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Assessment of strength and Durability of Geo-Polymer Concrete under Acidic Conditions

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***Abstract:** The degradation of concrete by acid attack has been a major problem which needs to be addressed with the utmost concern. This acid attack is primarily due to acid rain in low concentrations. This attack depends upon both type of the acid and the concentration of the acid and the vulnerability of concrete. In general the Geo-polymer concrete results obtained from the reaction of a source material i.e. high in silica, alumina and with alkaline liquid. The word geo-polymer was coined by Davidovit's. Geo-polymer substances lately described as being acid resistant. This present paper studies the experimental investigation data on the Behavior of fly-ash based geo-polymer concretes replaced in chemical solutions for up to four weeks. The fly-ash deployed geo-polymer concrete was at first restored (cured) for 24 hours at 60°C. And also the attained results are comparison with the conventional concretes replaced to 5% acid solutions for up to four weeks. Of The attained compressive strength of geo-polymer concretes and conventional concretes cubes of 150-mm @ an age of 4 weeks are 31.9MPa and 48.4MPa. At first concrete cubes were restored for a period of 4 weeks and after cubes were submerged in chemical solutions, After immersion in chemical solutions, samples were tested at an age of 1week, 2 weeks and 4 weeks. In this work compressive strength and the weight loss reduction were determined. In this experimental investigation three types of chemical solutions are utilized that are HCl, H2SO4 and MgSO4. The test results shows that the Geo-polymer concrete is more resistant to acid and having low loss of weight and compressive strength when compared to conventional concrete*
***Keywords:** Geo-polymer Concrete, Fly Ash, Compressive Strength, Acid Attack.*

I. INTRODUCTION

A. General

The Concrete usage around the world is second only after water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to generate concrete material. The environmental issues regarding with the production of OPC are well known to all. The amount of the CO2 released during the manufacture of Ordinary Portland cement due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum.

B. Geo-polymer Concrete

The emission of CO2 coupled with non-absorption of the same on account of deforestation etc has caused tremendous environmental pollution leading to global warming and other bad effects. It is estimated that about 7% of greenhouse gas is being emitted into the atmosphere annually on account of production of OPC alone. Therefore, it is necessary to reduce the emission of CO2 into atmosphere by reducing the cement production and consumption.

It is suggested that consumption of cement could be reduced by three ways.

1) Through economical mix design.
2) By replacing cement with fly ash by adopting high volume fly ash concrete (HVFC) or by using other supplementary cementations materials.
3) By using alternate binding materials for concrete such as Bacterial concrete or Geo- polymer concrete.(no cement in concrete)

C. Objective Of The Research

In acidic environment concrete the geo-polymer binders is to be a good alternative material. The Geo polymer cement having eminent properties with in both salt and acidic environment atmosphere. This present paper studies the experimental investigation data on the Behavior of fly-ash based geo-polymer concretes replaced in chemical solution.

D. Scope of Work

In this experimental work, study of the weight loss and compressive strength of geo- polymer material concrete against chemical environment is done. And also the variation in results of geo-polymer concrete in chemical environment with conventional concrete against acidic environment is studied.

E. Fly Ash

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. In U.K. it is referred as pulverized fuel ash (PFA). Fly ash is the most widely used pozzolanic material all over the world. In 1994 and 2003 Malhotra and ramezanianpour, indicated that the nature of fly ash can be dark gray colour, consist of an alumina silicate glass and it should be less than 10% of CaO.

F. Geopolymers

Compared with ordinary Portland cement, newly developed inorganic binder geo-polymers possess the following characteristics. Abundant raw material resources: Any pozzolanic compound or source of silicates or aluminosilcates that is readily dissolved in alkaline solution will suffice as a source for the production of a geopolymer.

G. Acid Attack

Concrete is not fully resistant to acids. Most acid solutions will slowly or rapidly disintegrate Portland cement concrete depending upon the type and concentration of acid. Certain acids, such as oxalic acid and phosphoric acids are harmless. The most vulnerable part of the cement hydrate is Ca(OH)2, C-S-H gel can also be attacked. Siliceous are more resistant than calcareous aggregates. Concrete can be attacked by liquids, with p^H value less than 6.5. But the attack is sever only at a p^H value below 5.5. Ata p^H value below 4.5 the attack is very sever. As the attack proceeds, all the cement compounds are eventually broken down and leached away. If acids or salt solutions are able to reach the reinforcing steel through cracks or porosity of concrete, corrosion can occur which will cause cracking.

II. EXPERIMENTAL INVESTIGATION

A. Fly Ash

The use of fly ash in portland cement concrete (PCC) has many benefits and improves concrete performance in both the fresh and hardened state. Fly ash use in concrete improves the workability of plastic concrete, and the strength and durability of hardened concrete.

Fly ash use is also cost effective. When fly ash is added to concrete, the amount of portland cement may be reduced.

In the current laboratory work, low calcium, dry fly ash collected from the Thermal Power Plant, near Vijayawada, A.P,INDIA, was used as the base material.

B. Alkaline Liquid

A composition of sodium hydroxide and sodium silicate solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions. The chemical composition of the sodium silicate solution was varied as fallowsNa2O=14.7%, SiO2=29.4%, water 55.9% by weight.

C. Physical properties of Cement

The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the cement. The obtained results are listedas fallows.

1) Fineness of cement = 6.50
2) Specific gravity = 3.10
3) Normal Consistency = 29%
4) Normal Consistency = 50min
5) Final Setting Time = 320min

D. Fine Aggregate

Fine aggregates can be natural or manufactured. The grading must be uniform throughout the work. The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the fine aggregate. The obtained results are listed as fallows.

1) Specific gravity =2.61
2) Fineness modulus=2.70
3) Bulk Density

Loose=16.20kN/m^3 Compacted =17.20kN/m^3

E. Coarse Aggregate

The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the course aggregate. The obtained resultsare listed as fallows.

1) Specific gravity = 2.77
2) Bulk density Loose = 14.90kN/m^3
   Compacted = 16.7kN/m^3
3) Water absorption = 0.5%
4) Fineness modulus = 7

F. Water

The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the water. The obtained results are listed as fallows.

1) pH = 7.10
2) Taste = Agreeable
3) Appearance= Clear
4) Turbidity = 1.75
5) Hardness = 250 mg/l

G. Fly Ash

Physical properties of Fly ash collected at Vijayawada Thermal Power Station are as fallows

1) Specific Gravity = 1.975
2) Fineness Modulus = 1.195

III. RESULT ANDDISCUSSIONS

A. Results

In this Chapter, the laboratory results are executed and discussed. The details are as fallows in tables and figures.

Table: 1.1 Residual compressive strength on acid sunk.

S. No	concrete	Compressive strength 28days (earlier acid immersion) (N/mm^2)	After 7 days Compressive strength (N/mm^2)			After14 days Compressive strength (N/mm^2)			After 28 days Compressive strength (N/mm^2)		
			Nature of curing: Acid immersion								
			Type of Acid			Type of Acid			Type of Acid		
			HCl	H_2SO_4	$MgSO_4$	HCl	H_2SO_4	$MgSO_4$	HCl	H_2SO_4	$MgSO_4$
1	Conventional concrete(M35)	49.83	44.34	35	45	42.35	29	44	40.86	21	42
2	Geo-polymer concrete	32	29.44	27.36	28.8	28.8	25.69	27.52	27.5	23.2	26.4

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Table: The percentage of loss compressive strength on acid sunk.

S.No	Type of concrete	7 days % loss of Compressive strength (N/mm2)			14 days % loss of Compressive strength (N/mm2)			28 days % loss of Compressive strength (N/mm2)		
		Nature Of Curing – Acid immersion								
		Type of Acid			Type of Acid			Type of Acid		
		HCl	H_2SO_4	$MgSO_4$	HCl	H_2SO_4	$MgSO_4$	HCl	H_2SO_4	$MgSO_4$
1	Conventional concrete (M35)	11	29.76	9.61	15	41.8	11.69	18	57.85	15.65
2	Geo-polymer concrete	8	14.5	9	10	19.7	14	14.06	27.5	17.5

S.No	Acid Type	Weight (Kg) of concrete cubes before acid sunk			Weight (Kg) of concrete cubes after acidsunk		
		7 days	14 days	28 days	7 days	14 days	28 days
1	Hcl	8.781	8.802	8.762	8.581	8.532	8.431
2	H_2SO_4	8.79	8.78	8.7	8.30	8.20	8.0
3	$MgSO_4$	8.78	8.79	8.8	8.60	8.60	8.56

Table: Geo-polymer concrete

S. No	Acid Type	Weight (Kg) of concrete cubes before acid sunk			Weight (Kg) of concrete cubes afteracid sunk		
		7 days	14 days	28 days	7 days	14 days	28 days
1	Hcl	7.841	7.852	7.833	7.81	7.792	7.761
2	H_2SO_4	7.95	7.78	7.82	7.87	7.64	7.65
3	$MgSO_4$	7.88	7.9	7.8	7.85	7.86	7.74

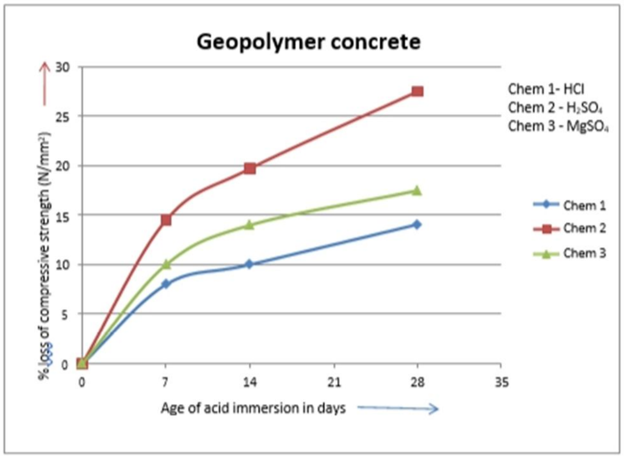
B. Percentage Weight loss on Acid Sunk

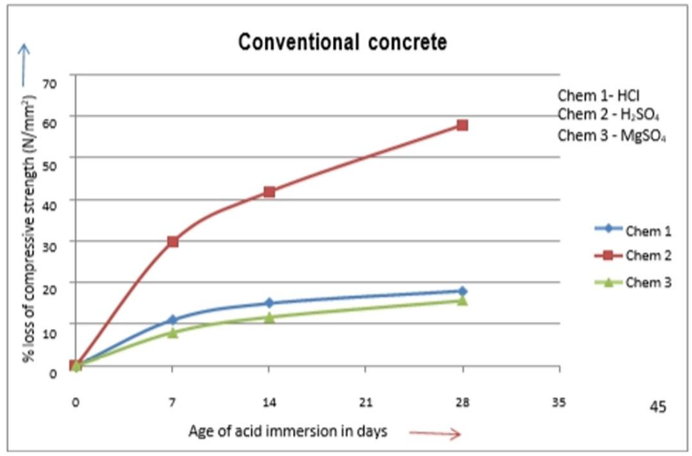
Table: Conventional concrete

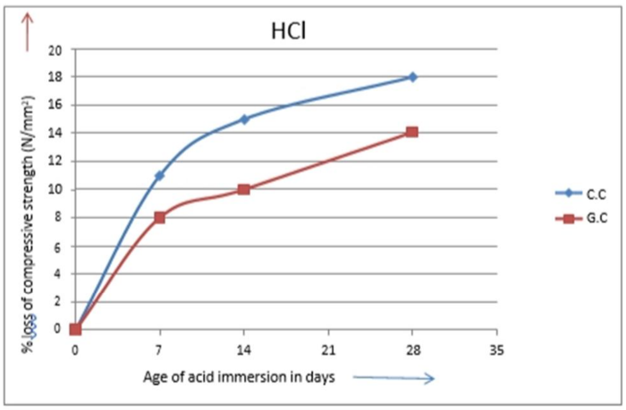
S.No	Acid type	% Weight loss of concrete cubes after acid sunk		
		7 days	14 days	28 days
1	Hcl	2.21	3.062	3.76
2	H_2SO_4	5.5	6.6	8
3	$MgSO_4$	2.0	2.16	2.72

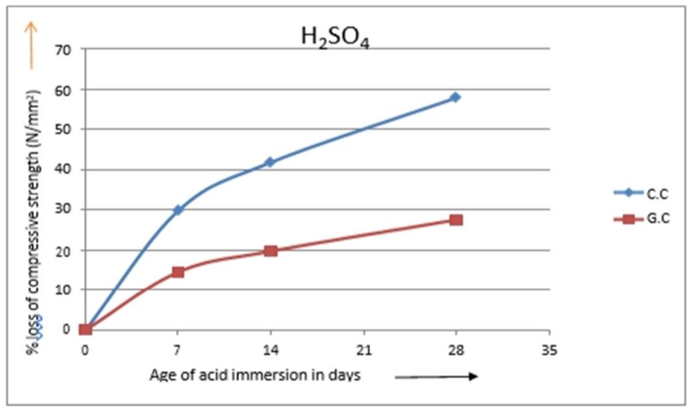
S.No	Acid type	% Weight loss of concrete cubes after acid immersion		
		7 days	14 days	28 days
1	Hcl	0.43	0.72	0.91
2	H_2SO_4	1.0	1.7	2.2
3	$MgSO_4$	0.3	0.5	0.7

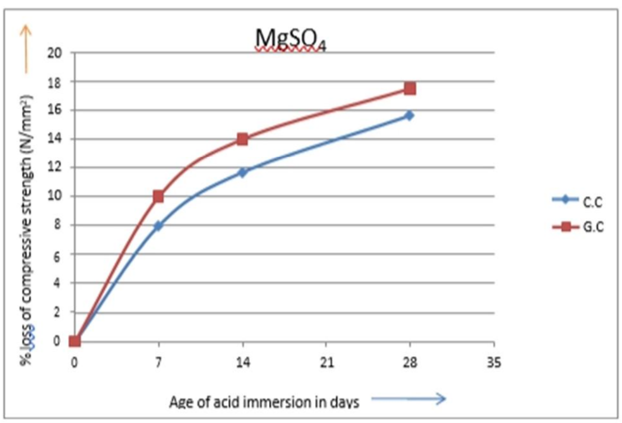
IV. GRAPHICAL MODELS

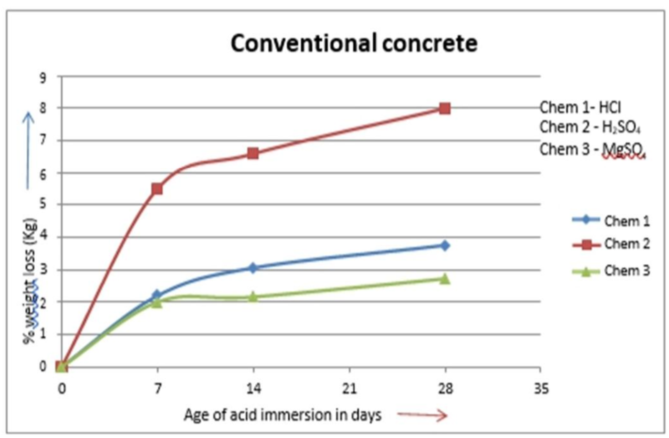


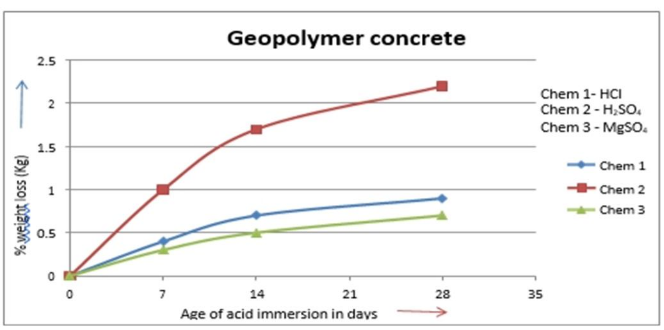


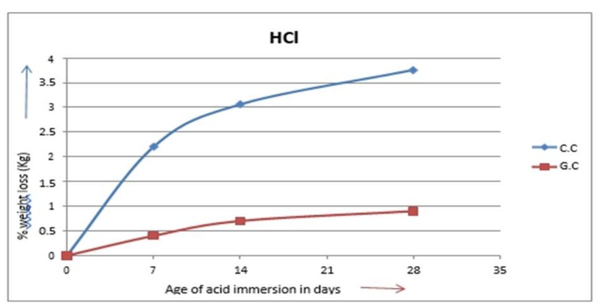












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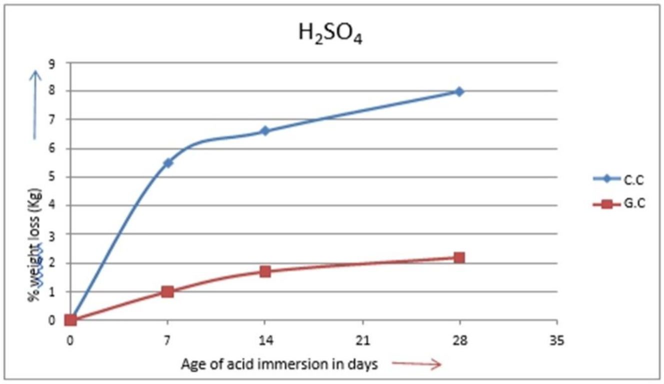

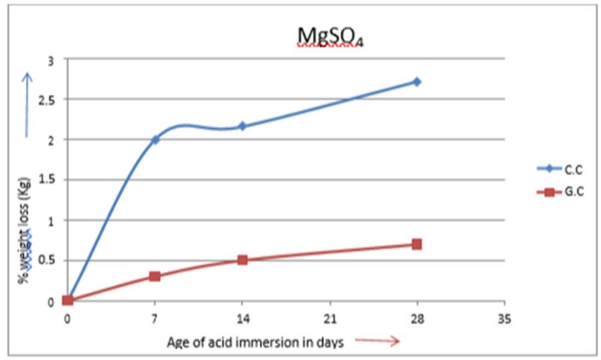

V. CONCLUSIONS

This explains a summary of the thesis, conclusions, and economic merits of using low-calcium fly ash-based geo-polymer concrete. Based on information available about geo-polymers, the trial-and-error method has to be implemented to develop the making of fly ash-based geo-polymer concrete. In order to avoid the number of variables in this trial-and-error method, the thesis was limited to low- calcium fly ash.

1) Geo-polymer concrete mixes oppose acid attack in a good manner as compared to conventional concrete at 7, 14, 28days of exposure to HCl, H_2SO_4 and $MgSO_4$.
2) It is noticed that the % loss of Compressive strength of all Geo-polymer Concrete mixes are significantly lesser than that of Conventional concrete mixes.
3) It is also observed that the great loss of compressive strength and weight found in case of H_2SO_4 acid sunk as compared to HCl and $MgSO_4$ acids.
4) The loss of compressive strength of conventional concrete is nearly twice the loss of compressive strength of geo-polymer concrete in H_2SO_4 acid sunk.
5) The % weight loss of Conventional concrete is high when compared to Geo-polymerconcrete.
6) It is noticed that the loss of compressive strength of Geo-polymer concrete is high when compared to conventional concrete in $MgSO_4$ acid sunk
7) The weight loss of Geo-polymer concrete is very less when compared to conventional concrete mixes are exposed to 5% acid attack.

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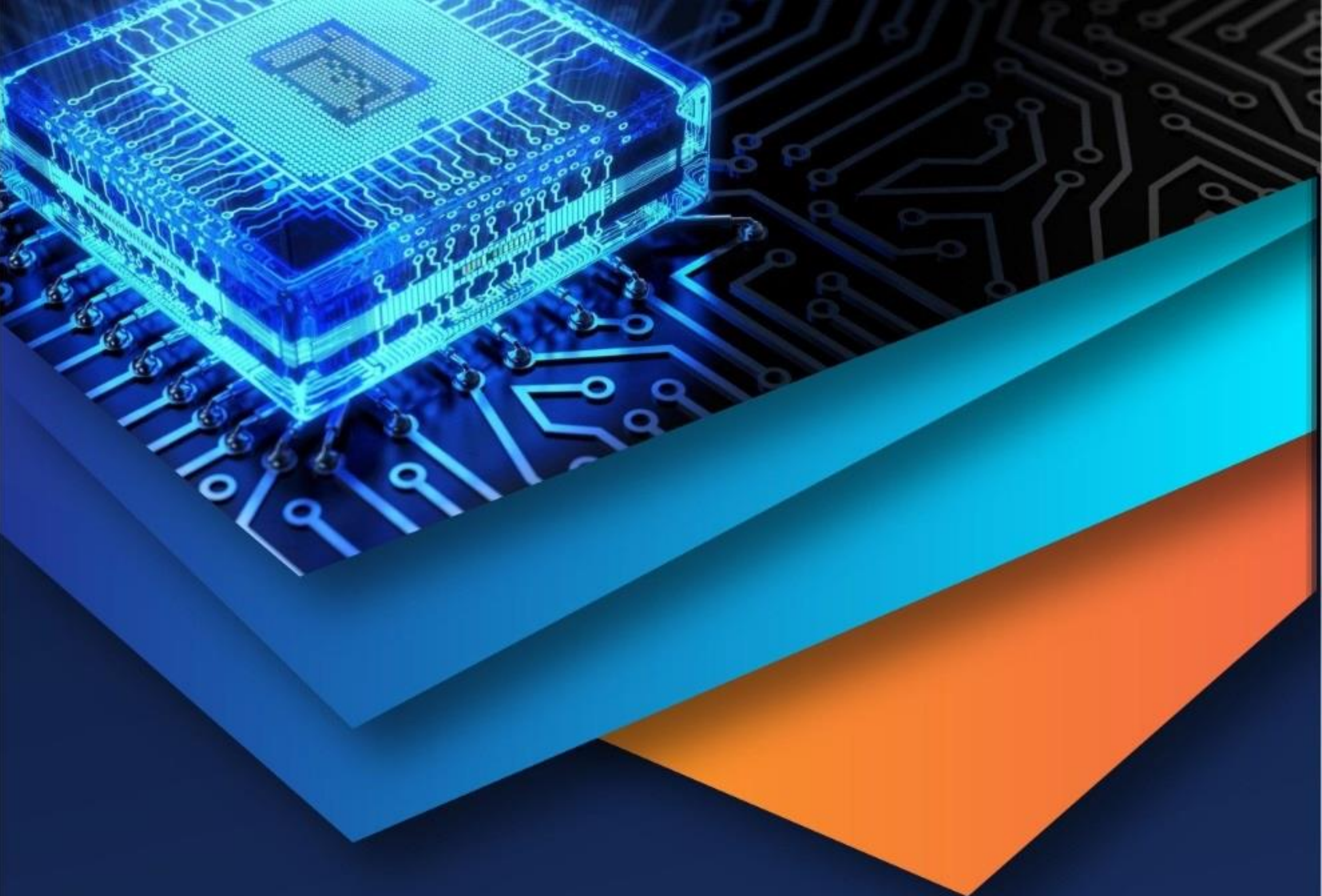

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