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Experimental Comparative Study by using Nano $CaCo_3$ and Nano Fe_2O_3 in Fly Ash containing Concrete

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Abstract: ***The application of nano material in concrete has added a new dimension to the efforts to improve its properties. Nano materials by virtue of their very small particles size can affect the concrete properties by altering the microstructure. In these study i completed a work of literature review. In the literature review I study a various nano materials used in the concrete and its effects on the properties of concrete. there are a various nano materials used in the concrete such as nano SiO_2,nano Fe_3O_4, nano $CaCo_3$, nano ZrO_2,nano CuO, nano Fe_2O_3,nano TiO_2 , nano ZnO_2, nano Al_2O_3 etc. By reffered a various research paper I decided that a in these study i note down that a nano $CaCo_3$ are improved a concrete compressive strength and durability properties and nano Fe_2O_3 are improve in such case flexural strength and in such a case improve the compressive strength and the durability properties. So, I Perform the experimental work to uses a nano $CaCo_3$ and nano Fe_2O_3 material replacement by the cement. Also replacement of the fly ash by the cement. Find out the compressive strength of different proportion of nano $CaCo_3$ and nano Fe_2O_3 and fly ash .Finally decided a optimum percentage is 1 % both nano $CaCo_3$ and nano Fe_2O_3 and 30 % fly ash. We concluded that the maximum compressive strength are occure at the 1 % $CaCo_3$ and 30 % fly ash. The compressive strength is 40.25 MPa at 28 days. the maximum compressive strength are occure at the 1 % Fe_2O_3 and 25 % fly ash. The compressive strength is 40.25 MPa at 28 days. For check out the tirtary effect of the fly ash, nano Fe_2O_3 and nano $CaCo_3$ the optimum % of nano Fe_2O_3 and nano $CaCo_3$ are taken as 1% and fly ash is 30%.In the optimum specimen the strength of the optimum specimen is 38.84 MPa at 28 Days and the compressive strength of normal concrete is 32.15 MPa at 28 days. The flexural strength and the splite tensile strength are good with compared to the normal concrete. There are no carbonation effect on the concrete. to provide a durable concrete in these study.***

Keywords: ***Concrete, nano material, compressive strength , durability properties, flexural strength, splite tensile strength, carbonation***

I. INTRODUCTION

A Concrete structure are usually exposed environmental conditions. Such as that involving chlorides, which may impact the mechanical and durability properties of the reinforced concrete structure through rebar corrosion. A strong and durable concrete can be produced by improving the behaviour of cement mortar. Various mineral additives such as fly ash and silica fume have been traditionally utilise composites not only for their environmental and economic advantages, but also for their technical benefits such as the ability to fill in micro and macro voids and displaying partial binder effect. The fly ash is used in concrete industries to reduced the amount of cement and to enhance durability and mechanical properties of concrete. Many of the available studies have focused on the uses of different types of nano materials such as nano SiO_2,nano Fe_3O_4, nano $CaCo_3$, nano ZrO_2,nano CuO, nano Fe_2O_3,nano TiO_2 , nano ZnO_2, nano Al_2O_3 etc Are effect on the properties of hardened cement paste, cement mortar and/ or concrete. Results of this study showed that nano particles can be very effective in improvement of both mechanical properties and durability of concrete.

Nano materials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area . Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved . Only a small percentage of cement can be replaced to achieve the desired results. These nano materials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure.

By using a nano materials in concrete the surface area of the nano material are high so improve the mechanical properties of the concrete. The different nano materials are different durability properties so to improve the durability properties of the concrete. Different Nano materials use in concrete are Nano-SiO_2,Nano-Fe_2O_3,Nano-ZrO_2,Nano-TiO_2,NanoAl_2O_3,Nano carbon tube, Nano ZnO_2,Nano CuO, Nano Fe_3O_4,Nano $CaCo_3$ etc….

The use of fly ash as partial replacement of cement in concrete is a common practice for many decades. During 2010–2012, the utilization of fly ash for construction application has achieved approximately 55% and become a commercial product which is the utilization of high volume fly ash in concrete addresses the challenges of sustainable construction. Chemically, fly ash has pozzolainic activity which is attributed to the presence of SiO_2 and Al_2O_3. It reacts with calcium hydroxide (C-H) during cement hydration, to form additional calcium silicate hydrate(C-S-H) and calcium alluminate hydrate (C-A-H) which are effective in forming denser matrix leading to higher strength and better durability.

II. MIX PROPORTION OF CONCRETE

A. The Concrete Mix Design Of M 25 is Done.

For a batch of 6 cubes of 150mm size, the volume of concrete required = $(0.15)3\times6\times1.2 = 0.024m^3$ (taking into account 20 % extra for losses) .

Cement required = 0.024x433 = 10.40 kg

Fine aggregate required = 0.024x614 = 14.73kg

Coarse aggregate required = 0.024x1192 = 26.60 kg

Water required = 0.024x186 =4.46 L

III. MATERIAL PROPERTIES

A. Fly Ash

The use of fly ash as partial replacement of cement in concrete is a common practice for many decades. During 2010–2012, the utilization of fly ash for construction application has achieved approximately 55% and become a commercial product which is the utilization of high volume fly ash in concrete addresses the challenges of sustainable construction. Chemically, fly ash has pozzolainic activity which is attributed to the presence of SiO_2 and Al_2O_3. It reacts with calcium hydroxide (C-H) during cement hydration, to form additional calcium silicate hydrate(C-S-H) and calcium alluminate hydrate (C-A-H) which are effective in forming denser matrix leading to higher strength and better durability.

TABLE.1 .Properties of Fly Ash

Chemical Analysis	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	K_2O	Na_2O	TiO_2	SO_3
Content (%)	51.80	26.40	13.20	1.61	1.17	0.10	0.68	0.31	1.44	0.21
Physical Properties	Particle Size	Specific Gravity	Los on Ignition(%)	-	-	-	-	-	-	-
Content (%)	40% of 10µm	2.6	0.5	-	-	-	-	-	-	-

B. Nano Materials

Nano materials are very small sized materials with particle size in nanometres.These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area . Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved . Only a small percentage of cement can be replaced to achieve the desired results. These nanomaterials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure .In these study I uses a nano $CaCo_3$ And Nano Fe_2O_3..

TABLE.2 Properties of nano material

Sr. No.	Parameters	Nano CaCo3 Properties	Nano Fe_2O_3 Properties
1	Physical state and appearance	Fine White Powder	Brown powder
2	Molecular Weight	100 g/mol	155 g/mol
3	Color	White	Brown
4	Average Particle Size	80 nm	20-50 nm
5	Surface area	20-40 m^2/gm	142 m2/gm
6	Bulk density(g/cm^3)	0.68	0.25
7	PH	8.5-9.5	-
8	Purity	98%	99.9%

C. Cement

The cement used in all mixtures is commercially available ordinary Portland cement of 53 grade confirming to IS : 12269-2013 is used in preparing a concrete specimen . Cement is a fine and genies grey powder. Cement is mixed with water and material such as sand ,aggregate to make concrete.

TABLE.3 Properties of 53 Grade cement

Chemical Requirements	Test Result	Requirement of IS:12269-2013
Fineness (m^2/gm)	311	225(Min.)
Standard Consistency(%)	30	
Setting Time(minutes)		
Initial	185	30 (Min.)
Final	290	600 (Max.)
Soundness		
Le-Chat Expansion(mm)	0.7	10 (Max.)
Autoclave Expansion(%)	0.052	0.8 (Max.)
Compressive Strength(MPa)		
3 days	38	27 (Min.)
7 days	50	37 (Min.)
28 days	66	53 (Min.)
Limestone(%)	4.9	5 (Max.)

D. Fine And Coarse Aggregate

Sand as fine aggregates are collected from locally available river SARASVATI and the sieve analysis of the samples are done. It is found that the sand collected is conforming to IS: 383-1970. For coarse aggregate, the parent concrete is crushed through mini jaw crusher. During crushing it is tried to maintain to produce the maximum size of aggregate in between 20mm to 4.75mm.

TABLE.4 Properties of Fine and Coarse Aggregates.

Properties	Coarse Aggregate	Fine Aggregate
Specifit Gravity	2.71	2.56
Bulk Density(kg/L)	1.40	-
Loose Bulk Density(kg/L)	1.25	-
Water Absorption(%)	4.46	0.065
Impact Value	26.91	-
Crushing Value	26.51	-
Fineness Modulus	3.38	3.13

E. Water

The water used in the manufacturing of concrete is portable water. water is needed for hydration of cement and molding of concrete to the desired shape. The relationship between compressive strength and water to cement ratio is well established. An increase in water to cement ratio leads to a reduction in compressive strength.

IV. EXPERIMENTAL RESULTS

A. Compressive Strength Test

The cube specimen size of 150mm×150mm×150mm are casted..The cube are casted for the results of 7 and 28 days. following are the cube ID for the compressive strength test of the different proportion of the fly ash, nano $CaCo_3$ And Nano Fe_2O_3.The C_0 Specimen is a control specimen.

TABLE.5 Cube ID of different cube specimen

CUBE ID	C_0	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}
FLY ASH (%)	0	25	25	25	30	30	30	35	35	35	25	25	25	30	30	30	35	35	35
Fe_2O_3 (%)	0	0.5	1	1.5	0.5	1	1.5	0.5	1	1.5	0	0	0	0	0	0	0	0	0
$CaCo_3$ (%)	0	0	0	0	0	0	0	0	0	0	0.5	1	2	0.5	1	2	0.5	1	2

1) compressive Strength Test Result of fly Ash And Nano fe $_2o_3$ Containing Concrete Cubes.

TABLE.6 Compressive Strength of Concrete with Fly Ash and Nnano Fe $_2O_3$

CUBE ID	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Compressive Strength (MPa)7 days	26.10	28.15	26.25	22.15	23.26	22.15	20.15	21.80	22.64
Compressive Strength (MPa) 28 days	34.70	39.70	35.26	32.42	37.46	35.70	30.20	34.25	31.40

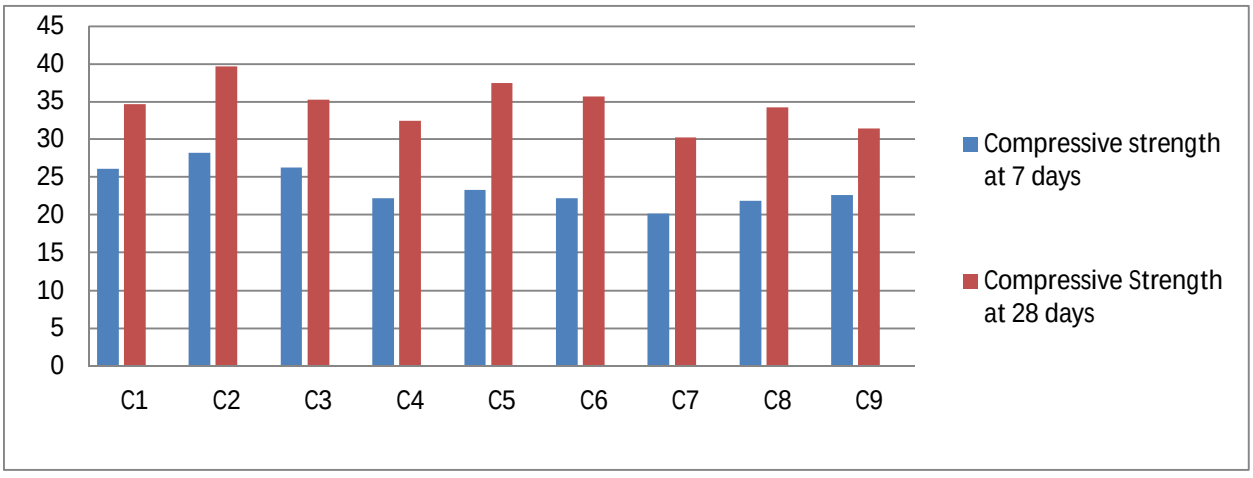

Fig.1 Compressive strength of concrete with fly ash and nano Fe $_2O_3$

2) Compressive Strength Test Result of fly Ash And Nano $Caco_3$ Containing Concrete Cubes.

TABLE.7 Compressive strength of concrete with fly ash and nano $CaCo_3$

CUBE ID	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}
7 days Compressive Strength (MPa)	23.75	26.18	22.12	21.15	30.42	20.24	19.80	22.65	22.90
28 days Compressive Strength (Mpa)	36.15	39.15	34.20	34.65	40.25	32.10	31.20	37.25	32.10

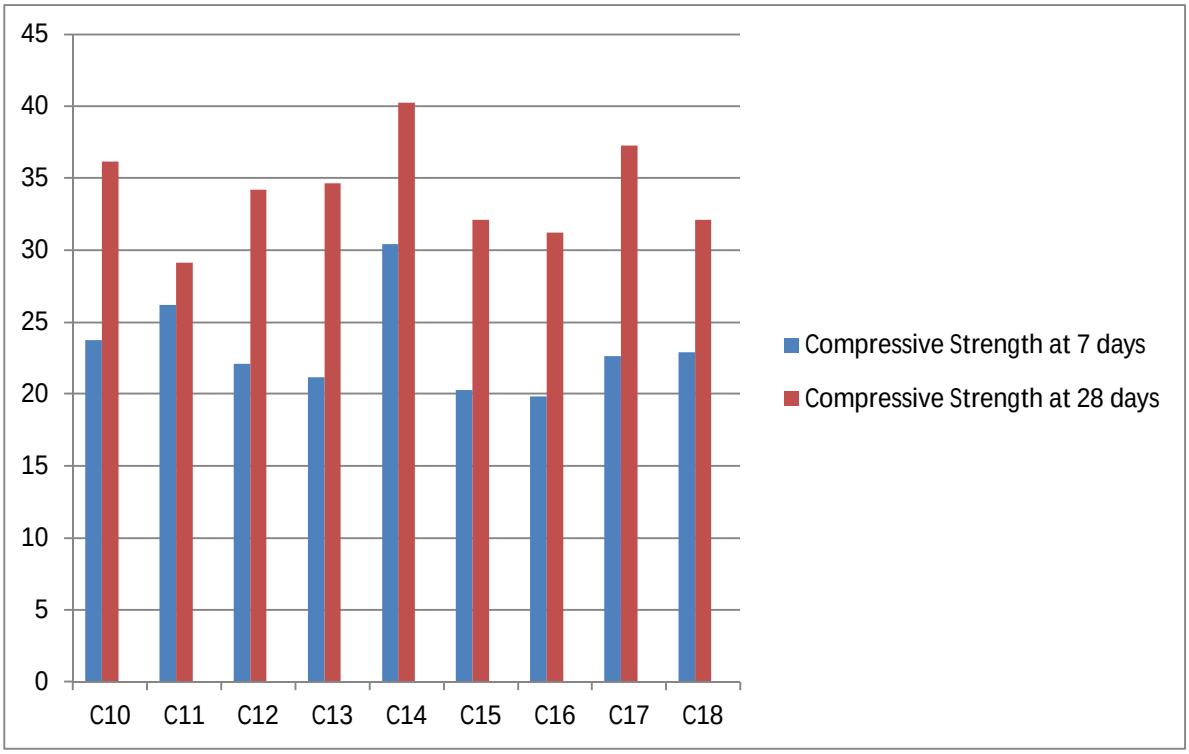

Fig. 2 Compressive strength of concrete with fly ash and nano $CaCo_3$

3) Compressive Strength Test Result of Fly ash And Both Nano $Caco_3$ and Nano fe_2o_3 Containing Concrete Cubes.

The Optimum % of fly ash is decided as 30 % and Nano Fe_2O_3 and $CaCo_3$ are 1 %.The cube ID of the optimum % contained cube is O_1.The cube ID of the control specimen is C_0.The optimum specimen and control specimen results are given below.

TABLE.8 Compressive Strength of Control Specimen and Concrete Specimen with Fly Ash, Nano Fe_2O_3 and $CaCo_3$

CUBE ID	C_0(Control specimen)	O_1 (optimum specimen)
7 days Compressive Strength (MPa)	19.85	22.34
28 days Compressive Strength (MPa)	32.15	38.84

B. Flexural Strength Test Results

In the flexural strength test the 150mm×150mm×700mm size beam (when size of aggregate is less than 38mm)or 100mm×100mm×500mm size beam (when size of aggregate is less than 19mm) specimen are used. The bed of the flexural test machine shall be provided with tow steel rollers,38 mm in diameter, on which the specimen is to be supported ,and these rollers shall be so mounted that the distance from center to center is 60 cm for 15 cm specimens or 40 cm for 10 cm specimens. The load shall be applied at a rate of loading of 400 kg/min for the 15 cm specimen and at a rate of 180 kg/min for the 10 cm specimen.

TABLE.9 Flexural Strength of Control Specimen and Concrete Specimen with Fly Ash, Nano Fe_2O_3 and $CaCo_3$

BEAM ID	B_0(Control specimen)	B_1 (optimum specimen)
7 days Flexural Strength (MPa)	6.30	6.92
28 days Flexural Strength (MPa)	8.04	8.42

C. Splite Tensile Strength Test Results

Splitting tensile strength test on concrete cylinder size 150mm Dia.×300mm Height is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile force. . Apply the load continuously without shock at a rate of approximately 14-21 kg/cm^2 per minute(which corresponds to a total load of 9900kg/minute to 14850 kg/minute) .Note down the breaking point.

TABLE.10 Splite Tensile Strength of Control Specimen and Concrete Specimen with Fly Ash, Nano Fe_2O_3 and $CaCo_3$

CYLINDER ID	CY_0(Control specimen)	CY_1 (optimum specimen)
7 days Spite Tensile Strength (MPa)	2.1	2.32
28 days Spite Tensile Strength (MPa)	2.68	2.81

D. Durability Test Results

1) Chloride Resistance Test : Cubes of 150mm×150mm×150mm dimension were casting and have cured for 28 days. After 28 days curing cubes were taken out and allowed for drying for 24 hours and weight were taken. For chloride attack test 5% dilute NaCl is used. The cubes were to be immersed in solution for a period of 56days. The concentration is to be maintained throughout this period. After 30 days the specimens were taken from acid solution. The surface of specimen has cleaned and weights were measured. The specimen was tested in the compression testing machine under a uniform rate of loading 140 kg/cm^2 as per IS 516.The loss of mass and loss of strength of specimen due to chloride attack was determined..

TABLE.11 NaCl Solution for 56 days

Concrete specimen	Loss of weight in %	Loss of Comp. Strength in %
Control specimen	1.98	2.61
Optimum specimen	1.95	2.54

2) Carbonation Test: In the carbonation test the concrete cube are casted and after 90 days to sprayed a phenolphthalein solution on the cube and to see the color of the cube. when the color are changed a pink color so the carbonation are not occur, and when the color are not changed then the carbonation are ocured.In these experiment the color of concrete are changed and pink color are occurred so the carbonation effect are not in the concrete.

V. CONCLUSION

In this study the effect of nano Fe_2O_3 and fly ash are study and the effect of nano $CaCo_3$ and the fly ash are study. According to these study to determined the optimum % of fly ash, nano $CaCo_3$, nano Fe_2O_3 .and to determined the tertiary effect of fly ash, nano $CaCo_3$, and nano Fe_2O_3 on the concrete and to compare the normal concrete**.**

A. We concluded that the maximum compressive strength are occure at the 1 % $CaCo_3$ and 30 % fly ash. The compressive strength is 40.25 MPa at 28 days.

B. We concluded that the maximum compressive strength are occure at the 1 % Fe_2O_3 and 25 % fly ash. The compressive strength is 40.25 MPa at 28 days.

C. For check out the tertiary effect of the fly ash, nano Fe_2O_3 and nano $CaCo_3$ the optimum % of nano Fe_2O_3 and nano $CaCo_3$ are taken as 1% and fly ash is 30%.In the optimum specimen the strength of the optimum specimen is 38.84 MPa at 28 Days and the compressive strength of normal concrete is 32.15 MPa at 28 days.

D. The flexural strength and the split tensile strength are good with compared to the normal concrete.

E. There is no carbonation effect on the concrete. to provide a durable concrete in these study**.**

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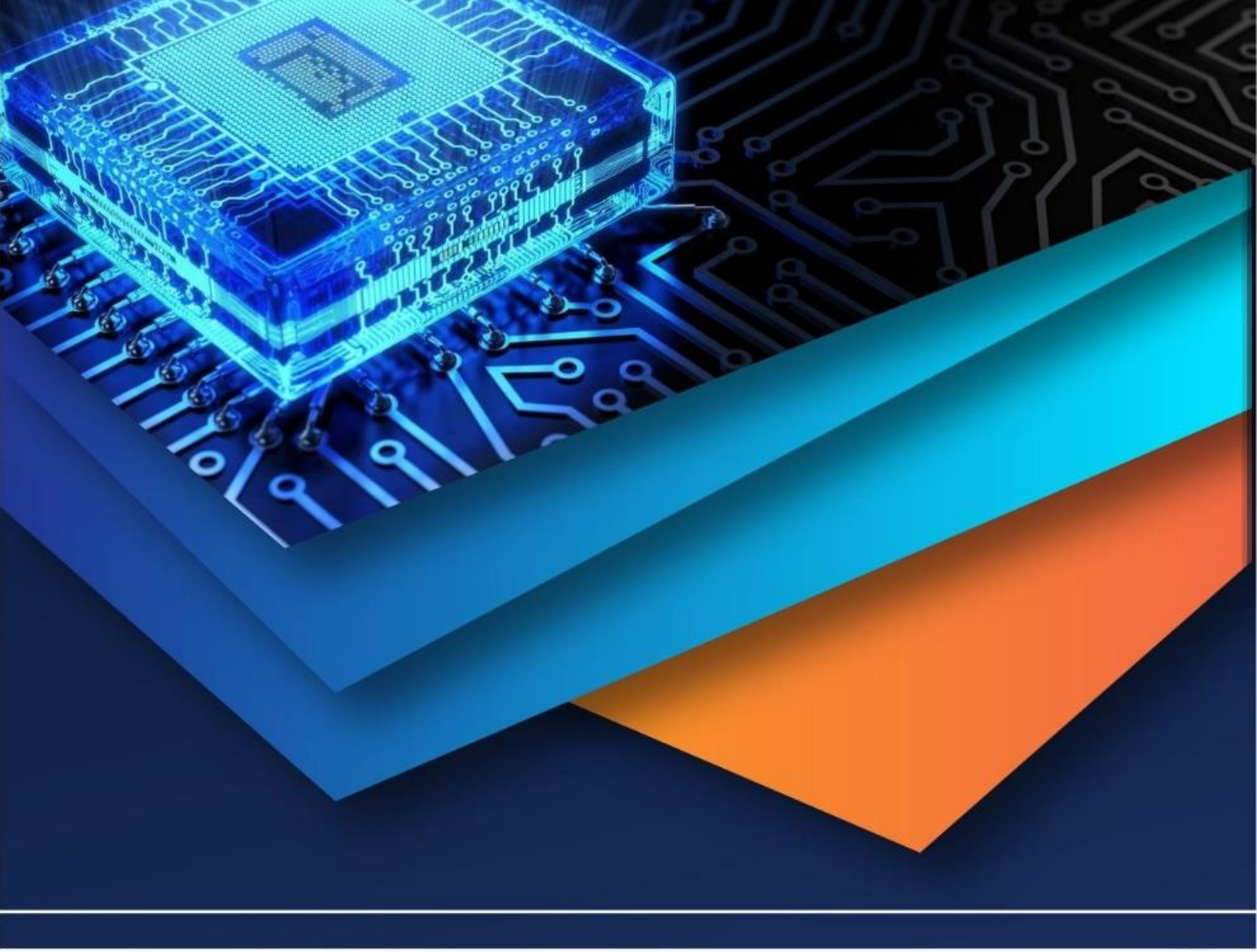

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