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Enhancing the Strength Properties of the Concrete by Partial Replacement of Conventional River Sand with Plastic Waste Fibers

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Abstract: Urbanization is growing day by day with respect to time so the infrastructure also developing in chronologically ascending order, a major part of the construction infrastructure is concrete in the words, concrete is the most significant material in the construction industry, concrete is made of four basic ingredients water, cement, fine aggregate, and coarse aggregate from which coarse and fine aggregates are chemically inert materials they do not perform any chemical formation therefore the replacement of the fine aggregate can be possible with the chemically inert material which fulfill the mechanical strength criteria, in this research replacement of the fine aggregate is done with the waste plastic fibers to enhance the strength and durability without compromising the workability of the concrete, at replacement of 1.5% of fine aggregate with plastic waste fibers increase the compressive strength by 11.7% and flexure strength by 17%, but workability is reduced by 7 mm on the slumpcone workability test.
Keywords: PW- Plastic waste, PWF- plastic waste fiber, CA- Coarse aggregate, FA- Fine aggregate, RAC- Recycled aggregate concrete.

I. INTRODUCTION

A. Introduction

The construction industry is increasing day by day concerning time due to infrastructure development and continuous urbanization, infrastructure consists of transportation infrastructure as well as building infrastructure.[15] A major part of the construction infrastructure is concrete in the words, concrete is the most significant material in the construction industry. Concrete is made of four basic ingredients water, cement, fine aggregate, and coarse aggregate.

Cement act as a binding material that performs the chemical reaction with water called the hydration process, for hydration 23% by weight of cement water is required for the process of hydration but we apply 15% more water as gel water.[9] Fine aggregate is filled in the voids of the coarse aggregate, with approximately half the volume of the fine aggregate applied in the voids of the coarse aggregate.[7]

Coarse and fine aggregates are chemically inert materials they do not perform any chemical formation, therefore, the replacement of the fine aggregate can be possible with the chemically inert material which fulfills the mechanical strength criteria.[7]

B. Construction Sustainability

Sustainability is to fulfill the present need without compromising the future needs, in the construction industry concrete is a vital element, and concrete aggregate natural products abstract from the conventional source cannot be recharged in the other words the conventional source of aggregate are nonrenewable and depleted day by day. Depletion of natural sources results in unsustainable construction and solid waste accumulation is also a big problem for the sustainability of infrastructure development. Recycling concrete with the help of the replacement of the conventional aggregate can leads to sustainability by saving natural conventional sources as well as reducing solid waste accumulation.

C. Plastic Waste Fibers

Plastic waste fibers are produced from the waste plastic material, these are long thread-like structures used to make carpets and bags, Strength of this material is quite good it is a chemically inert material, and ductile so it can increase the flexure strength and tenacity of the concrete. [7]It can be used in concrete due to its chemically inert behavior.

Figure 1 Plastic waste and plastic waste fibers

Plastic waste production in India- In India many products made up of plastic are banned, there is an eco-friendly alternative available in the Indian market, but still, annual plastic waste produced in India is very large, according to "Shwaksh Bharat Mission" India's plastic waste production is 5.5 million ton which is double in every five years. Per day plastic waste production is 15342 tons, 60% of the plastic waste is recycled in India but the rest is 6136.8 tons of plastic waste causing the solid waste accumulation.[15]

II. LITERATURE REVIEW

I. Waste accumulation is increased in the present time - Solid waste is increased day by day due to the overuse of non-recycled waste. EIA Annual energy outlook (2005) & United Nations World Urbanization Prospects(2016)- Demonstrate the strong squander amassing issue agreeing to wage lesson and urbanization of populace, and its unsafe effect over the period due to critical increase in urban populace and strong squander amassing, Singapore utilizing 100% of its reuse C&D squander in modern development and repair works. India is additionally created a few reuse aggregate plants Guideline of Environmental Management of Construction & demolition waste march 2017 shows working plants such as Burari (New Delhi), Sastri Park (New Delhi), Ahmadabad, Vikroli Mumbai, East Kiwai Nagar (New Delhi) with capacities as 500ton/day -2009 or 1200ton/day-2014 or 2000 ton/ day – permission, 500 ton/day, 100 ton/day, 1500ton production in 2002-06 respectively.

II. Plastic waste fibers- Ravpreet Kaur at el. (2020) gives the utilization of the plastic fiber concrete on the basis of the mechanical properties,. This experimental analysis is based on the property enhancement of the concrete by application of the fibers in the concrete. Paper In the past thinks about Steel fiber strengthened concrete, it has been set up that the execution of concrete can be upgraded by joining strands from squandering materials from the commercial advantage and natural angle. Fortifying concrete with steel filaments (SFRC) increments the ductile quality of concrete in this manner making strides in its delicate behavior. The major applications of SFRC are burrow lining, underground structures, and flooring. The examination displayed states that the lightweight concrete when consolidated with the squander steel from fortification and formworks with distinctive fiber substance surrender the comparable results as the as of now examined fiber strengthened concrete support and formworks with diverse fiber substance abdicate the comparable results as the as of now considered fiber fortified concrete.

Berestianskaya and Galagurya (2020) In this experimental analysis, concrete made with fibers was tested at high temperature to determine the behavior of concrete concerning temperature rise. In the experimental set up three samples are tested for strength (compressive and tesile as well as) and found fiber concrete shows accent brittleness with respect to the rise of temperature.

Bhagatkar and Nikhar (2020) In this experimental analysis concrete is made up of glass fibers to increase the strength criteria, compressive strength, and flexure strength is increased in concrete made up with Glass fibers. In the concrete, glass fibres were added in proportions of 0%, 0.50%, 1.0%, and 1.50% by volume, with each addition increasing by 0.50%. The findings of numerous experiments were compared in this study.

Nishane and Thakre (2017) In this experimental analysis comparison is done between the concrete made by different fibers such as Plastic fibers, Glass fibers, Steel fibers, and Aramid fiber, for glass and steel fortification, the quality of concrete expanded with, expanded in fiber measurement up to 0.5 % as compared to glass fiber, aramid fiber gives 48% more compressive quality, while when comparing aramid and steel fiber, aramid gives 66% expanded compressive strength. Aramid fortified concrete creates gigantic compressive quality as here, the aramid strengthened concrete is presenting compressive quality as rising to M35 review in the plan of M20 review.

V. S. PARAMESWARAN(1970) In this exploratory examination fiber support is utilized to improve the quality of the concrete this ponder states that Precast and in situ concrete buildings are progressively utilizing cement and concrete networks strengthened with arbitrarily adjusted brief filaments. Steel, polypropylene, and glass strands are as of now utilized in load-bearing basic components; in any case, natural and characteristic strands are right now being considered as macro reinforcement in cement and concrete lattices. Fiber strengthened concrete composites inquire about and improvement started in India within the early 1970s. Fiber concrete innovation is now not limited to research facility considerations; it is presently utilized within the making of precast concrete components as well as within the fortifying and repair of concrete structures in situ. Flooring and material components, channels, sewer vent covers and outlines, precast thin-wall parts, blast-resistant developments, and money vaults are all cases of current utilization.

III. METHODOLOGY

A. Material

Concrete is made up of four basic elements such as water, cement, fine aggregate, and coarse aggregate. And plastic fibers are used to enhance the strength properties of conventional concrete. Cement- Cement is utilized as folio fabric of concrete, PPC cement is utilized with a comparing review of 43N/mm2 (PPC cement does not have grades but OPC cement has reviews 33, 43, and 53).

Properties of cement	Detail of results and permissible limits
Consistency	29.5%
Initial setting time	71 minute > 30 minute(minimum permissible value for PPC)
Final setting time	212 minutes < 600 minutes (Maximum permissible value for PPC)

Table 1 Mechanical properties of the cement

1) Fine aggregate: Fine aggregate as waterway sand of Zone-II is utilized, it is an inactive fabric utilized to fill the void of coarse aggregate and make cover mortar with cement, have properties as follows -

Properties	Value
S.G.	2.7
F.M.	3.80
W.A.	0.8%

Table 2: Properties of fine aggregate

2) Coarse aggregate: 20mm coarse aggregate is used as coarse aggregate filler in the concrete with as following mechanical properties-

Property	Values (Conventional Coarse Aggregate)
Specific gravity	2.90
Size of Aggregates	20mm
F.M.	7.00
W.A.	0.25%

Table 3 Mechanical Properties of coarse aggregate (conventional coarse aggregate)

3) Plastic fibers: plastic fibers are taken from the waste plastic recycling industry as posses as following

Property	Values (Plastic fibers)
Specific gravity	0.90-0.96
Average diameter	0.035 mm
Average length	6 mm
Tensile strength	300-400 MPa
Elastic modulus	3.8
L/D (length to diameter ratio)	171.42

Table 4 Properties of the plastic fibers

B. Method of Sample Preparation

The preparation of the concrete is done for laboratory testing to check strength and durability criteria in the following steps-

(1) Control sample is produced without any additive fibers.

(2) Conventional fine aggregate is replaced by plastic fibers by 0.25%, 0.50%,0.75%,1.0%, and 1.25% .

(3) Samples are tested for workability from the slump cone test.

(4) samples are tested for compressive strength and split tensile test and comparison with control samples.

C. Nomenclature of the Samples

Name of the concrete samples are in the format of CN

where C= Concrete and N is plastic Fiber waste percentage.

eg: C0.5 = concrete with 0.5% plastic fibers.

IV. RESULTS AND ANALYSIS

A. Fresh Concrete Results

Workability- A slump cone test is performed to determine the workability of the concrete, results are as follows-

Sample	Slump value in mm
Control sample	41
C0.25	38
C0.50	36
C0.75	35
C1.0	32
C1.25	31

Table 5 Workability results

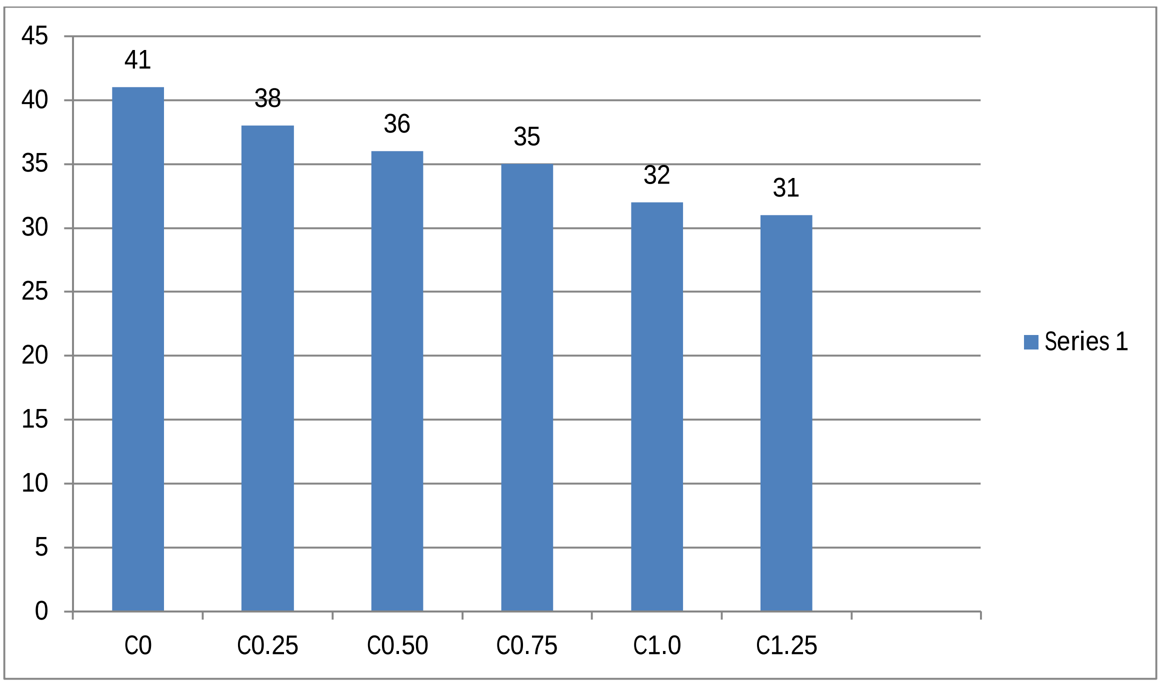

Figure 2 Workability results

Workability is dropping with respect to the alteration of the concrete therefore alteration of the concrete is possible up to a certain limit to serve under the permissible limit of the workability.

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B. Hard Concrete

1) Compression Strength Test: Compression test is conducted on the samples cubes of 15cm x15cm x15cm as following-(M25 concrete i.e. characteristic strength = 25MPa)

% Replacemen	Compressive Strength (N/mm²)		
	7 Days	14 Days	28 Days
0%	22.30	31.00	33.70
0.25%	23.05	32.50	35.20
0.50%	24.15	33.00	37.15
0.75%	24.60	33.05	37.80
1.0%	25.10	34.00	38.60
1.25%	23.50	32.25	36.20

Table 6: Compressive Strength of Cubes

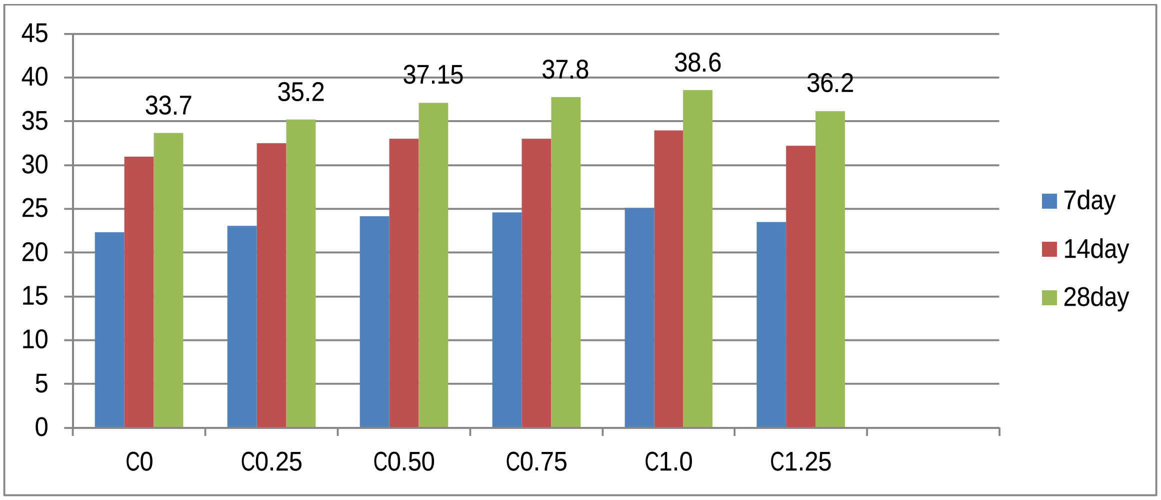

Figure 3 Compressive Strength of Cubes

The strength of the concrete is increasing up to 1% replacement after 1% replacement the strength is decreasing.

2) Spit Tensile Strength Test: Split tensile strength test results are as follows-

% Replacement	Tensile Strength (N/mm²) M-25
0%	4.05
0.25%	4.20
0.50%	4.39
0.75%	4.55
1.00%	4.75
1.25%	4.55

Table.7: Tensile Strength at 28 days

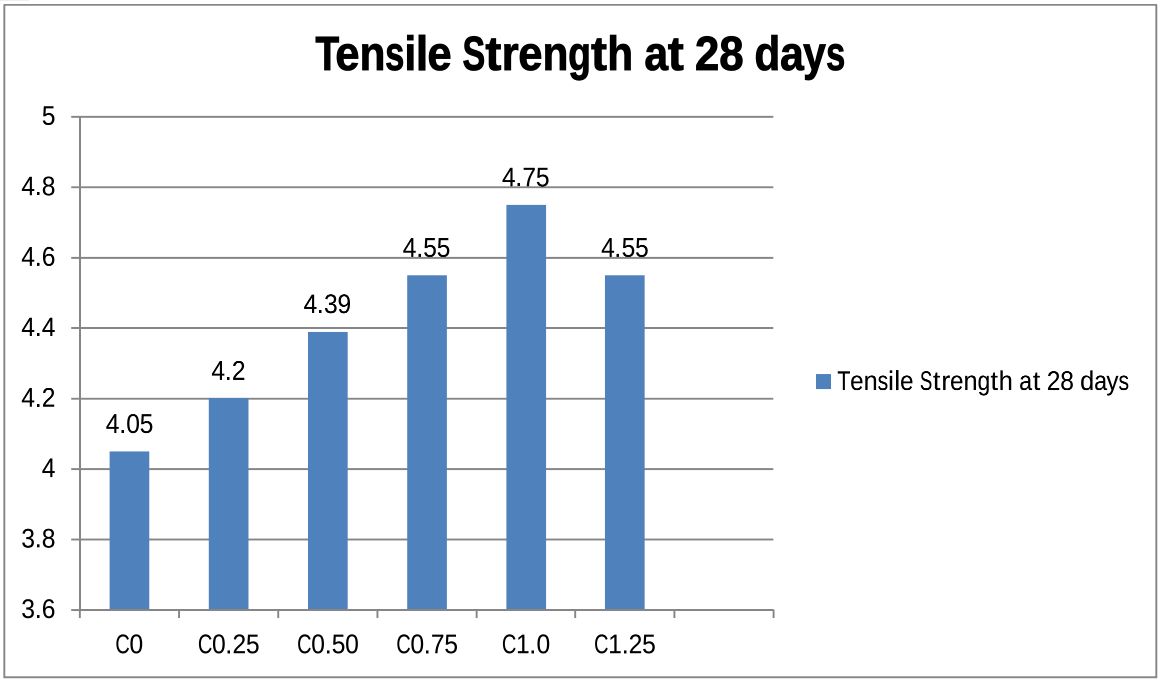

Figure 4 Tensile Strength at 28 days

The strength of the concrete is increasing up to 1% replacement after 1% replacement the strength is decreasing.

V. CONCLUSION

1) Workability is in decreasing manner due to interlocking in between the particles, it becomes stiffer concerning replacement.
2) The optimum value of plastic waste fiber in concrete is 1.00% of fine aggregate which is obtained based on compression and tensile strength criteria.
3) At the optimum value of replacement slump value is reduced by 9mm.
4) At the optimum replacement of fine aggregate with plastic fibers compression strength increased by 14.5% and the tensile strength of the concrete increased by 18.50%.
5) Increment in tensile strength is more dominating with respect to conventional fine aggregate replacement with plastic fiber.

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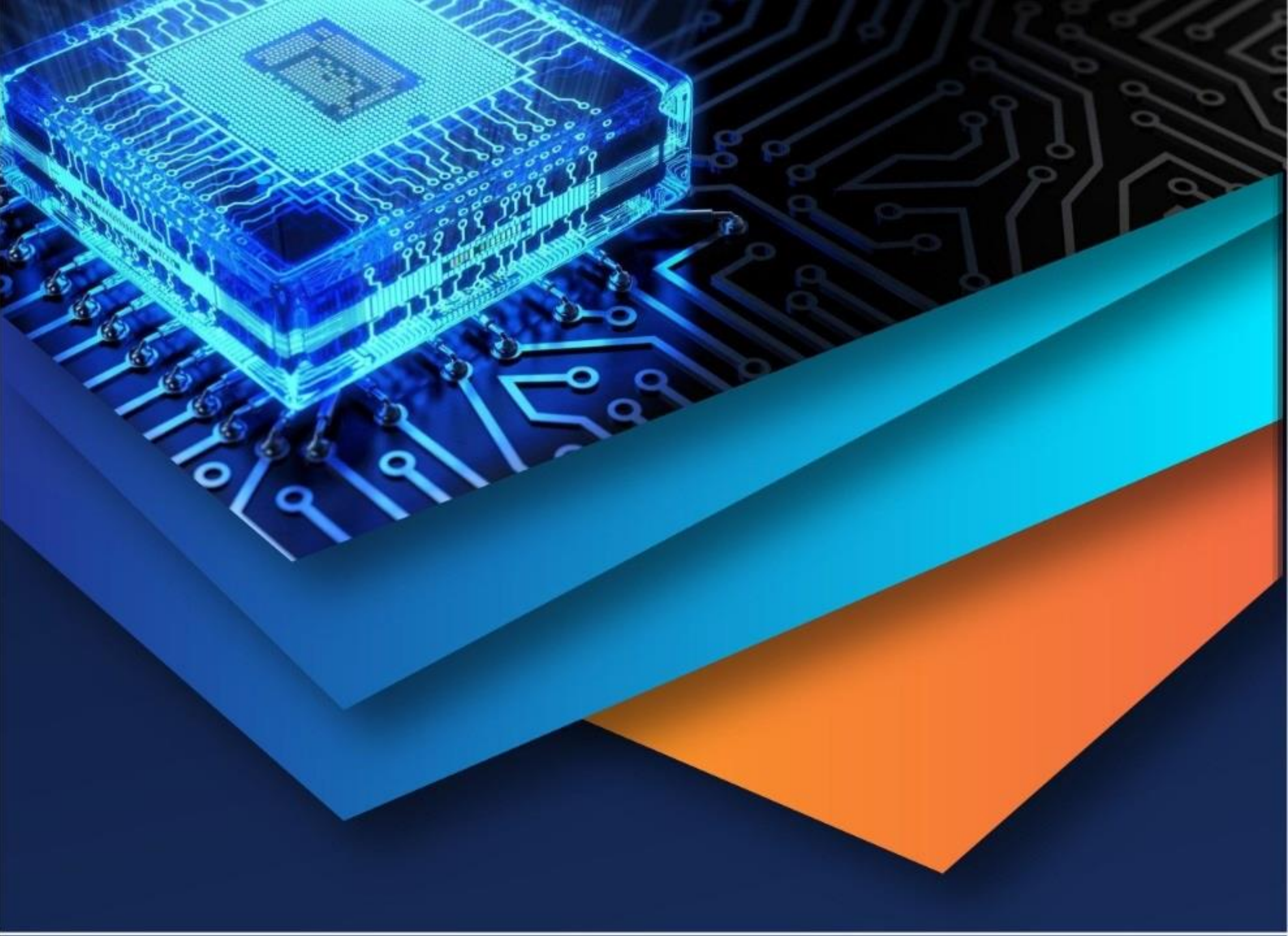

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