 25%.

Fig 3. Mortar cubes

Table 2: Quantities of material for different mixes for one cube

Mix	Cement (g/mm^3)	Fine Aggregate (g/mm^3)	Bottom Ash (g/mm^3)	Water (ml) (3% add for B.A)	Admix -ture (%)
M1 (0%)	200	800	0	120	0
M2 (10%)	200	720	80	144	1
M3 (15%)	200	680	120	156	1.5
M4 (20%)	200	640	160	168	1.5
M5 (25%)	200	600	200	180	2

IV. EXPERIMENTAL PROGRAM

A. Sieve Analysis

The sieve analysis was performed on bottom ash and sand. Sieve analysis was carried out on both bottom ash and natural sand to determine their particle size distribution.

This test helps to understand the grading and size range of the materials, which affects the workability and strength of the mortar. The results from the sieve analysis were used to compare the fineness of bottom ash with that of natural sand and to ensure the materials meet the requirements for use in mortar mixes. To perform the sieve analysis, samples were taken from the material. All the sieves were arranged in order from largest to smallest. The sample was placed on the top sieve and the stack was shaken about 25 times to help the material pass through the sieves. The material was collected on each sieve based on its size. Then, the material retained on each sieve was taken and its weight was measured.

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B. Water Content

To calculate the moisture content in sand by oven dry method. Take a container and weight it (W1). Take sample in container and weight it with container (W2). Then the sample are kept in oven for 24 hrs. at temperature 105 to 110* C. After 24 hrs. sample collect form oven then weight with container (W3).

To calculate:

weight of water =W2 – W3

Weight of sand= W3-W1

Water content w=W2-W3/W3-W1x100%

These all the calculation are given in following tables

Table no. 5- Water Content for Bottom Ash

Sr. no.	Description	Determination No.		
		I.	II.	III.
1.	Weight of empty container (W1) in g	22.5	22.3	22.5
2.	Weight of container + wet sand (W2) in g	36.4	33.6	37.2
3.	Weight of container + dry sand (W3) in g	35.1	32.7	35.8

Calculation:

1.	Weight of water =W2-W3	1.3	0.9	1.4
2.	Weight of sand = W3-W1	12.6	10.4	13.3
3.	Water content w=W2-W3/W3-W1 X 100%	10.31	8.65	10.52
	Average value	= 9.82%		

Table no. 6- water content for sand

Sr. no.	Description	Determination No.		
		I.	II.	III.
1.	Weight of empty container (W1) in g	22.5	22.3	22.5
2.	Weight of container + wet sand (W2) in g	34.6	32.4	36.4
3.	Weight of container + dry sand (W3) in g	33.0	31.3	34.6

Calculation:

1.	Weight of water =W2-W3	1.6	1.1	1.8
2.	Weight of sand =W3-W1	10.5	8.8	2.1
3.	Weight container w=W2-W3/W3-W1 X 100%	15.2	12.5	14.9
	Average value	= 14.2%		

sample-1000 gm.	Sieve analysis for Fine Aggregate				Remark As per IS 383-2016		
IS sieve size(mm)	Weight Retained in gm.	Cumulative weight retained in gm.	Cumulative % weight retained	Cumulative % weight Passing	Zone -II	Zone - III	Zone -IV
10	0	0	0	100	100	100	100
4.75	33.8	33.8	3.45	96.55	90-100	90-100	95-100
2.36	118.7	152.5	15.57	84.43	75-100	85-100	95-100
1.18	206.1	358.6	36.62	63.38	55-90	75-100	90-100
0.6	255.9	614.5	62.76	37.24	35-59	60-79	80-100
0.3	230.8	845.3	86.33	13.67	8-30	12-40	15-50
0.15	81.2	926.5	94.62	5.38	0-10	0-10	0-15
PAN	52.6	979.1	100	0			
	979.1		299.35	F.M.= $\frac{\text{Cumulative \% weight retained}}{100}$ Fineness modulus is 2.99			

V. TEST ON MORTAR CUBE

Various tests were performed on the mortar cube.

A. *Water Absorption Test*

A water absorption test was done on mortar cubes made with cement, fine aggregate, and bottom ash. The test helps to measure how much water the mortar can absorb, which also gives an idea of its porosity. Mortar cube specimens of size 70.6 mm × 70.6 mm × 70.6 mm were first dried in an oven at 65°C for 24 hours. After drying, the samples were cooled at room temperature for 12 hours. Then, they were fully soaked in water for 6 hours. After soaking, the specimens were taken out, surface dried, and weighed using a digital balance accurate to 0.1 mg. The porosity was determined by how much water the specimen absorbed.

The percentage of water absorbed was calculated using the following formula:

Water Absorption (%) = [(wet weight - dry weight)/ dry weight] x 100

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B. Sorptivity Test

Sorptivity is the rate at which a uniform material absorbs water through capillary action. To test this, mortar specimens of size 70.6 mm × 70.6 mm × 70.6 mm were used. After the required curing period, the specimens were dried in an oven at 65°C for 24 hours. Then, they were cooled at room temperature for 12 hours and weighed using a digital balance accurate to 0.1 mg.

For the sorptivity test, each specimen was placed in a setup where only the bottom part was in contact with water — with the water level kept no more than 5 mm above the base. The sides of the specimen were coated with a non-absorbent layer to prevent water from entering from the sides. The specimen was left in this position for 60 minutes, then taken out, surface dried, and weighed again to measure how much water it absorbed.

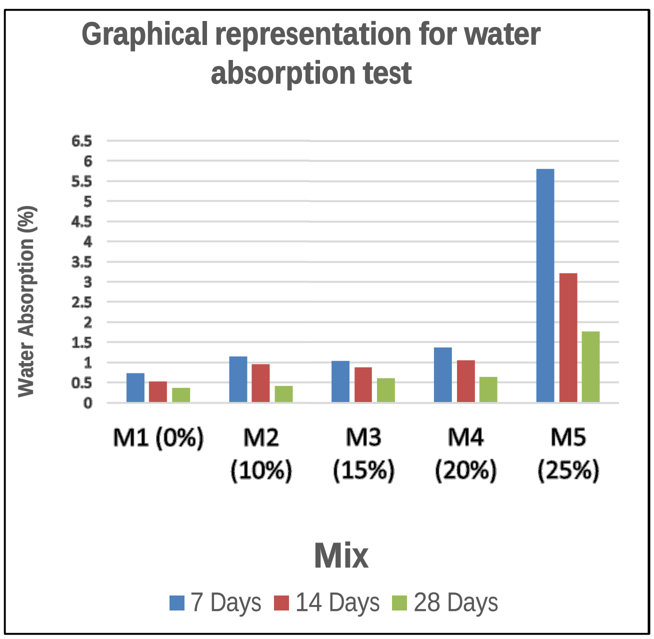
C. Compressive Strength

To find the compressive strength of a mortar cube, the cube is first made and cured (kept in water) for a specific number of days, usually 7 or 28 days. After curing, the cube is taken out, surface dried, and placed in a compression testing machine. The machine then applies pressure slowly from the top until the cube breaks. The maximum load the cube can handle before breaking is noted. This value is divided by the surface area of the cube to get the compressive strength. It tells us how much pressure the mortar can bear before failing.

VI. RESULTS

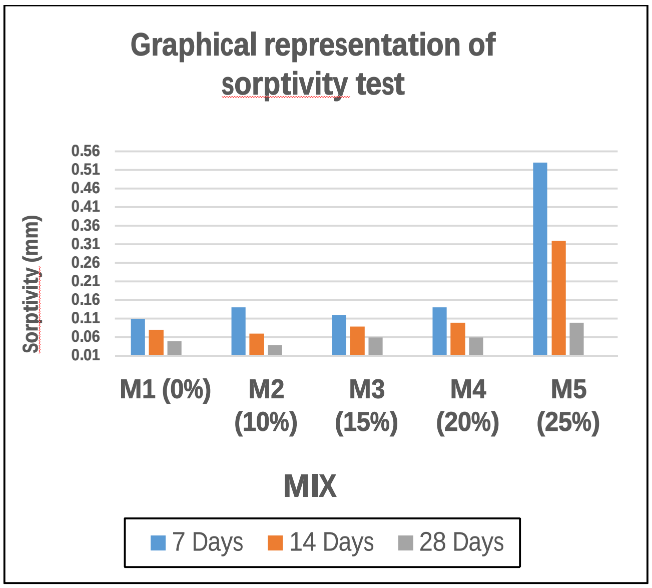
A. Water Absorption Test

Mix	% Water Absorption		
	7 Days	14 Days	28 Days
M1 (0%)	0.73	0.52	0.37
M2 (10%)	1.14	0.95	0.41
M3 (15%)	1.04	0.88	0.61
M4 (20%)	1.37	1.05	0.64
M5 (25%)	5.81	3.22	1.17



B. *Sorptivity Test*

Mix	Sorptivity (mm)		
	7 Days	14 Days	28 Days
M1 (0%)	0.11	0.08	0.05
M2 (10%)	0.14	0.07	0.04
M3 (15%)	0.12	0.09	0.06
M4 (20%)	0.14	0.10	0.06
M5 (25%)	0.53	0.32	0.10



C. *Compressive strength*

Mix	Compressive Strength (Mpa)		
	7 Days	14 Days	28 Days
M1 (0%)	18.5	23.8	26.5
M2 (10%)	20.1	24.5	28.0
M3 (15%)	20.4	25.0	27.8
M4 (20%)	19.0	23.5	26.0
M5 (25%)	17.8	22.0	24.5

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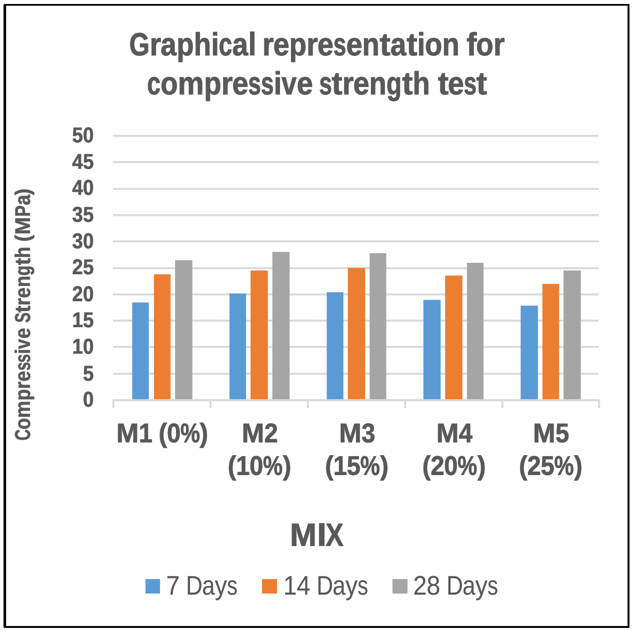

VII. CONCLUSION

1) Bottom ash is a waste material from coal-fired power plants. It is often thrown away in landfills, which harms the environment. This study explored how bottom ash can be used to replace natural sand in mortar mixes. The goal was to reduce waste and save natural resources.
2) Tests were done by replacing fine aggregate (sand) with bottom ash in different amounts: 0%, 10%, 15%, 20%, and 25%. The mortar cubes were tested for strength, workability, water absorption, and durability. The results showed that bottom ash can be safely used up to 15% without reducing the quality of the mortar.
3) When 10–15% of fine aggregate was replaced with bottom ash, the mortar still had good strength and performance. It was almost the same as the control mix with 0% bottom ash. This means bottom ash can work well in construction without affecting the final product too much.
4) The compressive strength of mortar decreased slightly when more than 15% bottom ash was used. However, at 10–15% replacement, the strength remained within acceptable limits. This shows that using a small to moderate amount of bottom ash is a safe and effective option.
5) The water absorption and sorptivity results also supported this finding. Mortars with up to 15% bottom ash had acceptable levels of water absorption. This means they are durable and can resist moisture well, which is important in construction.
6) Using bottom ash in mortar mixes helps in two ways. First, it reduces the need for natural sand. Natural sand is
7) becoming harder to find and its mining is causing damage to rivers and land. Second, it helps manage the waste produced by coal plants. Instead of dumping bottom ash, it can be reused in a useful way.
8) This method also saves cost. Bottom ash is cheaper than natural sand, so using it in mortar can reduce the overall cost of building materials. This makes it a good option for large-scale construction, especially in areas where natural sand is expensive or not easily available.
9) Future research can focus on improving the performance of mortar with higher levels of bottom ash. Also, combining bottom ash with other materials like fly ash or silica fume might give even better results.
10) In conclusion, bottom ash is a promising material for sustainable construction. It is cost-effective, eco-friendly, and performs well in mortar mixes. Using it helps reduce waste, protect natural resources, and promote greener building practices. It is a step towards cleaner and more responsible construction for the future.

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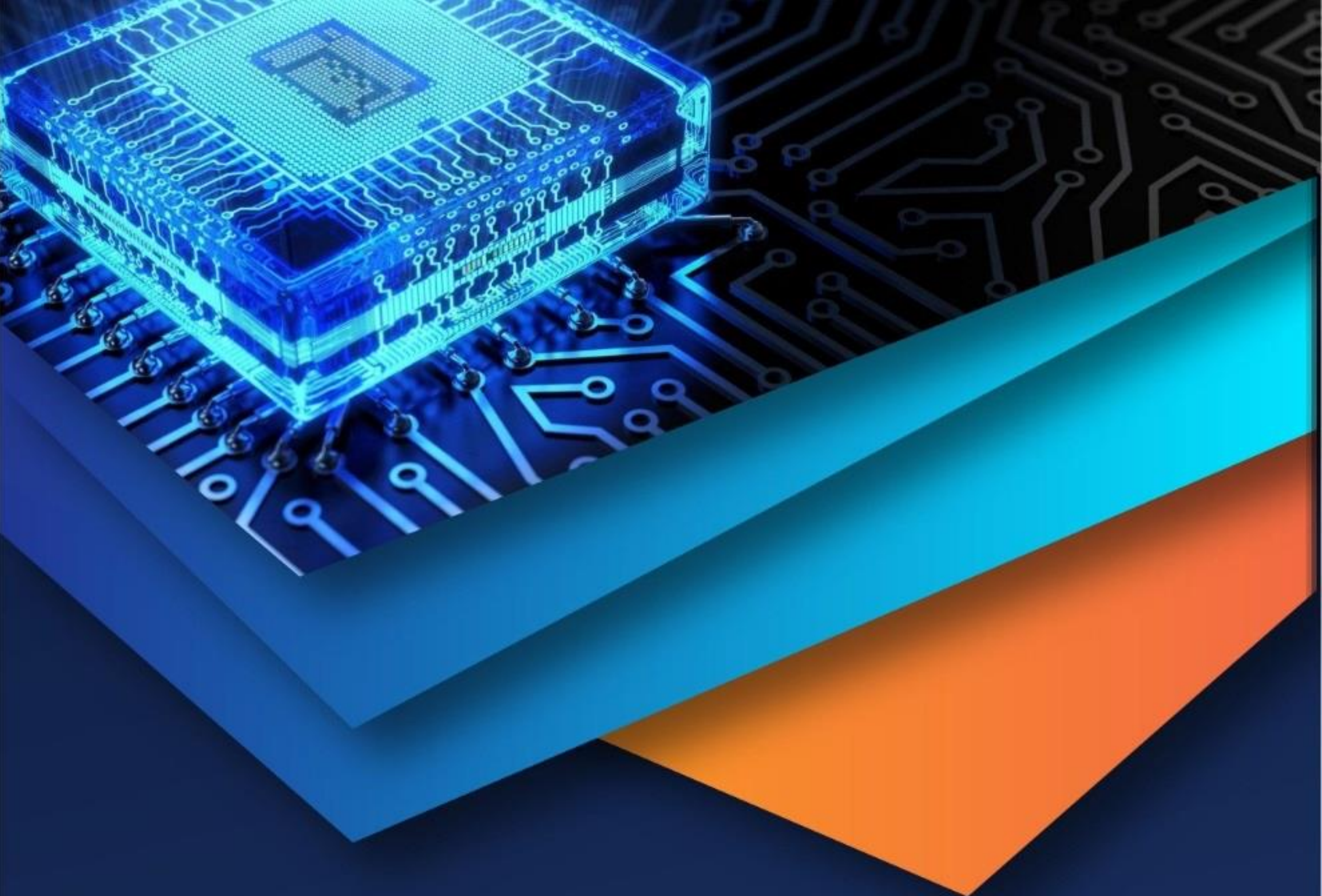

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