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An Experimental Study on Acid Resistance of Concrete by using Mineral Admixtures

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Abstract: Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage as well as the behaviour of durability of concrete structures, built during the last first half of the century with Ordinary Portland Cement (OPC) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their character) of concrete and the information that almost any mixture of the constituents leads to a mass of concrete have bred contempt. The Ordinary Portland Cement (OPC) is one of the most important ingredients used for the manufacture of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, it causes greenhouse effect and the global warming, and hence it is replacement of some other material, like mineral admixtures (Silica fume and Fly ash and GGBS).Acidic attack is one of the world's wide problems that may cause gradual but severe damages to concrete structures. Concrete can be attacked by the Sulphate present in the soil or in the sea water, and by sulphuric acid produced from either sewage or sulpurdioxide present in the atmosphere of industrial cities. Most acid attacks concrete by a process of dissolution and leaching, converting the constituents of the cement paste into readily soluble salts. The amount of attack depends on the properties of the aggressive agent and its concentration. Damage is to be estimated if the pH of the acidic solution is lower than six. In this study the past decades covered the Sulphate attacks from different aspects to improve the resistance of concrete to acid attacks, used mineral additives such as Fly ash and Silica fume. In this study, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and durability properties by the replacement of admixtures by 10%, 20% & 30% by the weight of cement.

Keywords: cidic Attack, Fly Ash, Silica Fume, Sulphate Attack, Mineral Admixtures

I. INTRODUCTION

Acidic attack is one of the world's wide problems that may cause gradual but severe damages to concrete structures. Concrete can be attacked by the sulphates present in the soil or in the sea water, and by sulphuric acid produced from either sewage or sulpur dioxide present in the atmosphere of industrial cities. Most acid attacks concrete by a process of dissolution and leaching, converting the constituents of the cement paste into readily soluble salts. The scale of hardness depends on the properties of the belligerent agent and its meditation. Damage is to be estimated if the pH of the acidic result is lower than six. Every concrete structure should perform its intended function through the expected life time of the structure, irrespective of external exposure conditions. The ability of concrete to withstand any environmental condition that may result in premature failures or several damages is a major concern to the engineering professional. The weakening achieve of acid media on cement based constructions has become a distressing problem all more than the world. These media generally occur as acidic rains and mist, industrial and urban sewages and acidic ground water. The extent of attack depends not only on the type of concentration of attacking acid, but also on the properties of the material including the cement used. Acid attack is one of the phenomena that may disintegrate concrete structures depending on the type and concentration of acid. Certain acids such as oxalic acid are considered as harmless, while weak solutions of some acids have insignificant effects. Even though acids normally attack and leach away the calcium compounds of the paste, they may not willingly attack confident aggregates, such as siliceous aggregates calcareous aggregates often react willingly with acids.

Many researchers in the past decades covered the sulphates attacks from different aspects to improve the resistance of concrete to acid attacks, many researchers used mineral additives such as Fly ash and Silica fume. The use of these artificial pozzolanas can achieve not only economical and ecological benefits, but technical benefits as well. However, it is also well known that mineral additives may decrease the premature might of concrete. In this study, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and durability properties by the replacement of admixtures by 5%, 10%, 15%& 20% by the weight of cement.

The main objectives of this study are:

1) To develop an acidic resistance concrete mix with good workability and high-early-strength to withstand harsh environmental conditions.
2) To study the physical and mechanical and durability properties of these concrete mixes in terms of changes with respect to time and duration.
3) To assess the effect of concrete containing different mineral admixtures cured under different curing regimes.

II. LITERATURE REVIEW

1) *N.I. Fattuhi and B.P Hughes (1988)* examined the effect of acid attack on concrete with different admixtures or protective coatings were used in an attempt to improve the chemical resistance of a standard concrete mix. The effects of admixture additions on the workability and compressive strength of the concrete were also investigated.
2) *S Turkel, B Felekoglu and S Dulluc (2007)* examined the Acidic attack represents a topic of increasing significance, owing to the spread of damages of concrete structures in both urban and industrial areas. Cement type is an important factor affecting performance of cement based materials in an aggressive environment, and compare the acid resistance of a pozzolanic cement (CEM IV-A/32·5) with Portland cement (CEM I 32·5) that was made from the same clinker. The acid resistance of mortars prepared from Portland cement was improved than the pozzolanic cement incorporated samples after 120 days of acid attack.
3) *E. Hewayde, M. L. Nehdi, E. Allouche and G. Nakhla (2007)* used concrete admixtures for sulphuric acid resistance in this study, five admixtures, which offer a range of potential improvement mechanisms, were used at various dosages to enhance the resistance of concrete made with Type 50E cement to chemical sulphuric acid attack. The struggle to sulphuric acid of concrete specimens incorporating these admixtures was calculated and compared to that of organize specimens. An attempt was made to determine whether there is a relationship between the effect of the various admixtures on mechanical strength and porosity and the resistance of concrete toH2SO4 attack. Results indicate that metakaolin reduced the mass loss of concrete specimens due to immersion for eight weeks in H2SO4 solutions having concentrations of 7% and 3% (by volume) by 38 and 25%, respectively, compared with that of the control specimens.
4) *Dr. B. Kotaiah, M. Satish Reddy and K. Lokesh (2014)* examined the topic of degradation of Concrete Structures and Protective measures represents an increasing significance, owing to the spread of damages of concrete structures in both urban and industrial areas. Type of cement being used in the structure is a main factor that affects performance of cement constituents in an aggressive environment. This was adopted to examine cement based materials and impact of chemicals on cementization i.e., Aggressive action of CO_2, Attack by strong acids, Action of ammonia, Action of sulphates, Attack by strong alkalis, Bacterial corrosion with H_2S. Based on the goal of this study is to find various possibilities of protecting cement based materials.

III.MATERIALS & METHODS OF INVESTIGATION

A. Introduction

In recent years, improvements in concrete properties have been achieved by blending cements with cementitious admixtures such as fly ash (FA), and silica fume (SF). Incorporation of these materials in concrete mixes improves the durability concrete. The movement of aggressive substances such as chloride ions and carbon dioxide into concrete which are the main causes of deterioration of concrete structures that affect their integrity and long term serviceability life, is thus very much reduced. The deterioration of concrete is not a result of only aggressive agents, but the overall quality of concrete and also plays a major role. In view of this problem, a growing number of concrete structures are constructed or under construction with the use of cement replacement materials. Therefore any attempt to alleviate the deterioration-risk implies producing good performance concrete capable of withstanding the harsh environmental conditions.

B. Cement

Ordinary Portland cement of grade 53 confirming to IS8112 (2013) was used for the experimental investigation. The tests on cement like specific gravity, standard consistency test, setting time test, soundness test and compressive strength test were carried out in accordance with IS: 1727-1967, IS: 4031-1968 (Part 3,4,5)respectively. The physical properties of 53 grade cement are given in Table 1 and the chemical characteristics are given in table.2. The cement was stored in a room with no contact with atmospheric moisture. Before its use the cement was subjected to physical examination for the presence of lumps.

C. Fly Ash

Fly ash is a by-product of the combustion of pulverized coal in power stations. It is a solid material extracted by electrostatic and mechanical means from the flue gases of furnaces fired with pulverized bituminous coal. Due to its unique mineralogical and granulometric characteristics, fly ash generally does not need any processing before use as a mineral admixture. Bottom ash is much coarser, less reactive and therefore requires fine grinding to develop a pozzolanic property. Average worldwide utilization of fly ash is about 15%, whereas in India, its utilization is form 2 to 5% only. In the present study Fly ash is collected from RTPP. It is conformed to grade1 of IS: 3812-1981. The chemical characteristics are given in table.2.

D. Silica Fume

Silica fume is a by-product of silicon or Ferro-Silica industry and is 100 times finer than cement. It consists of amorphous silica and has high reactivity towards lime. The substitute level of silica fume is generally low at about 10%. When SF is used in concrete mix, its beginning affects the physical understanding of the system, particularly near the aggregate surface where porosity exists. Silica fume starts reacting at the early stage of hydration procedure. The pozzolanic action of silica fume reduces considerably the quantity and size of "CH" crystals in hydrated cement paste. This phenomenon along with low W/C ratio reduces the thickness of conversion zones and thus the preferential orientation of CH crystals is significantly reduced. All these result in more uniform, stronger conversion zone potential of micro cracking. The silica fume used in all concrete mixes was obtained from Elkem Materials Limited. The chemical characteristics are given in table.2.

TABLE I
PHYSICAL PROPERTIES OF CEMENT

S.No	Physical Property	Test Values	Reference Code
1	Specific Gravity	2.7	IS:1727-1967
2	Standard Consistency (%)	32	IS:4031-1968 Part IV
3	Setting times Initial & Final (Minutes)	45 320	IS:4031-1968 Part V
4	Soundness (mm)	1	IS:4031-1968 Part III

Table Ii: Chemical Composition Of Cement & Mineral Admixtures

Chemical Composition	Cement and Mineral Admixtures		
	Cement	Fly Ash	Silica Fume
CaO	63	1.71	0.27
SiO2	22	60.48	85
Al2O3	4	23	0.28
Fe2O3	3.2	11	0.58
MgO	3	1.62	0.25
SO	3	-	-
K2O	0.79	1.41	0.58
Na2O	0.30	0.14	-
L.O.I	2.4	3.5	1.1

IV. EXPERIMENTAL INVESTIGATION

A. Compressive Strength Test

Cubes with Silica Fume and Fly ash individually were cast and left for 24 hours to dry and then cured for 28 days and then tested. The testing of cubes were shown in fig. (1) and results of test are shown in fig. (2) & (3) The load was applied till the failure occurred. The compressive strength at failure is calculated using the formula

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Area}} \text{ in N/mm}^2$$

Fig.1 Compression Testing Machine

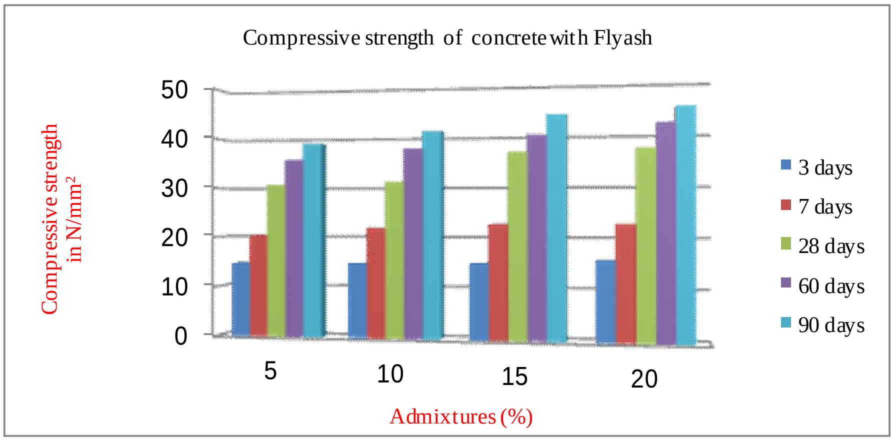

Fig.(2) Compressive strength of concrete with Fly ash

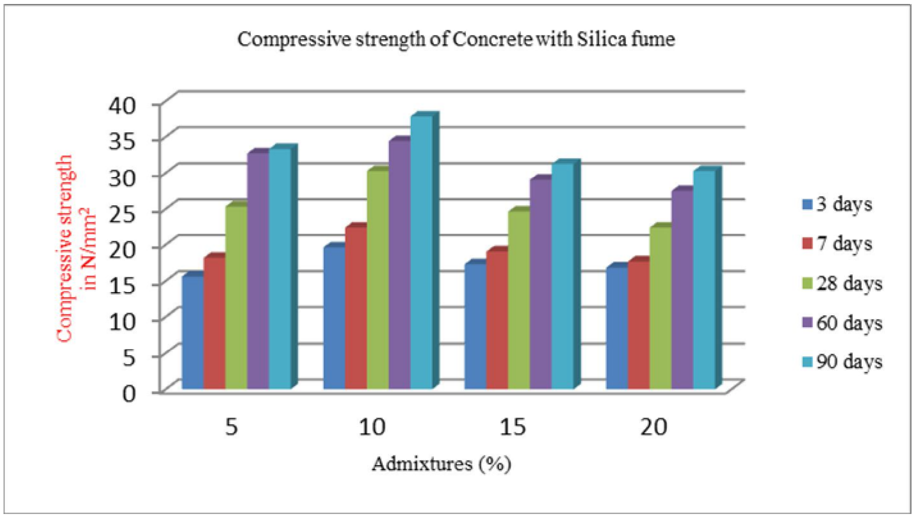

Fig.(3) Compressive strength of concrete with Fly ash

B. Split Tensile Strength Test

Cylinders for each mixture were cast and split tensile strength test was carried out in accordance with IS: 5816-1999. The diametrical compressive load along the height of the cylinder was applied as shown in Fig.(4) and the ultimate load at failure or rupture was noted for calculation. The maximum load when divided by the appropriate geometrical factors gives the split tensile strength of Concrete. The results of test are shown in fig. (5) & (6)

$$F_t = \frac{2P}{\pi DL}$$

Where,

P= Compressive load on the cylinder
L= Length of the cylinder
D= Diameter of the cylinder

Fig.(4) Split Tensile Strength Testing Machine

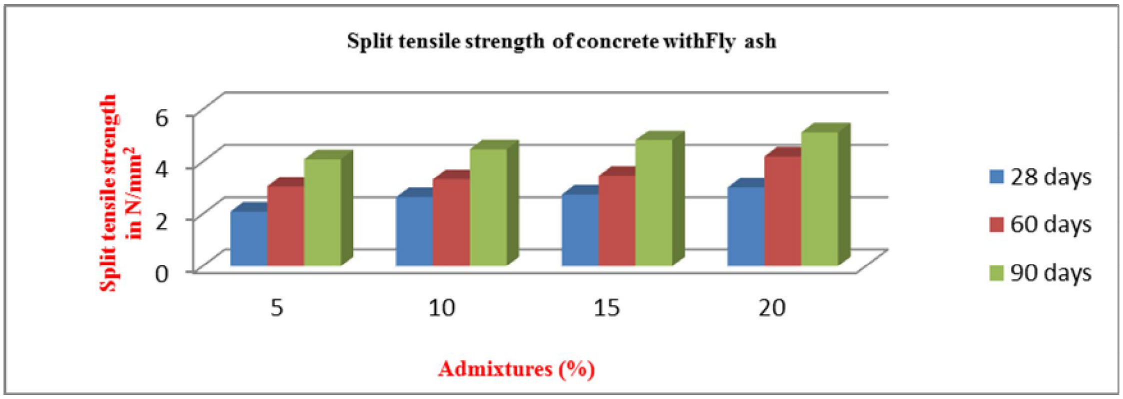

Fig.(5) Split tensile strength of concrete with Fly ash

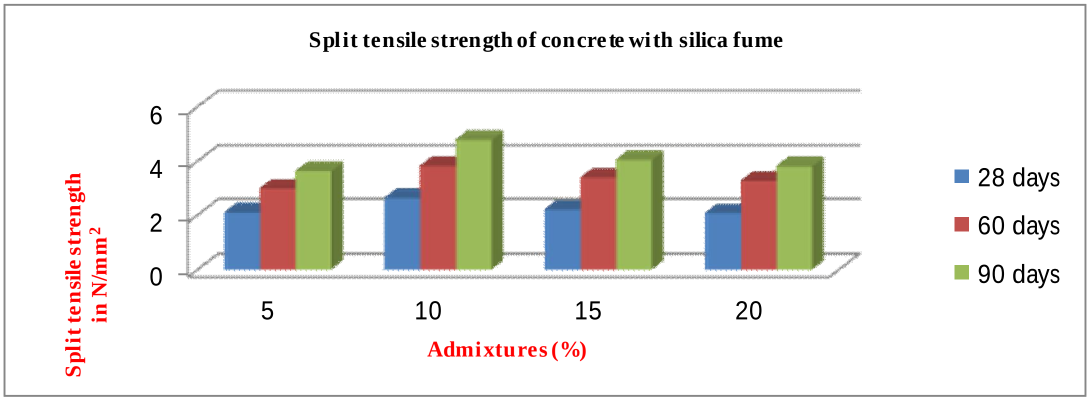

Fig.(6) Split tensile strength of concrete with Silica Fume

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C. Acid Attack Test

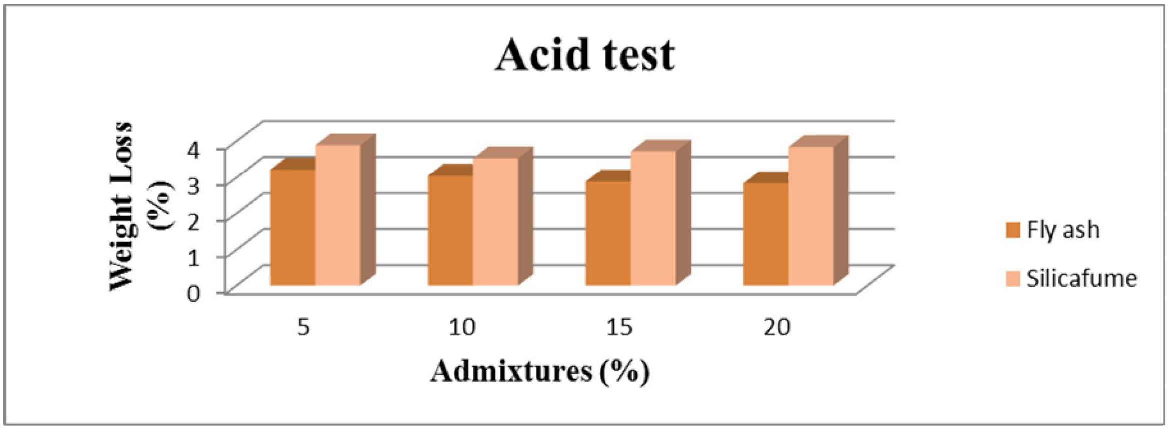
The action of acids on concrete is the conversion of calcium compounds into calcium salts of the attacking acid. These reactions destroy the concrete structure. The percentage of loss in weight was given in the following tables respectively. As per IS 516, cubes of sizes 150mm were cast and cured for 28 days. After 28 days curing cubes were taken out and allowed for drying for 24 hours and weights were taken. For acid attack 5% dilute hydrochloric acid is used. The cubes were to be immersed in acid solution for a period of 30 days. The concentration is to be maintained throughout this period. After 30 days the specimens were taken from acid solution. The surface of specimen was cleaned and weights were measured. The results are shown in table III & IV.

TABLE IIII
RESULTS OF ACID ATTACK OF CONCRETE WITH FLY ASH

Replacement (%)	Dry weight (kg)	Weight after Immersing in acid (kg)	Loss in weight (%)
0 %	8.335	8.015	3.99
5%	8.448	8.184	3.22
10%	8.600	8.345	3.05
15%	8.539	8.319	2.89
20%	8.556	8.315	2.84

TABLE IIIII
RESULTS OF ACID ATTACK OF CONCRETE WITH FLY ASH

Replacement (%)	Dry weight (kg)	Weight after immersing in acid (kg)	Loss in weight (%)
0 %	8.335	8.015	3.99
5%	8.376	8.062	3.89
10%	8.342	8.057	3.53
15%	8.214	7.919	3.72
20%	8.190	7.887	3.84



V. CONCLUSIONS

All mineral admixtures were very effective in improving the strength of concrete. It is found that compressive strength also increases with the increase in the percentage replacement up to a 10 percentage and beyond that it is found to be decrease. It appears that the water absorption values increases with the increase in the percentage replacement of fly ash beyond that it also found that water absorption values decreases with the increase in the percentage replacement of silica fume. It also indicates that the acid test values increases with the increase in the percentage replacement of fly ash, beyond that it also found that acid test values decreases with the increase in the percentage replacement of and silica fume.

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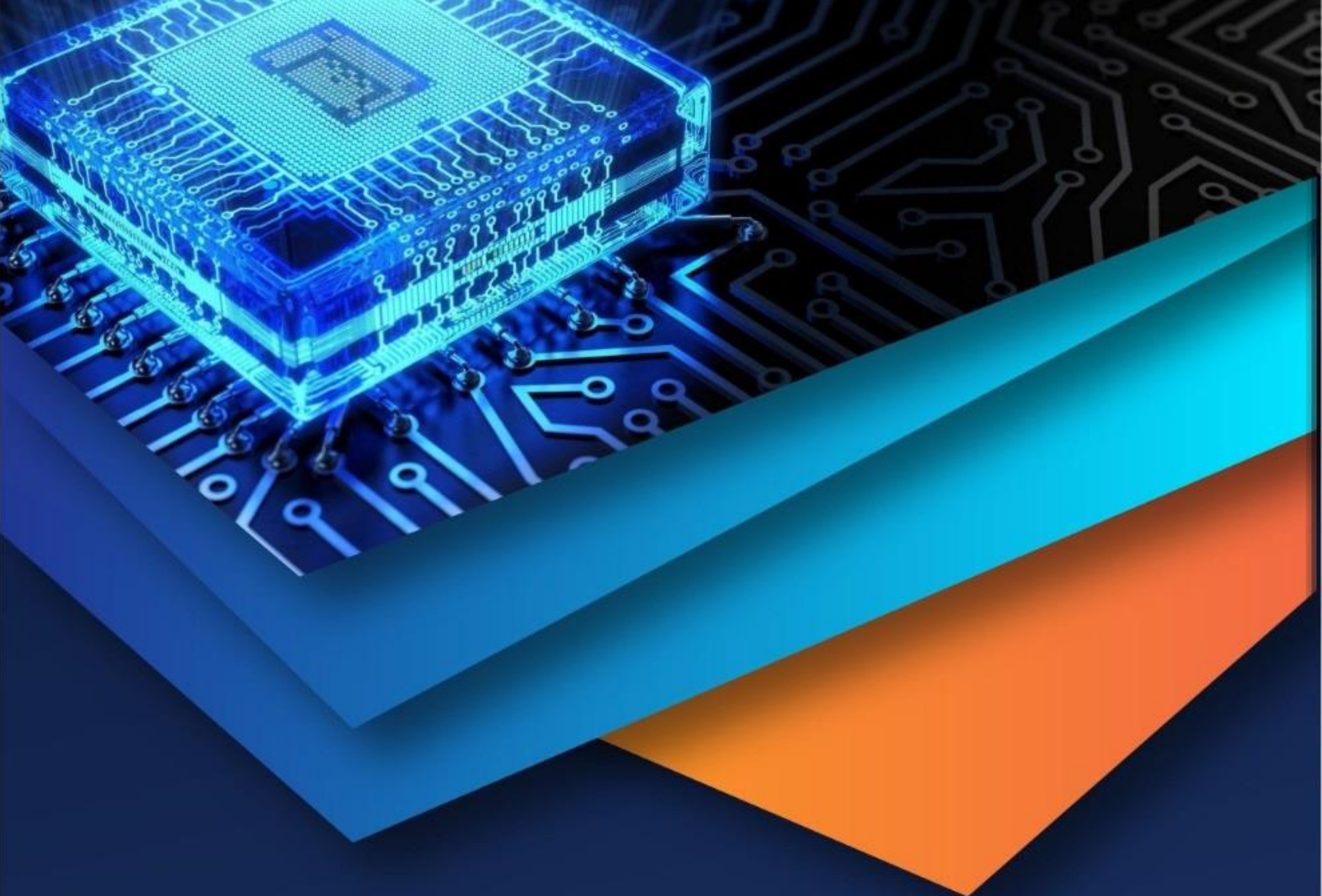

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