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Experimental Study on Workability, Strength & Durability of Geopolymer Concrete with use of Fly ash, Ground Granulated Blast Furnace Slag & Silica Fume

Jeet Vagadiya[1], Prof. Kishan Vekariya[2]
Department of Civil Engineering, Noble Group of Institution, Junagadh

Abstract: Geopolymer concrete, crafted from a blend of Fly Ash, GGBS, and Silica Fume activated by sodium silicate and sodium hydroxide, demonstrates excellent workability and strength over time.
It proves resilient against acid, chloride, water absorption, and carbonation, making it a sustainable choice for construction projects seeking durability and performance. These qualities position geopolymer concrete as a promising alternative to traditional concrete methods.
Keywords: Geopolymer Concrete, Silica fume, Fly ash, GGBS, Workability, Strength, Durability

I. INTRODUCTION

The construction industry's reliance on ordinary Portland cement (OPC) contributes significantly to global carbon dioxide (CO2) emissions, prompting a search for more sustainable alternatives. Geopolymer, derived from alkaline solutions reacting with aluminosilicate-rich waste materials, presents a promising solution.

Unlike OPC, geopolymerization occurs at room temperature, reducing energy consumption and emissions. Geopolymer concrete exhibits superior strength and durability, with the potential to reduce CO2 emissions by 10-30% compared to OPC. This innovative material offers benefits such as efficient waste management and enhanced concrete performance, positioning it to revolutionize construction practices toward a more sustainable future

II. . NEED OF STUDY

To investigate the feasibility and effectiveness of using a combination of fly ash, ground granulated blast furnace slag (GGBS), and silica fume as the sole binder in geopolymer concrete, focusing on its workability, strength, and durability.

III. OBJECTIVE OF STUDY

1) To determine the optimal proportions of fly ash, GGBS, and silica fume in the geopolymer concrete mix to achieve desired workability without the use of traditional cement.
2) To evaluate the compressive strength, splitting tensile strength, and flexural strength of geopolymer concrete at different curing ages.
3) To assess the durability of geopolymer concrete by evaluating its resistance to water absorption, chloride ion penetration, and sulfate attack.
4) To compare the environmental impact of geopolymer concrete with Portland cement concrete in terms of CO2 emissions and energy consumption, focusing on the reduced carbon footprint by eliminating traditional cement.
5) To develop a cost-effective and sustainable mix design for geopolymer concrete utilizing only industrial by-products as the binder

IV. PROPOSED MIX PROPORTION

1) The given value is shown in Percentage (%)

Mix No.	GGBS	Fly Ash	Silica Fume
1	100	0	0
2	90	10	0
3	80	20	0
4	70	30	0
5	60	40	0
6	50	50	0
7	85	10	5
8	75	20	5
9	65	30	5
10	55	40	5
11	45	50	5
12	80	10	10
13	70	20	10
14	60	30	10
15	50	40	10
16	40	50	10

2) The given value of Mix Proportion of M30 Geopolymer Concrete by Weight

Mix No.	GGBS	FLYASH	SILICA FUME	Sodium Hydroxide	Sodium Silicate	Coarse Aggregate	Fine Aggregate	Water	Super Plasticizer
1	438.13	-	-	50.072	125.18	983.77	556.76	104.93	4.38
2	394.32	43.81	-	50.072	125.18	975.44	552.04	104.93	4.38
3	350.51	87.63	-	50.072	125.18	967.11	547.33	104.93	4.38
4	306.69	131.44	-	50.072	125.18	958.78	542.62	104.93	4.38
5	262.88	175.25	-	50.072	125.18	950.45	537.9	104.93	4.38
6	219.07	219.07	-	50.072	125.18	942.12	533.19	104.93	4.38
7	372.41	43.81	21.91	50.072	125.18	971.27	549.69	104.93	4.38
8	328.6	87.63	21.91	50.072	125.18	962.95	544.97	104.93	4.38
9	284.79	131.44	21.91	50.072	125.18	954.62	540.26	104.93	4.38
10	240.97	175.25	21.91	50.072	125.18	946.29	535.55	104.93	4.38
11	197.16	219.07	21.91	50.072	125.18	937.96	530.83	104.93	4.38
12	350.51	43.81	43.81	50.072	125.18	967.11	547.33	104.93	4.38
13	306.69	87.63	43.81	50.072	125.18	958.78	542.62	104.93	4.38
14	262.88	131.44	43.81	50.072	125.18	950.45	537.9	104.93	4.38
15	219.07	175.25	43.81	50.072	125.18	942.12	533.19	104.93	4.38
16	175.25	219.07	43.81	50.072	125.18	933.8	528.8	104.93	4.38

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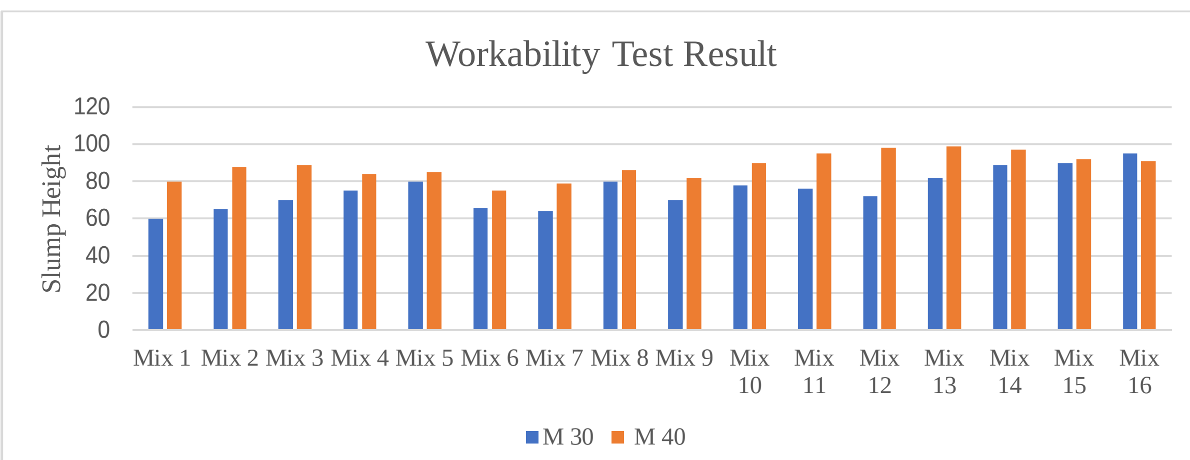
3) The given value of Mix Proportion of M40 Geopolymer Concrete by Weight

Mix No.	GGBS	FLYASH	SILICA FUME	Sodium Hydroxide	Sodium Silicate	Coarse Aggregate	Fine Aggregate	Water	Super Plasticizer
1	518.84	*	*	59.29	148.24	680.35	739.3	87.94	5.19
2	466.96	51.88	*	59.29	148.24	672.99	731.31	87.94	5.19
3	415.07	103.77	*	59.29	148.24	665.63	723.31	87.94	5.19
4	363.19	155.65	*	59.29	148.24	658.27	715.32	87.94	5.19
5	311.32	207.54	*	59.29	148.24	650.92	707.32	87.94	5.19
6	259.42	259.42	*	59.29	148.24	643.56	699.33	87.94	5.19
7	441.02	51.88	25.94	59.29	148.24	669.31	727.31	87.94	5.19
8	389.13	103.77	25.94	59.29	148.24	661.95	719.31	87.94	5.19
9	337.25	155.65	25.94	59.29	148.24	654.6	711.33	87.94	5.19
10	285.36	207.54	25.94	59.29	148.24	647.24	703.32	87.94	5.19
11	233.48	259.42	25.94	59.29	148.24	639.88	695.33	87.94	5.19
12	415.07	51.88	51.88	59.29	148.24	665.63	723.31	87.94	5.19
13	363.19	103.77	51.88	59.29	148.24	658.27	715.32	87.94	5.19
14	311.31	155.65	51.88	59.29	148.24	650.92	707.32	87.94	5.19
15	259.42	207.54	51.88	59.29	148.24	643.56	699.33	87.94	5.19
16	207.54	259.42	51.88	59.29	148.24	636.2	691.33	87.94	5.19

V. TEST RESULTS GRAPH

1) Workability Test



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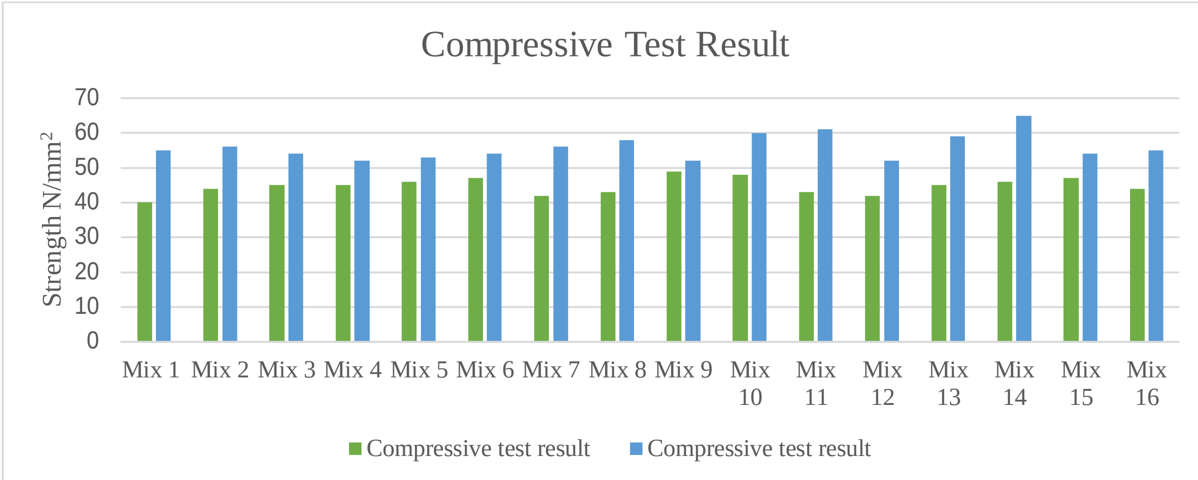
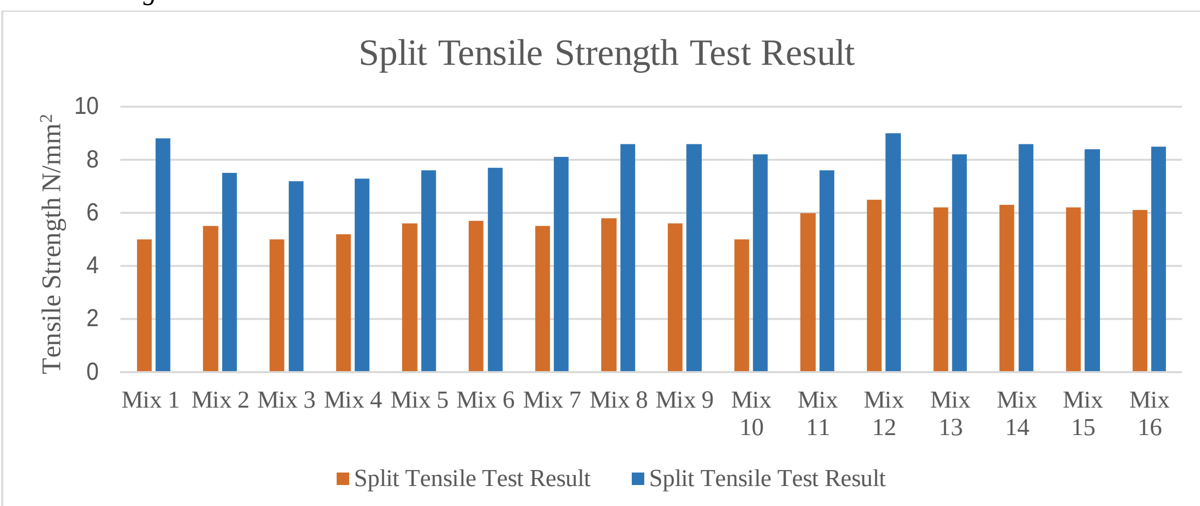
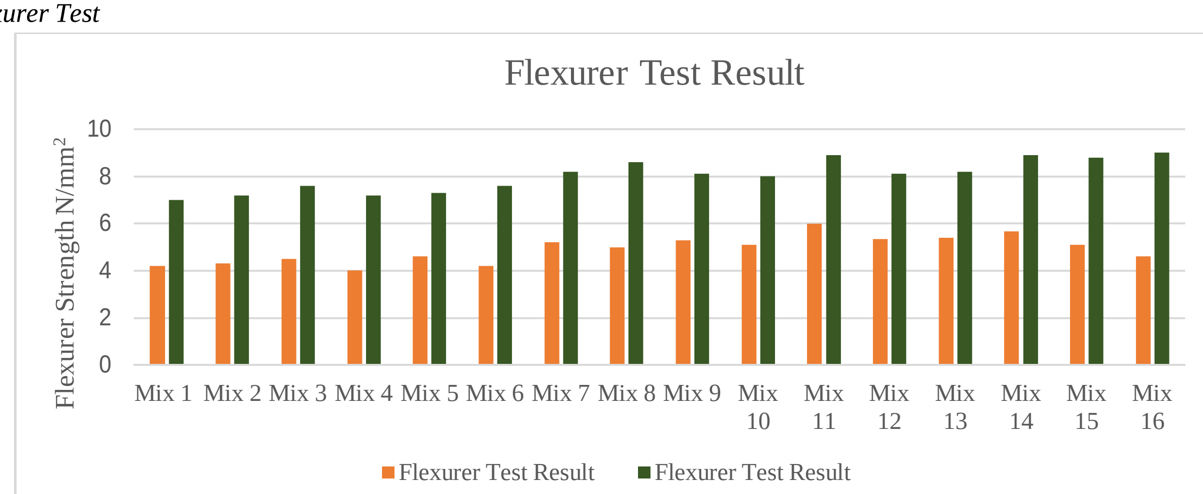
2) Compressive Strength Test



3) Split Tensile Strength Test



4) Flexurer Test



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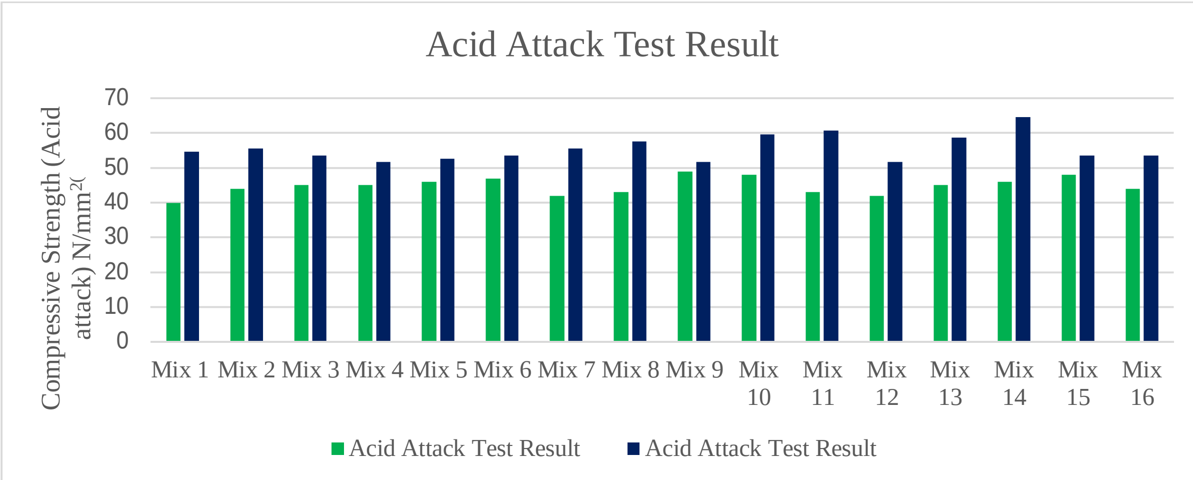
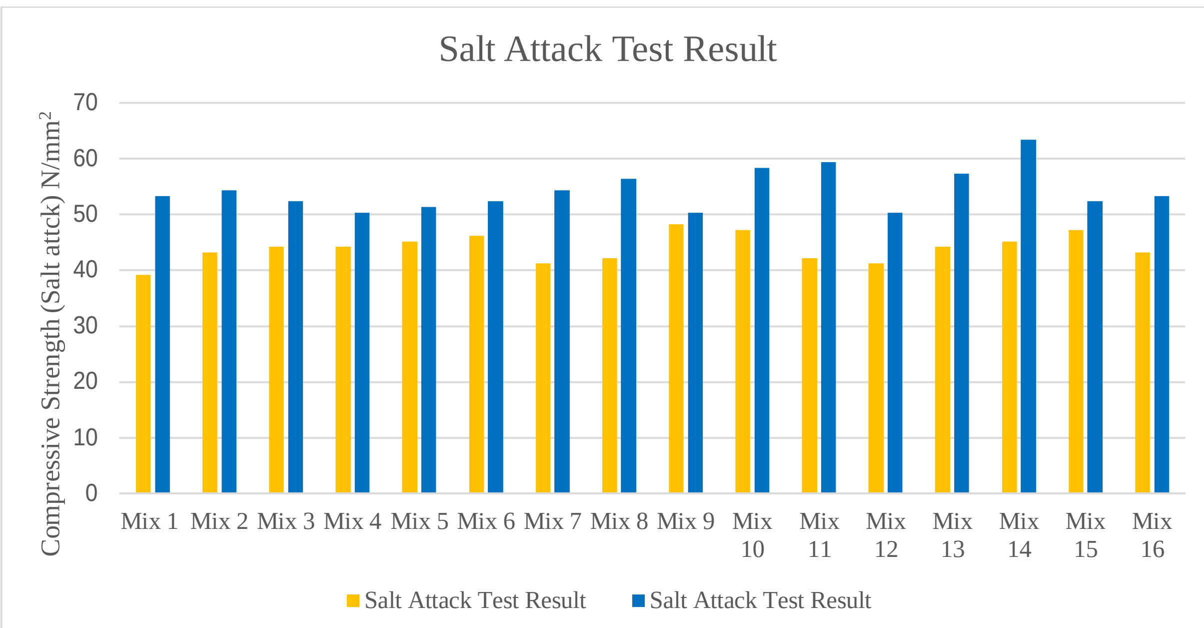
5) Acid Attack Test



6) Salt Attack Test



VI. CONCLUSION

In summary, the use of GGBS activated with neutral water glass effectively regulates setting times in slag-based geopolymer concrete, while incorporating fly ash and GGBS with sodium silicate enhances workability. Higher GGBS percentages decrease setting time and workability but increase compressive strength. Geopolymer concrete typically shows higher density than OPC, with formulations high in fly ash content capable of curing in ambient conditions. Regarding comparisons with OPC, GPC exhibits lower modulus of elasticity but higher deformation capacity and ductility at equivalent strengths. Optimizing GPC performance involves specific ratios of NaOH, Na2SiO3, and total alkali activator to fly ash. Geopolymer technology offers a sustainable alternative to OPC, utilizing fly ash to reduce CO2 emissions. Recent advancements highlight the potential for enhancing compressive strength, especially in cast-in-situ applications. Further research is needed to explore long-term durability and structural applications, but experimental studies demonstrate promising mechanical properties and offer insights into mix design optimization for sustainable construction with geopolymer concrete.

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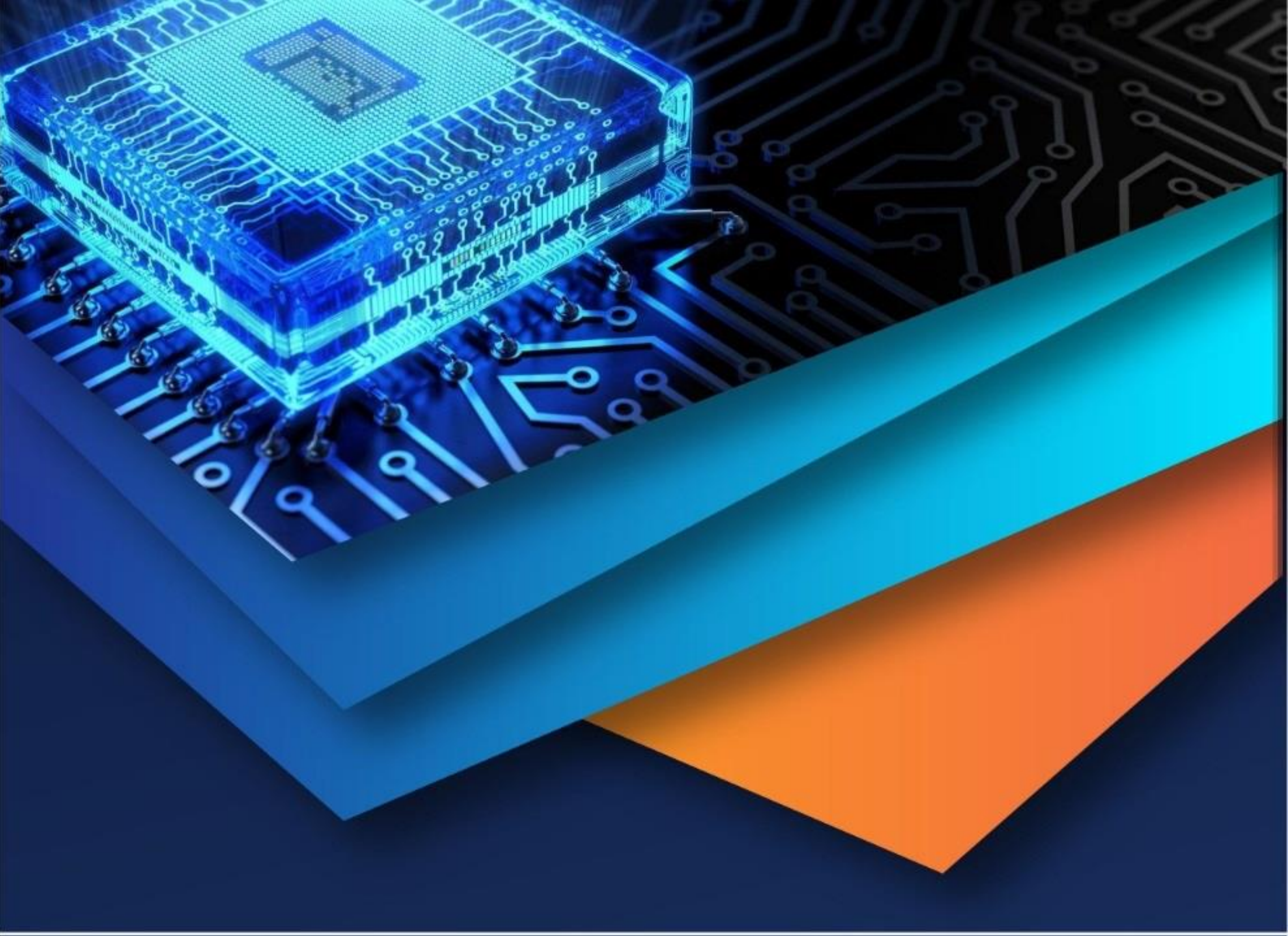

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