iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** IV **Month of publication:** April 2019

DOI: https://doi.org/10.22214/ijraset.2019.4621

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

Experimental Study of Concrete on Partial Replacement of Cement Using Rice Husk Ash and Addition of Polypropylene Fibres

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Abstract: Sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural waste components. Cement is the most important ingredient in the production of the concrete but Production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming. Rice husk is an agro-waste material and by burning it, rice husk ash is obtained which is highly pozzolanic in nature. RHA and Polypropylene fibres are used in this study to enhance the properties of concrete. This study was conducted to investigate the strength properties of rice husk ash concrete along with addition of polypropylene fibre. The properties included are the workability, compressive strength, flexural strength development of the concrete. For this, an experimental program was planned in which concrete mixes were prepared. OPC was partially replaced by RHA at 5%, 10%, 15% and 20% with addition of fibres at 0.5%, 0.75% and 1% by weight of binder. The water/binder (w/b) ratio was kept constant. The compressive strength study at different percentage of rice husk ash and the flexural strength at maximum percentage of rice husk ash with different percentages of polypropylene fibres fraction are carried out.
Keywords: Rice Husk Ash (RHA) Concrete, Polypropylene Fibres, Mix Design, Workability, Compressive Strength, Flexural Strength.

I. INTRODUCTION

Concrete is a well-known heterogeneous mix of cement, water and aggregates. The admixtures may be added in concrete in order to enhance some of the desired special properties. In its simplest form, concrete is a mixture of paste and aggregates. Various materials are added such as fly ash, rice husk, and admixture to obtain concrete of desired property. The search for any such material, which can be used as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. The use of supplementary cementitious materials (SCMs) such as fly ash, ground granulated blast-furnace slag, silica fume, metakaolin and rice husk ash as part of binders for concrete has been increasing throughout the world, particularly in the production of high strength and high performance concrete. This is due to the potential ability of these materials to enhance the properties and performance of concrete through their filler effect as well as pozzolanic reaction. The cement industry contributes over 6% to global CO_2 emissions, thus making cement production an important sector for CO_2 emission mitigation strategies, such as increasing use of pozzolanic additions. As cement industry contributes significantly to global CO_2 emissions, making cement production greener is currently a very urgent challenge. Reducing the rate of clinker production by using mineral replacements. Rice husk is an agro-waste that creates great environmental problems due to its abundance. Concrete properties can be improved by the use industrial and domestic wastes such as fly ash, rice husk ash, blast furnace slag, timber ash, steel fiber, glass fiber and plastic wastes. These wastes can be found as natural materials, by-products or industrial wastes. Dumping of these wastes on earth surface is causing the environment pollution. Rice husk ash (RHA) is a waste material, is a by-product obtained from the burning of rice husk. It has high reactivity and pozzolonic property. To conserve resources, utilization of industrial and biogenic wastes as supplementary cementing materials has become an important part of concrete construction.

Following are the writing audits on different papers in light of exploratory research regarding these type of supplementary cementitious materials in the concrete.

Bansal et al. (2015) reasoned that there was a critical change in Compressive quality of the Concrete with rice husk fiery remains substance of 10% for various evaluations specifically M30 and M60. [6]

Dangi et al. (2014) found that Rice husk fiery remains (RHA), Wheat Straw Ash (WSA), Fly Ash, (FA),Glass powder (GP) blend gives over 85% compressive quality so all waste blend can be utilized for paver squares select just a single material the recommend fly Ash with FA30 blend based on compressive quality in light of the fact that here 30% cement is spared and furthermore it gives better outcome.[7]

Khassaf et al. (2014) expressed that there can be a huge diminishment of workability in crisp fixing concrete with the expansion measure of Rice Husk Ash content in concrete and adding of Rice Husk Ash to concrete will diminish the drying shrinkage with the increment of Rice Husk Ash % replacement. [8]

Ganiron et al. (2013) researched that rice husk is relevant to concrete for inside concrete divider. The wet climate conditions cause decay of husks that influence the solidness of the concrete. [9]

Deotale et al. (2012) expressed that rice husk fiery debris concrete low workability and fly slag concrete high workability additionally expanding fibre content diminished workability. [10].

This study is carried out to verify the application of RHA concrete in the structural use by incorporating polypropylene fibres along with RHA. From the earlier studies it is found that such a study is so far not carried out. This experimental program is carried out to study the compressive strength at different percentage of rice husk ash and to study the flexural strength at maximum percentage of rice husk ash with different percentages of polypropylene fibres fraction (.5%, .75%, 1%)

II. MATERIAL USED

A. Rice Husk Ash (RHA)

RHA was collected locally from V.A.R Modern Rice Mills, located in Puduppariyaram, Palakkad Kerala.

TABLE NO.1: Physical Properties of R.H.A.

S.No.	Particulars	Properties
1	Colour	Grey
2	Shape texture	Irregular
3	Mineralogy	Non crystalline
4	Particle size	>45 micron
5	Odour	Odourless

TABLE NO.2: Chemical Properties of R.H.A. Collected

S.No.	Particulars	Properties
1	Silicon	86.94%
2	Aluminum oxide	0.2%
3	Iron oxide	0.1%
4	Calcium oxide	03.-2.2%
5	Magnesium oxide	0.2-0.6%
6	Sodium Oxide	0.1-0.8%
7	Potassium Oxide	2.15-2.30%
8	Ignition Loss	3.15-4.4%

TABLE NO.3: Sieve analysis of R.H.A.

IS Sieves	% weight retained	Cumulative % weight retained
4.75mm	0	0
2.36mm	0	0
1.18mm	0	0
600 micron	11.5	11.5
300 micron	51.5	63
150 micron	26	89
90 micron	7	96
75 00 micron	1	97
Pan	3	100

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B. Cement: Cement may be defined as the adhesive substance capable of uniting fragments or masses of solid matter to a lumped whole. Various types of cements can be used in the concrete production. It should be fresh, free from foreign matters and of uniform consistency. **OPC 53 Grade** is used in this experimental study.

TABLE NO.4: Chemical Properties of Cement

S.No.	Name	Result
1	Specific Gravity	3.17

C. Fine Aggregate

The most common fine aggregate used in the concrete is river sand. River sand is a vital ingredient in making the two most normally used construction material viz. cement concrete and mortar. The sand should be clean, hard, strong and free from the organic impurities and deleterious substances.

D. Coarse Aggregate

The aggregates are formed due to natural designation of rocks or by artificial crushing of the rock or gravel. Specific gravity and fineness modulus of aggregate is 2.65 and 6.98 respectively.

E. Water

Mixing water should be clean, fresh and potable. Water should be free from impurities like clay, loam, soluble salts which leads to deterioration in properties of concrete, Potable water is fit for mixing and curing of concrete.

F. Polypropylene Fibre

Polypropylene fibre: In this experimental investigation was collected **from Siddha Chemicals, Pune.** These are polypropylene fibres with 20mm cut length. They are used in concrete. The long length of fibres holds the different components of concrete together.

TABLE NO. 5: Physical Properties of Fibre

Fibre length	20mm
Shape	Monofilament
Acid and salt	High resistance
Absorption	Nil

G. Super-Plasticizer

TABLE NO. 6: Properties of Glenium SKY 777 super-plasticizer

Aspect	Light brown liquid
Relative Density	1.10 ± 0.01 at 25°C
pH	>6
Chloride ion content	< 0.2%

III. CONCRETE MIX DESIGN AND SLUMP VALUE

The mix design procedure adopted to obtain M25 grade concrete is in accordance with IS 10262:2009.

TABLE NO.7: Mix Proportion

w/c ratio	Cement	Fine aggregate	Coarse aggregate
0.45	451kg/m^3	699 kg/m^3	1048 kg/m^3
	1	1.6	2.4

TABLE NO.8: Mix Proportion for different % of RHA

Mix designation	Rice husk ash	Cement in kg/m^3	Fine aggregate in kg/m^3	Coarse aggregate in kg/m^3	Water in litres /m^3
M0	0%	451	699	1048	186
M1	5%	428.45	696	1044	186
M2	10%	405.9	692	1037	186
M3	15%	383.35	689	1033	186

M4	20%	360.8	685	1028	186

Table NO.9 : Concrete Mix Designations

Mix designation	Description
M0	Control concrete of Grade M25
M1	5% RHA + 95% cement
M2	10% RHA + 90% cement
M3	15% RHA + 85% cement
M4	20% RHA + 80% cement

TABLE NO.10: Slump Values

Mix designation	Slump Values
M0	75
M1	70
M2	65
M3	40
M4	40

IV. TESTING METHODS

Experimental investigation of fresh mix concrete and Rice Husk Ash concrete along with the addition of polypropylene fibre were conducted based on IS:516-1959. In this project tests such as compressive strength and flexural strength of the casted specimens were determined.

A. Compressive strength

One of the most important properties of concrete is the measurement of its ability to withstand compressive loads. This is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is to apply a load at a constant rate on a cube (150 x 150 x 150 mm), until the sample fails. The compression tests performed in this project were completed in accordance with IS standard 516 “Methods of Tests for Strength of Concrete”. The apparatus used to determine the compressive strength of concretes in this experimental work was a universal testing machine (UTM). For this study samples were tested for compression testing at 7, 14, 28 days of curing and the results are given in table no.11&12

TABLE NO. 11: Compressive strength of control concrete

Control Specimen	Compressive strength in N/mm2		
	7 days	14 days	28 days
M 25	27.84	29.84	36.19
	26.11	29.84	32.82
	26.27	29.84	32.82

TABLE NO. 12: Compressive strength of RHA Concrete

Mix Designation	Compressive strength in N/mm2		
	7 days	14 days	28 days
5% RHA	28.88	31.18	35.94
	28.84	31.16	34.45
	28.86	31.16	34.12
10% RHA	26.86	30.28	34.10
	26.86	30.28	34.14
	26.86	30.26	34.12
15% RHA	15.6	19.42	22.48
	15.9	19.46	22.5

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	15.75	19.44	22.46
20% RHA	12.82	15.54	19.2
	12.84	15.56	19.11
	12.88	15.52	19.17

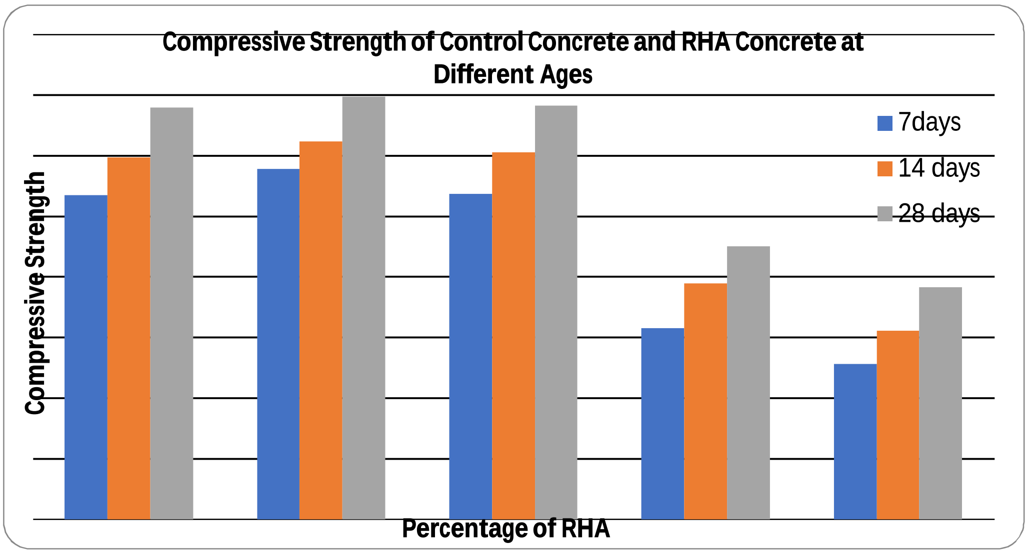
B. Flexural Strength

To study the behavior of beams under pure flexure, two point loading system was established on the beams. The beam of size 100mm x 150mm x 2200mm has been cast and it was subjected to the bad deflection test. The test is used to compare the flexural behaviour of conventional concrete beam along with the concrete beams having RHA replacement and addition of Polypropylene fibres. Comparison values are provided in the results section.

V. RESULTS AND DISCUSSIONS

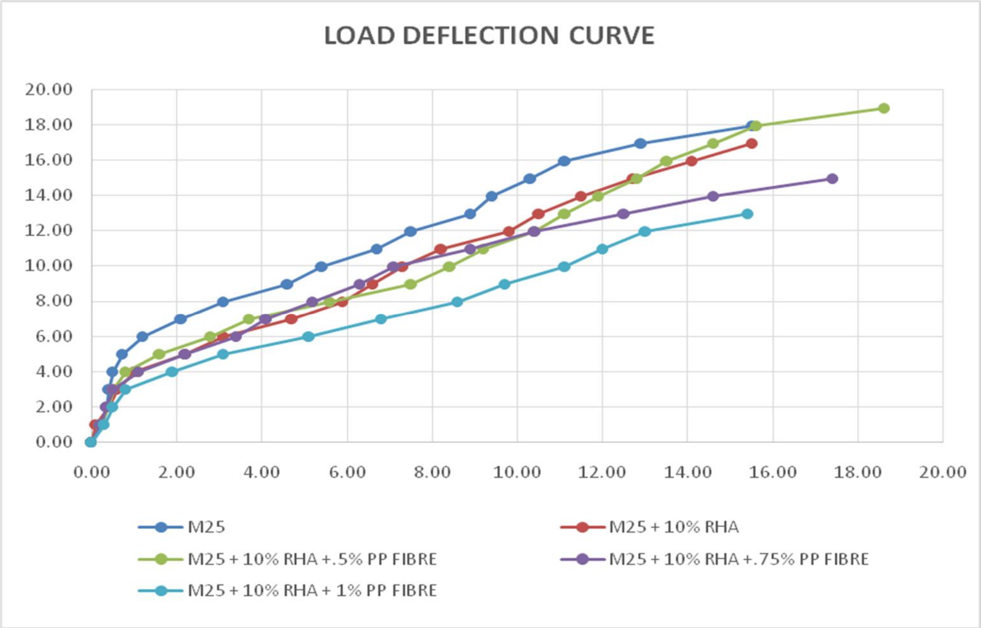
A. Effect of Age on Compressive Strength

This strength results are presented in the form of graphical variation where the compressive strength is plotted against the curing period.



B. Load Deflection Curve based on Beam Test

The results are presented in the form of graphical variation were the load in KN is plotted against the deflection in mm.



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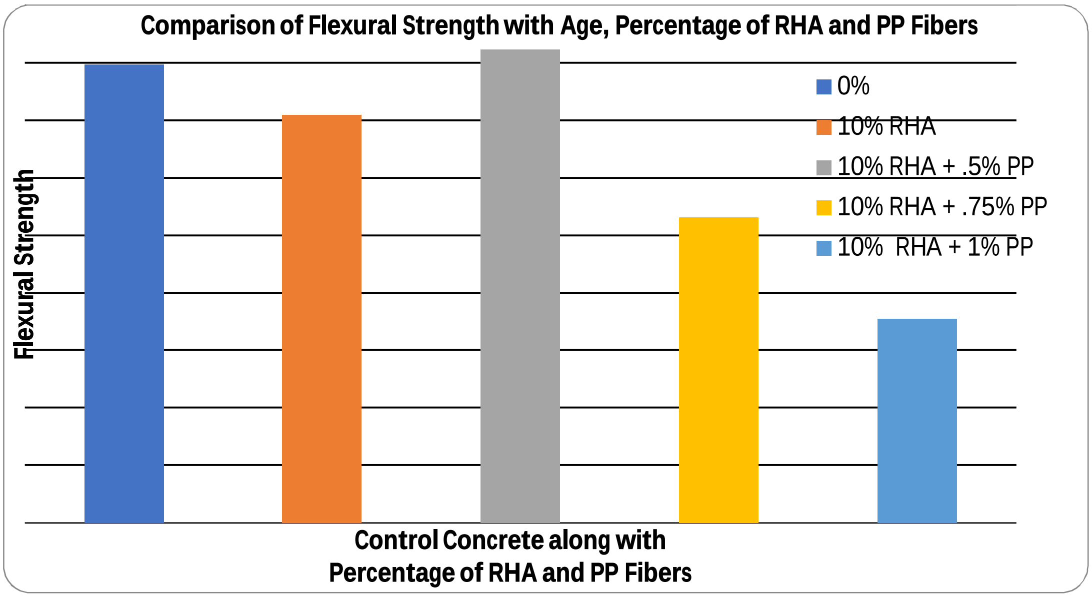
C. Variation of Flexural strength with age and percentage of RHA and Polypropylene fibers



D. Crack Formation

Most of the cracks are formed in between two point loads. At the stage of crack initiation, initial cracks developed towards the neutral axis more quickly. On further loading, new cracks were formed in all the beams for each increase in load. But the crack width in control concrete beam was smaller when compared to the other beams having RHA and PP Fibers. No shear cracks are appeared until failure. This may be due to sufficient shear reinforcement.

FIG NO. 1: Crack pattern in rectangular beam

TABLE NO.13: Load applied during crack formation and load at failure

Sl. No	Beam	Property	Load at crack formation (KN)	Load at failure (KN)
1	R-I	Rectangular Beam of M25	8.968	17.935
2	R-II	Rectangular Beam of M25+10% RHA	7.971	16.939
3	R-III	Rectangular Beam of M25+10% RHA + .5% PP fibres	8.968	18.932
4	R-IV	Rectangular Beam of M25+10% RHA + .75% PP fibres	5.978	14.946
5	R-V	Rectangular Beam of M25+10% RHA +1% PP fibres	3.986	12.953

TABLE NO.14: Comparison of crack width of control specimen along with specimens replaced with RHA and polypropylene fibres

Sl.No	Beam	Property	Load at failure	Crack width in mm
1	R-I	Rectangular Beam of M25	17.93	4
2	R-II	Rectangular Beam of M25+10% RHA	16.94	4
3	R-III	Rectangular Beam of M25+10% RHA + .5% PP fibres	18.93	3
4	R-IV	Rectangular Beam of M25+10% RHA + .75% PP fibres	14.95	5
5	R-V	Rectangular Beam of M25+10% RHA +1% PP fibres	12.95	7

VI. CONCLUSION

The following conclusions can be drawn from the experimental investigation carried out:-

A. As the replacement of cement by RHA in concrete mix increases, the workability of concrete mix had been found to be decrease.

B. The addition of RHA in concrete was found to increase the compressive strength at 10% replacement as compared to control mix whereas further addition of RHA at 15% and 20% decreases the compressive strength.

C. The load deflection curve has been plotted based on flexural strength test.

D. The inclusion of polypropylene fibres into RHA concrete mix increases the flexural strength at .5% fibre content with 10% RHA replacement as compared to control mix whereas at .75% and 1% fibre content decreased flexural strength. The addition of RHA in concrete mix was found to increase the flexural strength at 10% replacement.

E. As flexural cracks appeared at the middle part of the span and with further loading, flexural cracks began to get distributed around the middle part and increased in their lengths and widths.

F. Addition of polypropylene fibres have significant role in the crack width formation. In this experiment fibre content of 0.5% along with 10% RHA replacement shows less crack width as compared to control mix, RHA concrete and the combination of RHA concrete with 0.75% and 1% fibre content.

G. By using this Rice husk ash in concrete as replacement the emission of green house gases can be decreased to a greater extent. As a result there is greater possibility to gain more number of carbon credits.

H. The technical and economic advantages of incorporating Rice Husk Ash in concrete should be exploited by the construction and rice industries, more so far the rice growing nations of Asia.

I. The pozzolonic activity of rice husk ash is not only effective in enhancing the concrete strength but also reduces the cost of construction as it is a waste material.

VII. SCOPE FOR FUTURE WORK

A. In the present study the Flexural Strength of RHA beam concrete with PP fibres is found to be the same as that of the plain concrete beam, the present work can be extended to study the polypropylene replacement in the cement concrete.

B. In the present study influence of RHA and Polypropylene fibres on compressive and flexural strength were investigated it can be extended for higher percentage of RHA and polypropylene fibres along with higher grade of concrete.

C. Other innovative low cost locally available materials that can be used, as mineral admixtures are required to be developed.

D. The study can be carried out with varying percentage replacement of the material for specific low cost housing applications.

E. The engineering properties like water absorption, reduction in weight of concrete, effect of temperature of RHA concrete with polypropylene fibres can be further studied.

F. The study can be extended to assess the durability aspects of the concrete with varying replacement proportions.

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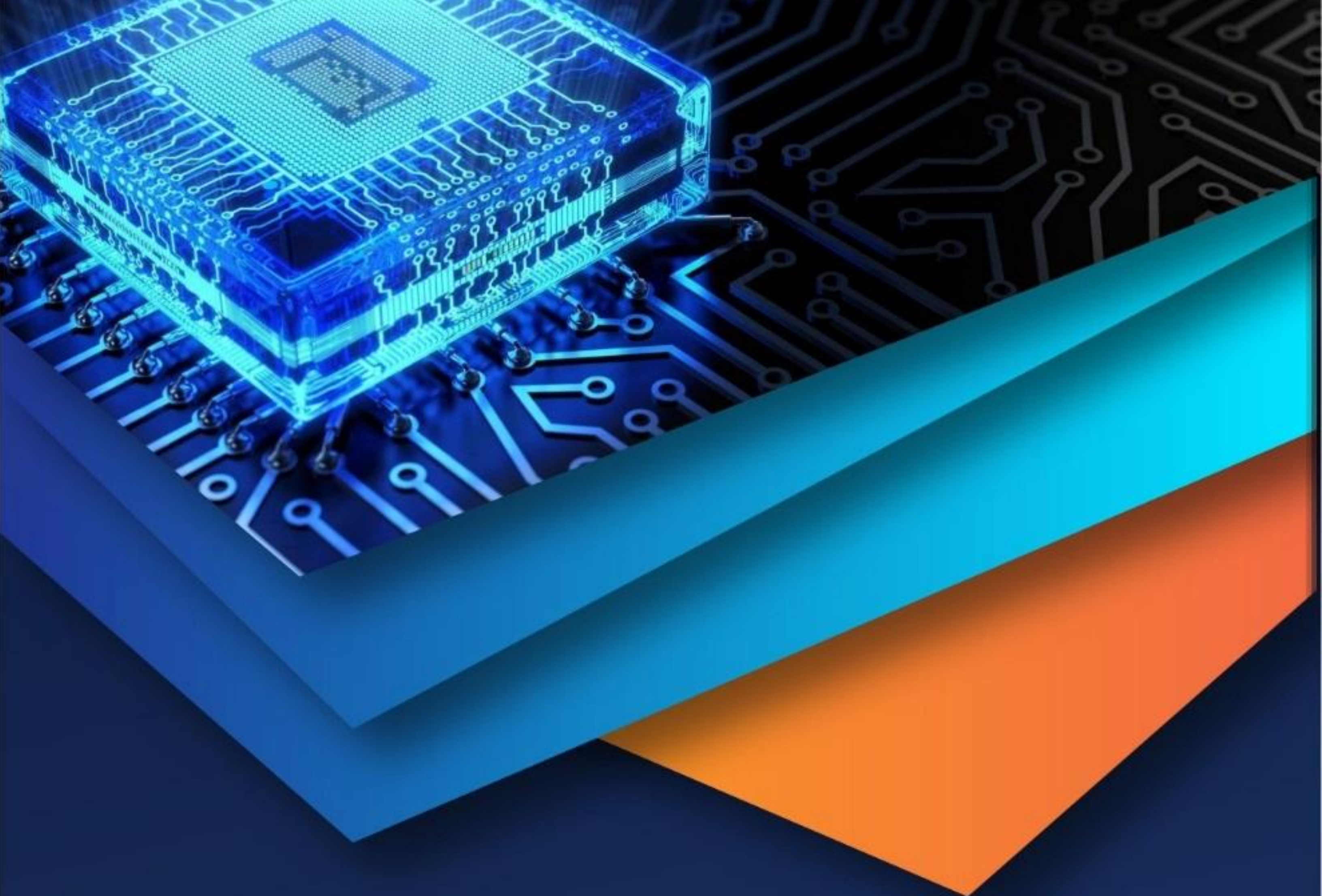

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