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Experimental Study on Geopolymer Concrete with Replacement of Fly ASH and GGBS

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Abstract: In Twenty First century infrastructure development concrete has come out as the dominant construction material due to its longevity and strength. The main component used in the concrete preparation is ordinary Portland cement whose production release large amount of carbon dioxide into atmosphere that causes greenhouse effects. Various surveys suggest industries around the globe contribute about 6%of carbon dioxide that is releasing into the atmosphere. In spite of this major environmental concern, we cannot reduce the use of ordinary Portland cement for making concrete. In this study concrete is prepared by using geopolymer technology i.e. by mixing fly ash, ground granulated blast furnace slag, sodium silicates, sodium hydroxide are mixed. Specimen curing is done at regular intervals of 3 days, 7days, and 28days. Compressive, split and flexural strength obtained after 3 days, 7 days and 28 days. Acid, Sulphate test and permeability test done for 14 and 28 days of curing the specimen. More strength occurred at mix 5 of fly ash 30% and GGBS 70%.
Keywords: fly ash, GGBS, compression strength, split tensile, acid attack, flexural strength.

I. INTRODUCTION

Construction The main problem facing the world today is environmental pollution. In the industry mainly caused by ordinary Portland cement emission of pollutants because damage to the environment. Its production is widely known ordinary Portland cement uses a lot of energy simultaneously contributes high amount of carbon dioxide. In greenhouse gases, carbon dioxide it contributes 65% to global warming. The cement industry account for 6%of total co2 emission, because one ton of ordinary Portland cement production releases one ton of carbon dioxide. The use of Portland cement will inevitably require a lot of efforts later Portland was developed to reduce the use of cement in concrete. These efforts include application auxiliary cementing materials such as fly ash, silica fumes, ground granulated blast furnace slag, rice husk ash, met kaolin, and finding alternative binder for ordinary Portland cement. In this respect show the geopolymer method for use in the concrete industry as an alternative binder to ordinary Portland cement. Geopolymer proves that concrete is not the only effective alternative to ordinary Portland cement but reduces the disposal problem associated with it. To develop geopolymer concrete using fly ash, ground granulated blast furnace slag, with different mix proportion. From alkaline metals soluble in alkaline liquids usually sodium or potassium based. Very common alkali liquid compound used in geopolymerisation sodium hydroxide (Noah) or potassium hydroxide and sodium silicate or potassium silicate. To develop the strength by adding the molarity Noah solution. To study the geopolymer concrete performance under water absorption, acid, alkaline test, permeability test. Fly ash, Ground Granulated Blast Furnace Slag, is used in different mix proportions. Determine the compressive strength, tensile strength, flexural strength of geopolymer concrete. B.V Rangan low calcium fly ash has been used successfully stabilize the geopolymer when silicon is resent large amount of alumina oxide is 80%. The silicon to alumina ratio is about 2. Iron oxide content usually 10 to 20% by weight calcium oxide content I less than 5% the carbon content of fly ash indicate damage once ignited by mass, less than 2% article size distribution tests revealed that 80% fly ash particle smaller than 50mm reaction of low calcium fly ash in geopolymer.

II. METHODOLOGIES

A. Material Used

1) *GGBS:* GGBS was according to the specification of IS 12089-1987 as the primary binder for the production of geopolymer concrete, fly ash was replaced by different proportions mix. The chemical composition and physical properties of GGBS tested as Per ASTM D3682-01
2) *Fly Ash:* It is byproduct of coal. It is a fine powder. The chemical composition and physical properties of fly ash tested as Per ASTM C 618, Class F fly ash.
3) *Aggregates:* Natural river sand according to zone 3 of IS 383(1987). The best module of 3.54 and the specific gravity of 2.61 were fixed completeness. Granite coarse gravel crushed according to IS 383(1987) used. The maximum nominal size is 20mm coarse gravel of 2.72 gravity and 6.29 were used. Gravel tested according to IS 2386(1963).

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4) *Alkaline Solution:* A mixture of sodium hydroxide and odium silicates was used alkaline solution. Commercial grade sodium hydroxide in granular form (97%-100%) purity and a mixture of 14.7% sodium silicates solution na2o, 29.4% sio2(total solids 45.4%) and 55.6% water by mass. The alkaline liquid ratio was determined to be 0.4 and the sodium ratio silicates 2.5 of sodium hydroxide was taken, which was subjected to several tests consistent with practicality and power. Sodium ratio recommended for all experiments except studied on the effect of hydroxide 14M in the compressive strength of sodium hydroxide containing concentration was used.
5) *Mix Design:* Mix design for m25 grade of concrete. Here in the place cement we are using fly ash and GGBS with 100 % of replacement.

Table 1 Percentage of fly ash and GGBS

MIX NO.	FLY ASH	GGBS	ALKALINE RATIO
1	70	30	14
2	60	40	14
3	50	50	14
4	40	60	14
5	30	70	14

Table 2 Mix ratio of each material mix

S.NO	QUNATITES	M1	M2	M3	M4	M5
1	GGBS	16.209	21.612	27.01	32.418	37.82
2	FLY ASH	37.82	32.418	27.01	21.612	16.209
3	COARSE AGGREGATE	166.49	166.49	166.49	166.49	166.49
4	FINE AGGREGATE	76.59	76.59	76.59	76.59	76.59
5	SODIUM HYDROXDE	3.51	3.51	3.51	3.51	3.51
6	SODIUM SILICATES	8.81	8.81	8.81	8.81	8.81

III. TEST AND RESULTS

A. Experimental Test

1) *Compressive Strength:* Geopolymer concrete compression strength tested according to IS 516:1959. The allowable error should not exceed 2% of maximum load. Several studies discuss the effect of important parameters on abstraction strength of geopolymer concrete. Accordingly two parameters, temperature curing effects of concentration of sodium hydroxide on the compressive strength of geopolymer concrete examined separately. Effect of sodium hydroxide concentration Noah has been studied for five different mix proportions. In the study compression strength of geopolymer concrete was studied different treatment condition. The rational for Noah is set to 14M for all models.
2) *Split Tensile Strengh Test:* The tensile strength test according to ISS 5816:1999. Equipment test accuracy is similar to IS 516:1959. If no other conditions Specific laboratory test sample requirements will be tested immediately they are removed from the water when wet. Surface water and grids are cleaned Removed from any projecting wing pattern and associated surfaces packing strips. The load is used without stupidity and consistently Growing Nominal ratio in the range of 1.2 N / (mm² / min) to 2.4 N / (mm² / min).

$$fct = 2p / \pi LD$$

Where,

P = the maximum load applied to the sample at N.
L = length of the sample in mm.
D = diameter of the sample in mm

3) *Flexural Strength Test:* The flexibility of the geopolymer concrete was established in accordance with IS 516:1959. The allowable error should not exceed 0.5 to the applied load. 100mm*100mm*500mm the flexural force is expressed as the modulus of the crack, which are the maximum pressure intense fibers in bending. It is calculated by the principle of flexibility. After the beam is removed Samples from the curing tank, they are tested on a load frame with a capacity of 20kN According to IS 9399: 1679.

The modulus of the crack is $fb = pl / bd^2$ for a> 133 mm

Where,

P = Maximum load applied in kg model.
L = cm for a sample.
b = cm is the width of the measured sample.
d = measured depth of the specimen in cm.

4) *Acid Resistance Test:* Geopolymer resistance to acid was determined in cubes initial load after 28 days of casting days of casting day samples were identified and then immersed in 1% cubes hydro chloric acid (HCL) and 1% of sulfuric acid (h2so4) separately a 3,7,28 days more concentration of solution is maintained during this period. After 3, 7, and 28 days samples taken from acidic water.
5) *Sulphate Resistance Test:* In this study 1% sodium sulfate was prepared. Which is strong base 1% sodium sulfate was prepared by dissolving na2so4 in water. The strength of the cubes model with dimension was developed an alternative. The samples were placed in 1% sodium sulfate solution and there for 3,7,28 days. The sample were extracted from the sulfate solution after 3,7,28 days followed by compression strength. And the losses of samples were determined.
6) *Permeability Test:* The continuous flow method is suitable for concrete with relatively high permeability, while the depth of penetration system is optimal for very low permeable concrete. The parallel efficiency of penetration is measured using a concrete permeable tool compressed air at 7 kg/cm2. The permeable particle was supplied to the assembly using an air compressor. The reservoir of the machine was filled with clean water. As the reservoir was completely filled with water, air pressure was created on the water pressurized reservoir. The clean collection bottle was placed to collect permeable water by weight. After reaching the steady state the percolate level is measured at regular intervals. In continuous flow mode the coefficient of penetration can be calculated using the formula.

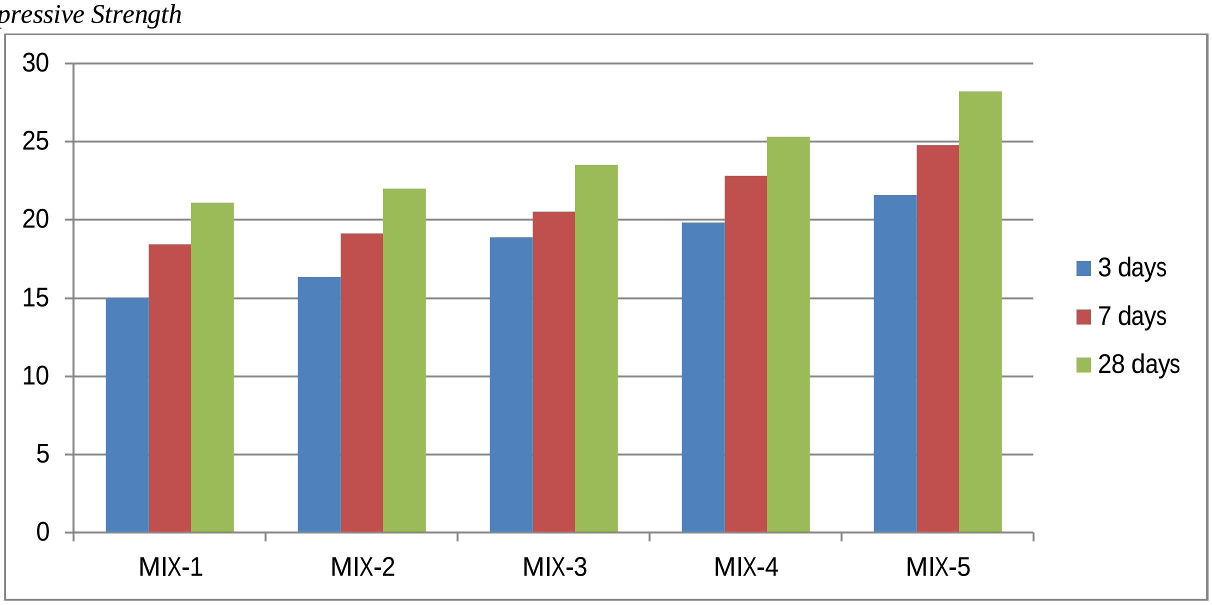
$$K=QL/ATH$$

Where,

K- The coefficient of penetration in Meter/sec
Q- The amount of dissolved water is m3.
L- Sample length in m.
A- The cross sectional area of the model in m2.
T-Total time in seconds
H- Water head

B. Experimental Results

1) Compressive Strength



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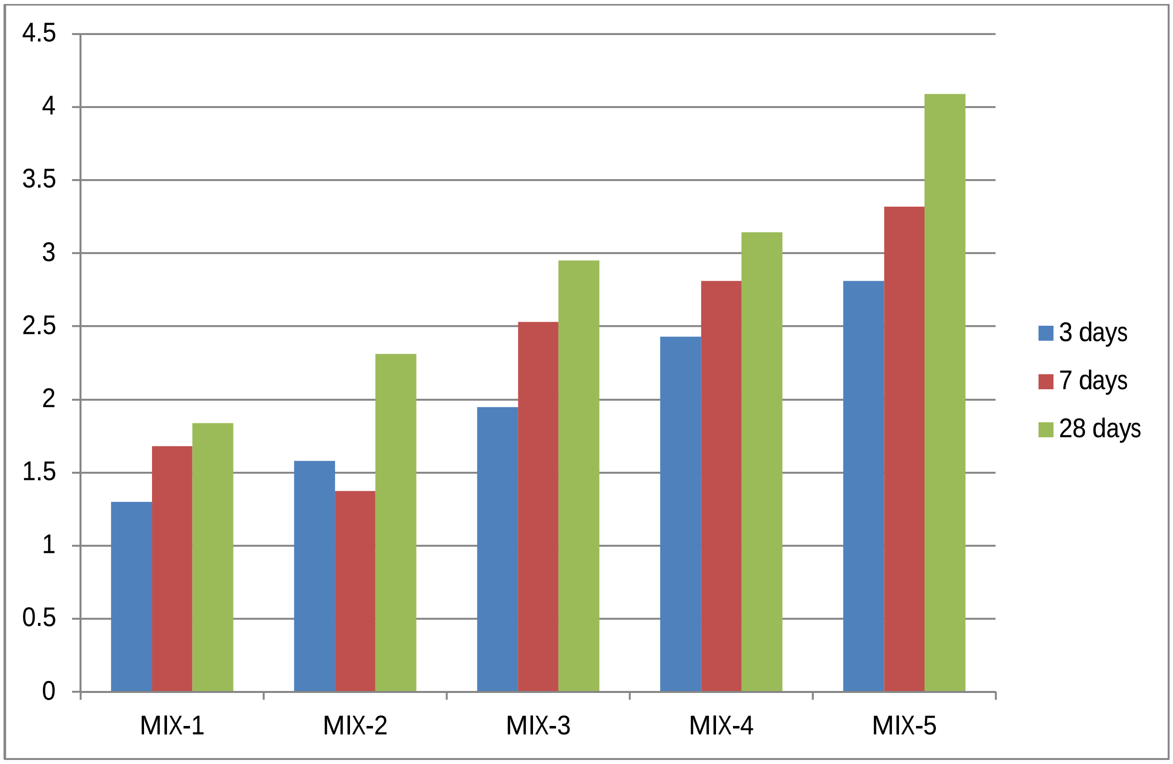
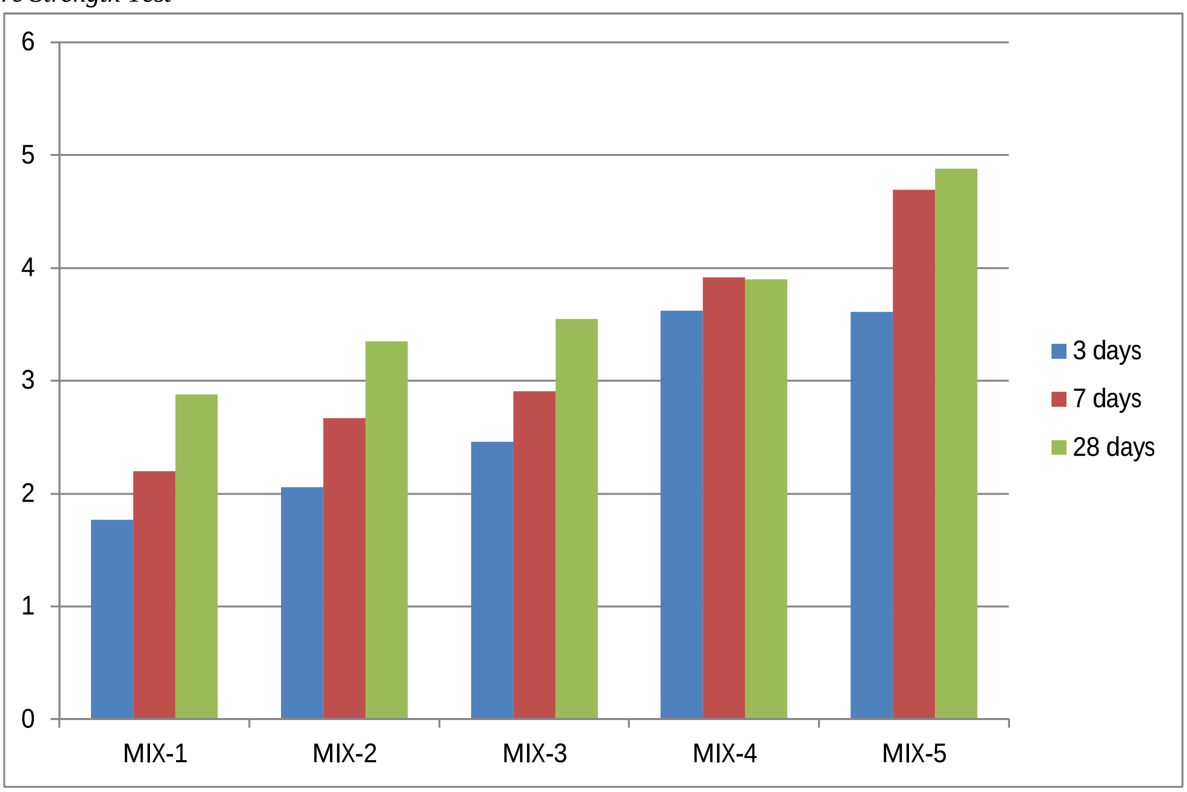
2) Split Tensile Strength



3) Flexure Strength Test



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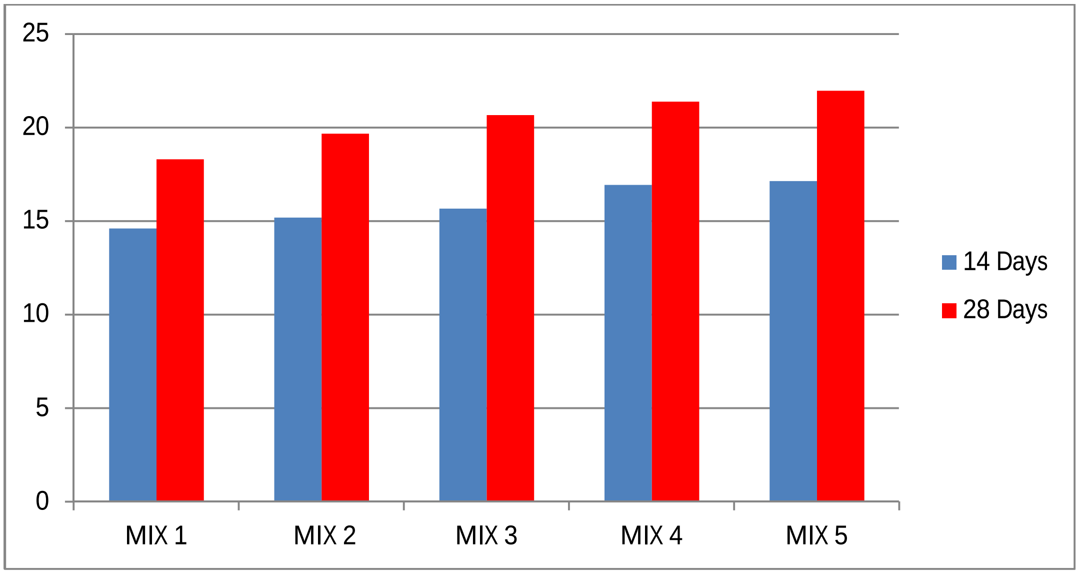
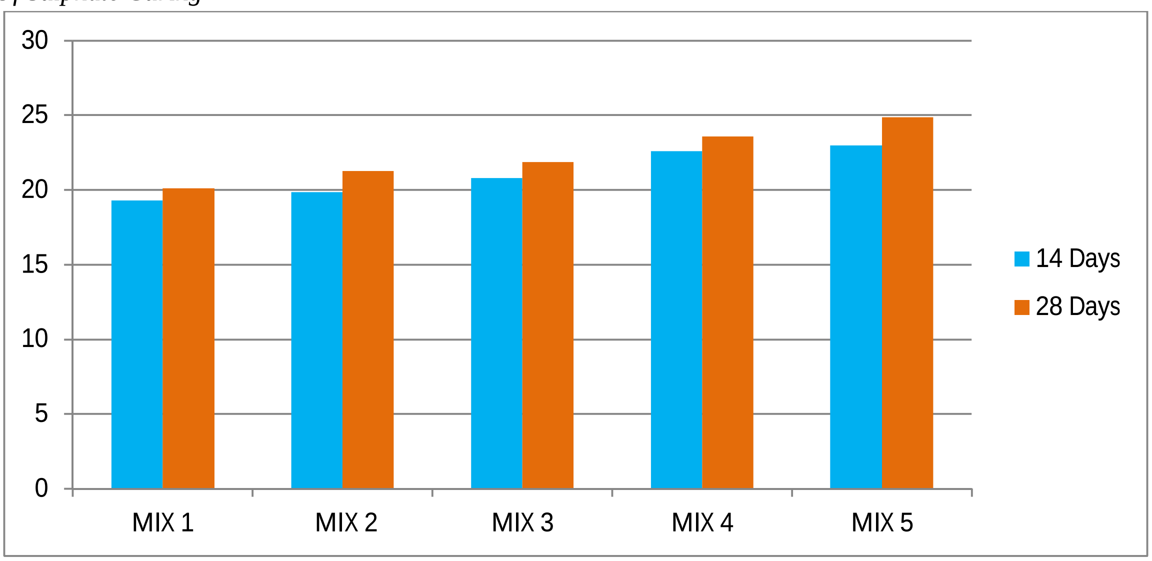
4) Effect Of Acid Curing



5) Effect Of Sulphate Curing



IV. CONCLUSIONS

A. As the mass to sodium silicates to sodium hydroxide ratio is higher, the compressive strength of geopolymer concrete based on fly ash GGBS based is higher.

B. As the curing temperature increases the compressive strength of fly ash and GGBS based geopolymer concrete also increases.

C. The maximum split tensile strength is 2.81 MPa which is comparable at 14M with Noah solution and at 24 hours curing and 28 days in the sun. Maximum flexibility strength occurred after curing the specimen is 4.09(for compound mix 5).

D. Increase in molarity of Noah solution compressive strength flexural, split tensile strength increased by 3.61 and 4.88 respectively.

E. The compressive strength is 21.97 during 1% HCL acid attack in 28 days.

F. The compressive strength is 24.87 during 1% Na2SO4 in 28 days.

G. Geopolymer concrete absorption of water is less when compared to conventional concrete.

H. Geopolymer concrete based fly ash and GGBS can be easily maintained for 120 minutes without signs of alignment and without any reduction in compressive strength.

I. Increase in molarity of Noah solution in flexural strength increased by 3.61 and 4.88 respectively.

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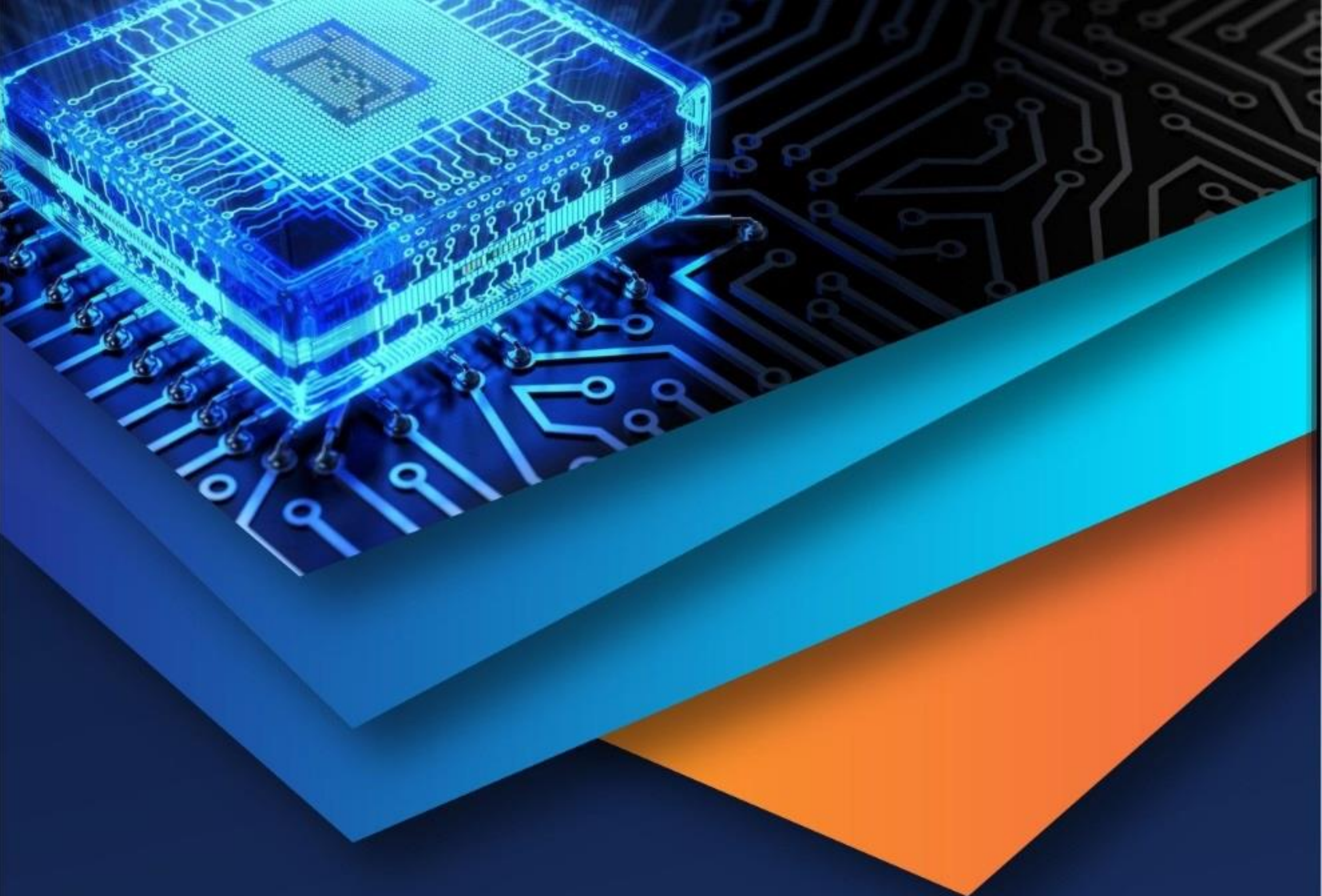

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