iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** VI **Month of publication:** June 2018

DOI: http://doi.org/10.22214/ijraset.2018.6159

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

Experimental Investigation on Strength and Durability Properties of Concrete by Replacing Natural Sand by Manufacture Sand and Fly Ash

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Abstract*: Durability of concrete is very important factor as it affects the performance of concrete. When the durability aspect of concrete taken into account, the factors affecting it should be given an important consideration as it directly affect the performance of concrete. One such factor is chemical attack on the concrete by sulphate ions (SO^{-}_{4}) which results in the volume change, cracking and consequent deterioration of concrete thus hampering its durability and reducing its strength. The objective of this experimental study is to find out the behaviour of concrete produced by replacing natural sand by Fly ash and Manufactured sand in varying percentages subjected to with sulphate attack and without sulphate attack. Magnesium sulphate solution with concentration of 5% subjected to sulphate attack for 58 days is used in present work. Thus in this research programme the prime attention will be given to find out properties of concrete produced by replacing the natural sand by Fly ash and Manufactured sand in various percentages like 0%, 20%. 40%, 60%, 80%. The mechanical properties such as compressive strength, tensile strength and flexural strength are found and compared for concrete produced by replacing natural sand by Fly ash and Manufactured sand.

Keywords*: Manufactured sand, fly ash, sulphate attack, compressive strength, split tensile strength, flexural strength.

I. INTRODUCTION

Ordinary Portland cement is an always demand, expensive and extremely important material in the construction industry. Now in India, it is evaluated that the once-a-year consumption of cement concrete is to the tune of 400metric tones. This will clearly cause an equal demand on the materials like sand, groups and other materials needed to produce huge amount of cement concrete. This will naturally cause reduction of all the valuable things from nature linked in making cement concrete every year. Also the production of huge amounts of cement needs large amount of energy, cause emission of CO2 and carry forward the connected problems. Therefore investigators are concentrating on finding out the additional cementations materials which can replace the cement partially or fully. In this direction, fly ash, blast furnace slag, silica fume, metakaolin and rice husk ash have shown a promising results to replace the cement partially. This way came into existence the blended cements. This way some of the industrial wastes are effectively used in the production of concrete. Fly ash is usually used as replacement of cement, as an admixture in concrete, and in manufacturing of cement. Whereas concrete comprising fly ash as partial replacement of cement poses problems of delayed early strength development, concrete containing fly ash as partial replacement of fine aggregate will have no delayed early strength development, but rather will increase its strength on long- term basis. Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. The dust-collection system eliminates the fly ash, as a fine particulate residue, from the combustion gases before they are discharged into the atmosphere. Manufactured sand is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand is less than 4.75mm. Manufactured sand is alternative choice for river sand. Due to wild expanding construction industry, the demand for sand has increased very, causing shortage of good river sand in most part of the word. The use of manufactured sand has been increased, due to the reduction of good quality river sand for the use of construction. Another purpose for use of M-Sand is its accessibility and transportation cost. Another important ingredient is river sand. Sand is a naturally occurring granular material composed of finally divided rock and mineral particles. As the term is used by geologists, sand partials range in diameter from 0.0625 to 2 millimeter and individual practical in this range size is termed a sand grain. The next smaller size class in geology is silt: particles smaller than 0.0625 mm down to 0.004 mm in diameter. The next larger size class above sand is gravel, with particles ranging from 2mm up to 64mm. Sand is transported by wind and water and deposits in the form of beaches, dunes, sands spits, and bars and related features.

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II. MATERIALS AND METHODOLOGY

A. *Cement*

In this experiment 43 grade ordinary Portland cement (OPC) with was used for all concrete mixes. The cement used was fresh and without lumps. The testing of cement was done as per IS: 8112- 1989. The specific gravity of cement was found to be 3.12 the physical properties of cement used are as given in table 2.1.

Table2.1. Physical properties Ordinary Portland cement

Particulars	Experimental results	As per standard
1.Normal consistency	31%	-
2. Soundness		
By Le Chatelier mould	2.00 mm	10mm
3. Setting time		
a) Initial setting	75 minutes	30 minutes minimum
b) Final setting	380 minutes	600 minutes maximum

B. *Fine Aggregate*

Locally available sand collected from the bed of river Krishna was used as fine aggregate. Sand used was having fineness modulus 3.15 and conformed to grading zone-I as per IS: 383-1970 specification.

Table 2.2 Physical properties of fine aggregate (IS: 2386 – 1963)

Properties	Results	Permissible limit as per IS : 2386 – 1963
Specific gravity	2.78	Should be between the limit 2.6- 2.7
Fineness modulus	3.15	
Bulking of sand	18%	Should not be more than 40%
Moisture content	0.60%	-

C. *Coarse Aggregate*

The Crushed stone aggregate were collected from the local quarry. Coarse aggregate use in the experimentation were 20mm and 10mm down size and tested as per IS 2386-1963 (I, II and III) specification.

Table 2.3 Physical properties of coarse aggregate (IS: 2386 – 1963)

Properties	Results	Permissible limit as per IS : 2386 – 1963
Specific gravity	2.7	In between range 2.6-3.0
Moisture content	0.2%	-

D. *Methodology*

The methodology carried out as shown below.

1) The materials were procured as per the quantities in the design and tests were performed to Evaluate the properties of materials.
2) Conventional concrete was prepared and kept as a reference mix.
3) Further, Natural sand is replaced by Fly ash and Manufactured sand in 20%, 40%, 60% and 80%.
4) Concrete cubes, beams and cylinders were casted and cures for a period of 28 days.
5) After completion of 28 days half of the specimens are immersed in magnesium sulphate ($MgSo_4$) with 5% concentration subjected to sulphate attack for 30 days.
6) After 58 days the specimens were removed and allowed to dry at room temperature. Compressive strength test, split tensile strength test and flexural strength test were performed.

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Table 2.4 Mix Design for M30 Grade

Sl. No	Material	Quantity Kg/m^3
1.	Cement	372
2.	Fine aggregate	772.84
3.	Coarse aggregate	1125.9
4.	Water	186
5.	Water-cement Proportion	0.50

III. RESULTS AND DISCUSSIONS

A. Mechanical Properties

1) *Compressive Strength Test:* The compressive strength of M30 grade of concrete with varying percentages of Fly ash & Manufactured sand. The test was conduct on 100x100x100mm cube specimens after the concrete specimens were cured for 28 days. The test procedure was carried out in accordance with IS: 516-1959 specification.

Compressive Strength = (Failure Load / Area) in N/mm^2

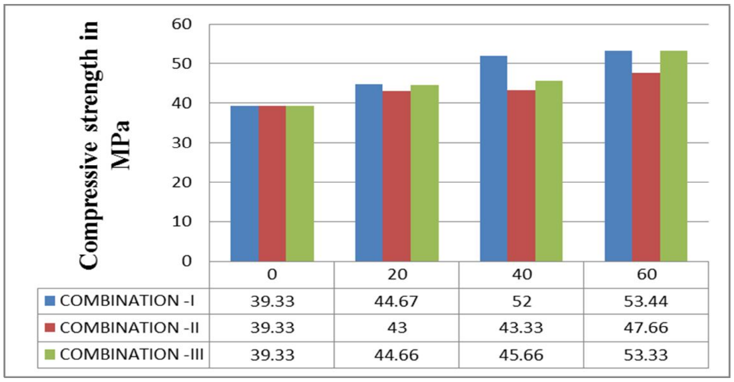

Fig.3.1 Variation of compressive strength of combination I, II and III

2) *Split Tensile Strength;* It is defines as the strength of concrete in tension. Due to the brittle nature of concrete, it is very weak in tension and take less tensile load. Whenever tensile force is applied it develops cracks and leading to failure. The test Concrete specimens for split tensile test were of 150mm diameter and 300mm height. Procedure was carried out in accordance with IS: 5816-1999.

Split tensile strength is

(2*failure load) / (π* dia. of specimen*length of specimen)

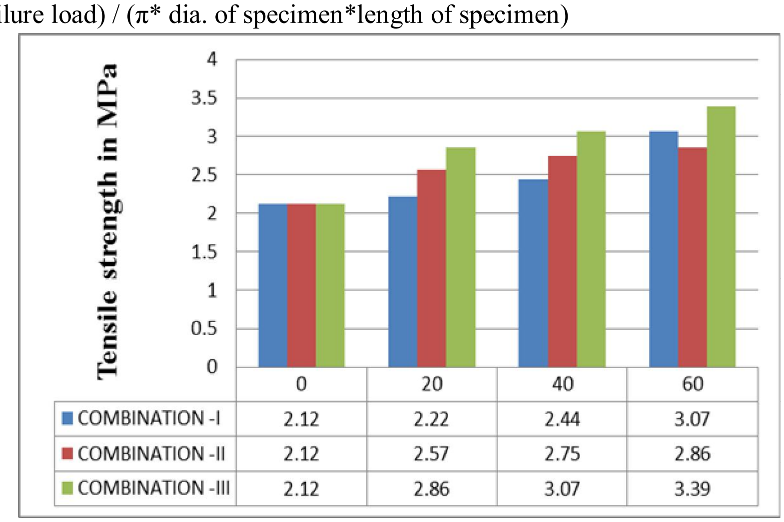

Fig. 3.2 Variation of Tensile strength of Combination I, II and III

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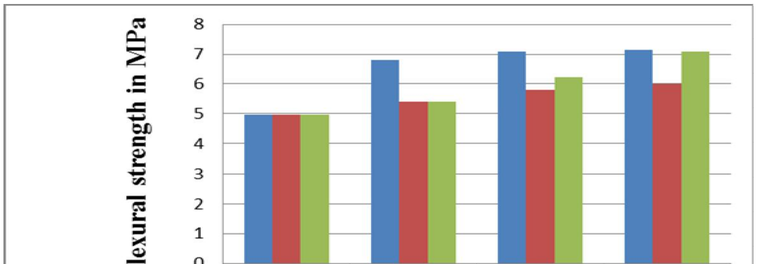
3) *Flexural Strength Test*Flexural strength of a concrete is a measure of its ability to resist bending. Flexural strength can be : expressed in terms of 'modulus of rupture'. Concrete specimens for flexural strength were of dimensions 100x 100x500 mm. The specimen is subjected to bending, using two point loading unit it fails. The distance of the loading point is 133mm and the effective span (L) is 400mm. The test procedure was carried out in accordance with IS: 516-1959 specification.



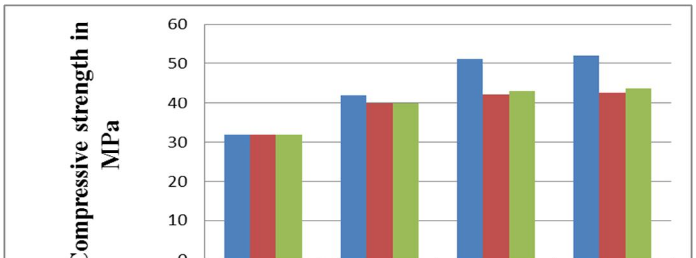
	0	20	40	60
COMBINATION -I	4.97	6.8	7.08	7.14
COMBINATION -II	4.97	5.4	5.8	6
COMBINATION -III	4.97	5.4	6.21	7.08

Fig. 3.3 Variation of Flexural strength of Combination I, II and III

B. *Durability Studies*

1) *Sulphate Attack:* For durability performance of concrete after initial curing of 28 days, half of the specimens are kept immersed in 5% Magnesium sulphate ($MgSo_4$) solution for a period of 30 days. After 58 days the specimens were removed and allowed to dry at room temperature. Compressive strength test, split tensile strength test, and flexural strength test were performed.

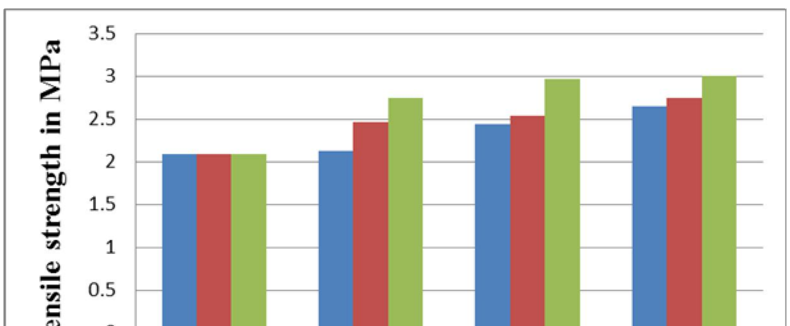
2) *Compressive Strength Test*



	0	20	40	60
COMBINATION -I	32	42	51.33	52
COMBINATION -II	32	40	42.33	42.67
COMBINATION -III	32	40	43.1	43.63

Fig 3.4 Variation of Compressive strength of combination I, II and III when subjected to Sulphate attack of 5% concentration

3) *Split Tensile Strength*



	1	2	3	4
Series1	2.09	2.12	2.44	2.65
Series2	2.09	2.46	2.54	2.75
Series3	2.09	2.75	2.97	3

Fig.3.5.Variation of Tensile strength of combination I, II and III when subjected to Sulphate attack of 5% concentration

4) Flexural Strength Test

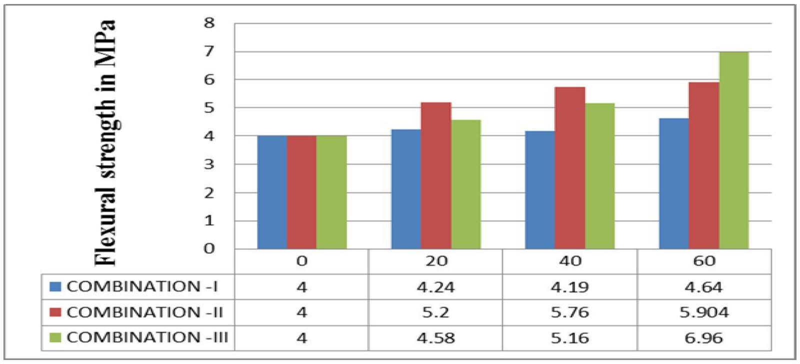


Fig.3.6 Variation of Flexural strength of combination I, II and III when subjected to Sulphate attack of 5% concentration

IV. OBSERVATION AND DISCUSSIONS

A. It is observed that the compressive strength of the concrete produced by replacing natural sand by Fly ash (combination –I) goes on increasing until 60% replacement. This may be the fact that 60% replacement level the fly ash will undergo the maximum pozzolanic reaction and also it fills effectively at all the pores of concrete so that penetration of Sulphate ions into the concrete is minimum. Thus it can be concluded that the concrete produced by replacing 60% natural sand by fly ash (combination –I) exhibits higher compressive strength.

B. It is observed that the compressive strength of the concrete produced by replacing natural sand by M-sand (combination –II) goes on increasing until 60% replacement. This may be the fact that 60% replacement level pores in the concrete are filled effectively. Thus it can be concluded that the concrete produced by replacing 60% natural sand by M-sand (combination –II) exhibits higher compressive strengthIt is observed that the compressive strength of the concrete produced by replacing natural sand by (Fly ash + M-sand)(combination –III) goes on increasing until (30% +30%) replacement. There onwards the compressive strength decreases.

This may be the fact that (30% + 30%) replacement level the (fly ash+ M-sand) will undergo the maximum pozzolanic reaction and also it fills effectively at all the pores of concrete so that penetration of Sulphate ions into the concrete is minimum.

Thus it can be concluded that the concrete produced by replacing (30%+ 30%) natural sand by (fly ash + M-sand) (combination –III) exhibits higher compressive strength

C. It is observed that the variation is obtained after comparison of compressive strength of combination I, II & III. The higher compressive strength is achieved at 60% replacement level in Combination- I than Combination – II & III.

D. Similarly above results are obtained in case of Tensile strength test & flexural strength test.

E. It is observed that the compressive strength of the concrete produced by replacing natural sand by Fly ash (combination –I) when subjected to Sulphate attack with 5% concentration goes on increasing until 60% replacement. This may be the fact that 60% replacement level the fly ash will undergo the maximum pozzolanic reaction and also it fills effectively at all the pores of concrete so that penetration of Sulphate ions into the concrete is minimum.

Thus it can be concluded that the concrete produced by replacing 60% natural sand by fly ash (combination –I) exhibits higher compressive strength

F. It is observed that the compressive strength of the concrete produced by replacing natural sand by M-sand (combination –II) when subjected to Sulphate attack with 5% concentration goes on increasing until 60% replacement. This may be the fact that 60% replacement level pores in the concrete are filled effectively.

Thus it can be concluded that the concrete produced by replacing 60% natural sand by M-sand (combination –II) exhibits higher compressive strength.

G. It is observed that the compressive strength of the concrete produced by replacing natural sand by (Fly ash + M-sand) (combination –III) when subjected to Sulphate attack with 5% concentration goes on increasing until (30%+30%) replacement. There onwards the compressive strength decreases.

This may be the fact that (30% + 30%) replacement level the (fly ash+ M-sand) will undergo the maximum pozzolanic reaction and also it fills effectively at all the pores of concrete so that penetration of Sulphate ions into the concrete is minimum.

Thus it can be concluded that the concrete produced by replacing(30%+ 30%) natural sand by (fly ash + M-sand) (combination –III) exhibits higher compressive strength.

H. It is observed that the variation is obtained after comparison of compressive strength of combination I, II & III when subjected to Sulphate attack with 5% concentration. The higher compressive strength is achieved at 60% replacement level in Combination- I than Combination – II & III.

I. Similarly above results are obtained in case of Tensile strength test & flexural strength test when subjected to 5% concentration of sulphate attack

V. CONCLUSION

A. The higher compressive strength is achieved at 60% replacement level of natural sand by fly ash (combination-I) without Sulphate attack. Thus concrete produced by replacing 60% natural sand by fly ash can resist the sulphate attack more effectively.

B. The higher Tensile strength is achieved at 60% replacement level of natural sand by (fly ash & M-sand) (combination-III) without Sulphate attack. Thus concrete produced by replacing 60% natural sand by (fly ash & M-sand) can resist the sulphate attack more effectively.

C. The higher Flexural strength is achieved at 60% replacement level of natural sand by fly ash (combination-I) without Sulphate attack. Thus concrete produced by replacing 60% natural sand by fly ash can resist the sulphate attack more effectively.

D. This may be due to the fact that at 60% replacement level the fly ash will undergo maximum pozzolanic reaction and also it fills effectively at all the pores of concrete so that the penetration of sulphate ions into the concrete is minimum.

E. It is observed that the strength of the concrete produced by replacing natural sand by fly ash and M-sand goes on increasing until 60% replacement. There onwards the strength decreases.

F. It is recommended not to exceed a replacement level of more than 60% as concrete become harsher.

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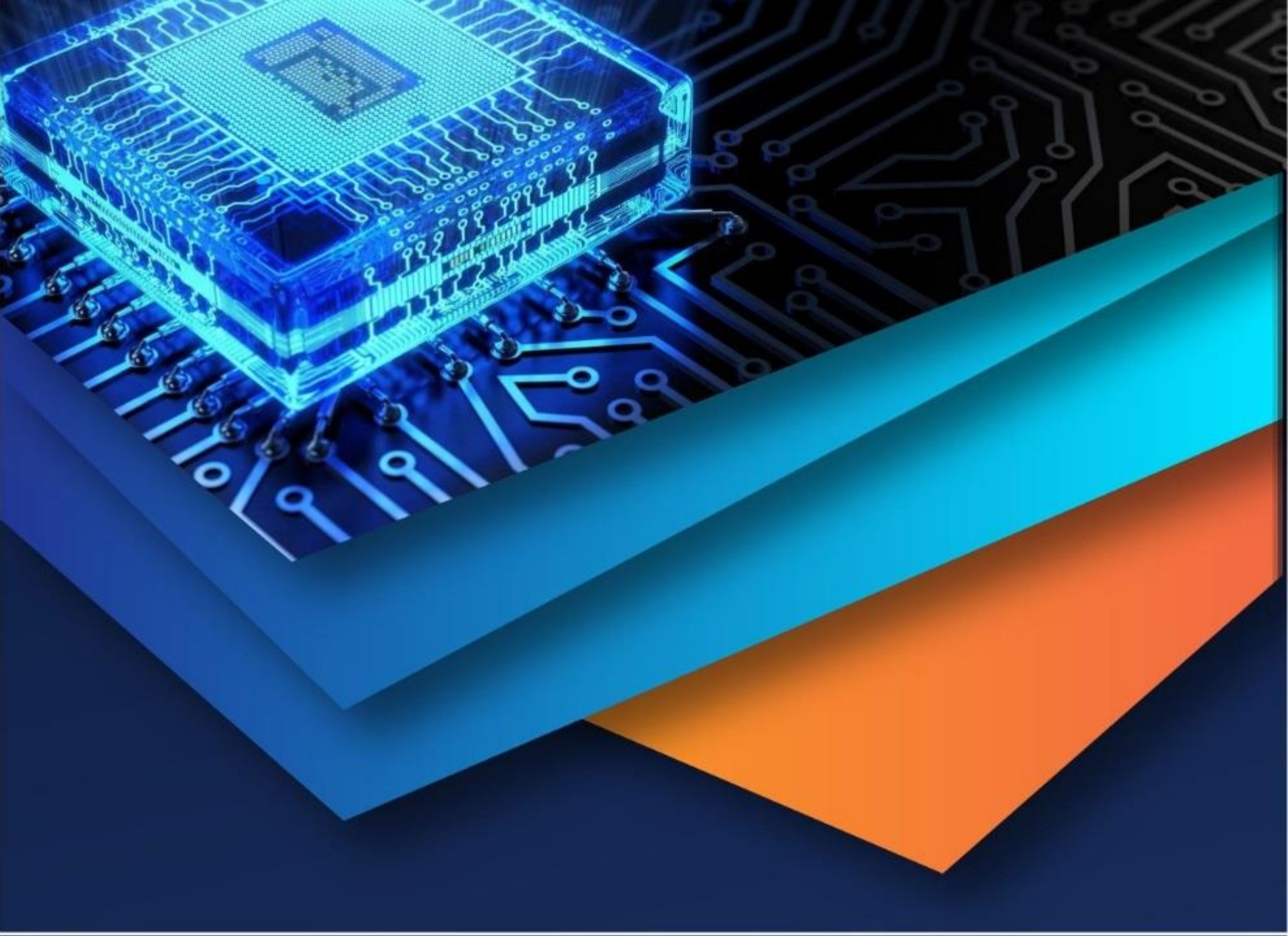

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