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Partial Replacement of Cement with Alccofine to Enhance the Mechanical Properties of Concrete

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Abstract: ***In the construction field, supplementary cementitious materials (SCMs) have brought about a technological revolution in the manufacturing of concrete as a partial replacement or addition to conventional binder mass. Keeping this in mind, this paper aims to summarise and discuss the reported findings on the mechanical and durability properties of alccofine-1203 based concretes. It is also aimed to give a better understanding of the behaviour and effect of alccofine-1203 as an SCM in various types of concretes. The alccofine-1203 has ultra-fine particles with a unique chemical composition that improves the hydration process and pozzolanic reaction. Therefore, its incorporation in concrete has resulted in good workability, reduction in segregation, reduction in heat of hydration, and reduction in permeability to concrete, and increased the rate of hydration process and improved the pozzolanic reaction to achieve high strength to concrete at the early curing stage. The presence of calcium (CaO) and silica (SiO2) in alccofine-1203 improved the mechanical and durability properties of concrete better than the other SCMs. From the literature review, the optimum dosage of alccofine-1203 is obtained between 8% to 12%, and at these percentages, the improvement in mechanical and durability properties of the concrete is highest.***

Keywords: Alccofine , strength , supplementary cementious material.

I. INTRODUCTION

General: Cement production significantly contributes to environmental pollution due to substantial carbon dioxide emissions. To mitigate this, substituting cement with supplementary cementitious materials (SCMs) is crucial. This approach addresses environmental concerns, resource depletion, and rising cement costs. SCMs, such as fly ash, ground granulated blast furnace slag (GGBS), silica fume, and others, possess pozzolanic properties, enabling them to enhance concrete strength and durability. Utilizing SCMs reduces cement consumption, thereby decreasing environmental impact. Furthermore, these materials are often derived from industrial waste, offering a sustainable solution to waste disposal.

Recycling industrial waste into SCMs provides economic, technical, and environmental benefits. The global adoption of SCM-based concretes is increasing due to their eco-friendly nature and performance advantages. SCMs are employed as mineral admixtures or partial cement replacements, driving the development of sustainable concrete. The implementation of SCMs lowers carbon dioxide emissions from cement plants and minimizes the extraction of raw materials. It also facilitates the safe disposal of industrial waste. Recent advancements have introduced Alccofine, a micro-mineral SCM produced by Ambuja Cements Pvt Ltd. Alccofine is available in three types: Alccofine-1101, Alccofine-1203, and Alccofine-1206, each with varying calcium content. Alccofine-1101 is used for grouting and soil stabilization. Alccofine-1203 and Alccofine-1206 are low-calcium silicate materials used in the production of high-strength and high-performance concrete. Alccofine-1203, conforming to ASTM C 989–99 standards, is an eco-friendly, microfine material with high glass content and reactivity. Its use promotes sustainable construction practices by reducing reliance on traditional cement. The adoption of SCMs, including Alccofine, is a vital step towards minimizing the environmental impact of the construction industry.

II. REPLACED CONCRETE

Alccofine is replaced in place of cement by 5%, 10%, 15%. The cement was replaced in combinations with Alccofine . That is replacement of cement with alccofine at a time in single mix.

ALCCOFINE

Alccofine is a dense pore structure with some CaO components induced in it improves the secondary hydrated product as it increases the strength in shorter and longer time span.

Alccofine have better particle size distribution compared to other Supplementary Cementations Materials which provides dense matrix pore structure resulting in to reduced water contains and batter workability. Alccofine has the lime contain 34% which provides more quantum of secondary hydrated product. This results in prolonged chemical reaction and responsible for reduced heat liberated by the hydration process. Alccofine has batter particle packing which results into increased rheology resulting in to improved flow ability. The study aims on the comparative study on the concrete cubes. M25 grades of concrete was made and used two different water cement ratio after conducting slump cone test, 0.4, 0.45 and 0.5 . These include a control mixture containing 4,8,12,16,17,20,25,50,75 and 100% Alccofine as cement replacement. The specimens casted are undergone curing at atmospheric temperature. The specimen is tested for 7 and 28 days curing. A large number of cubes were cast and subjected to normal curing at atmospheric temperature. The compressive strength was determined 7 and 28 days.

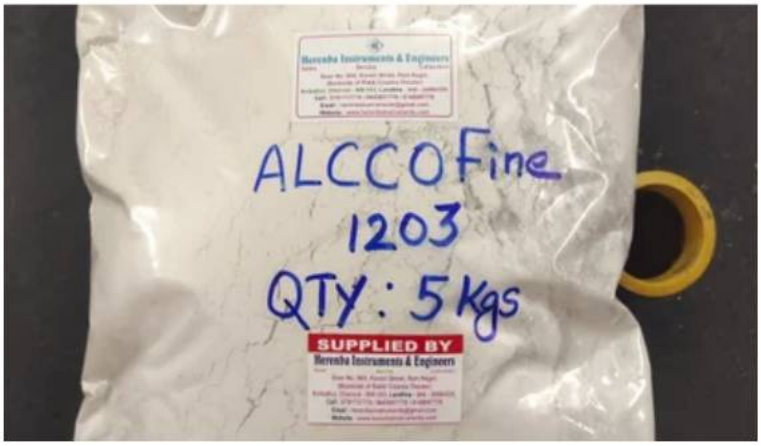


Fig: Alccofine

SPECIFIC GRAVITY AND WATER ABSORPTION OF ALCCOFINE

Alccofine is a brand of micro-fine ground granulated blast furnace slag (GGBFS), which is often used as a partial replacement for cement in concrete. The specific gravity and water absorption characteristics of Alccofine are important to understand its behavior in concrete mixtures.

Here are typical values for these properties:

1) *Specific Gravity of Alccofine:* The specific gravity of Alccofine generally ranges from 2.8 to 3.0. It is important to note that specific gravity can vary slightly depending on the specific type or batch of Alccofine used.
2) *Water Absorption of Alccofine:* Alccofine, like other fine powders, tends to have very low water absorption when compared to aggregates. The water absorption of Alccofine typically ranges from 0.5% to 1.0%. This can vary based on factors like the particle size distribution and the surface texture of the material.

For precise values, it is always recommended to refer to the technical datasheet provided by the manufacturer of the specific Alccofine product you are using, as these properties can vary slightly based on the production process

For analyzing the suitability of these alccofine in the concrete mix, compressive strength test and split tensile strength test is conducted for 7, 14 and 28 days curing periods by casting concrete specimen to analyze the strength variation by different percentage of this waste materials. This present study is to understand the behavior and performance of these materials in concrete. The alcoofine is used to partially replace cement by 5%, 10%, and 15%.

III. ENVIRONMENTAL AND ECONOMIC BENEFITS OF REPLACED CONCRETE

The environmental and economic benefits of partially replacing cement with Alccofine in concrete are significant. Environmentally, cement production is a major source of CO2 emissions, contributing to global climate change. By using Alccofine, which is a byproduct of industrial processes, the overall carbon footprint of concrete is reduced. Alccofine's use lowers the demand for cement, resulting in less energy consumption and fewer greenhouse gas emissions. Additionally, it enhances the durability and longevity of concrete, leading to structures that require less maintenance and have a reduced environmental impact over time.

Economically, the partial replacement of cement with Alccofine can lead to cost savings. Alccofine is often more affordable than cement, and its use can lower material costs in large-scale concrete production. Its ability to improve the strength and durability of concrete also means that less material may be needed for the same performance, further reducing overall costs.

Additionally, the extended lifespan and reduced maintenance requirements of concrete with Alccofine contribute to long-term savings in construction projects. In summary, the environmental and economic benefits make Alccofine an attractive alternative to traditional cement in concrete production.

IV. OBJECTIVES

1) Determine how Alccofine-1203 affects concrete strength.
2) Find the best amount of Alccofine-1203 to use in concrete.
3) Measure concrete strength at 7, 14, and 28 days of curing.
4) See if Alccofine-1203 is a good replacement for some cement.
5) Help make concrete more environmentally friendly.
6) Understand how Alccofine-1203 changes how concrete sets.
7) Compare Alccofine-1203 to other cement replacement materials.
8) Evaluate the cost and environmental benefits of using Alccofine-1203.

V. TESTING

QUANTITIES OF MATERIALS FOR CUBES

s.No	Mix Designation	Cement In Kg	Fine Aggregate In Kg	Coarse Aggregate	Alccofine In Kg (5%,10%, 15%)	w/c Ratio
1.	C0	12.15	20.95	34.44	0	0.45
2.	C10	11.52	20.95	34.44	0.625	0.45
3.	C20	10.9	20.95	27.55	1.25	0.45
4.	C30	10.3	20.95	24.11	1.85	0.45

Mix calculation for 1 cylinder
Volume of cylinder = 0.15 *0.3
= $\pi/4 \times d2 \times h$
= $\pi/4 \times 0.152 \times 0.3$
= 5.30 × 103 m3
Total volume of cylinder in 1 m3 = 188.62 m3
Mass of cement in 1 cylinder = 400/188.62 = 2.12 m3
Mass of Fine aggregate in 1 cylinder = 690/188.62 = 3.65 m3
Mass of coarse aggregate in 1 cylinder = 1134/188.62 = 6.012 m3

TABLE: QUANTITIES OF MATERIALS FOR CYLINDERS

s.No	Mix Designation	Cement In Kg	Fine Aggregate In Kg	Coarse Aggregate In Kg	Alccofine (5%, 10%, 15%)	w/c Ratio
1.	C0	19.08	32.913	54.09	0	0.45
2.	C1O	18.12	32.913	54.09	0.954	0.45
3.	C20	17.172	32.913	54.09	1.908	0.45
4.	C30	16.218	32.913	54.09	2.862	0.45

VI. RESULTS AND DISCUSSIONS

TABLE : RESULTS OF CEMENT TESTS

S.NO	TESTS ON CEMENT	RESULTS
1	Fineness of cement	25%
2	Standard consistency of cement	34%
3	Initial setting time of cement	0
4	Final setting time of cement	5mm

5	Specific gravity of cement	3.16

TABLE :RESULTS OF FINE AGGREGATE TESTS

S.NO	TESTS ON FINE AGGREGATE	RESULTS
1	Specific gravity of fine aggregate	2.6
2	Water absorption of fine aggregate	1.6%
3	Sieve analysis of fine aggregate	3.78

TABLE : RESULTS OF COARSE AGGREGATE

S NO	TESTS ON COARSE AGGREGATE	RESULTS
1	Specific gravity of coarse aggregate	2.64
2	Water absorption of coarse aggregate	0.62%
3	Sieve analysis of coarse aggregate	3.49
4	Impact value of coarse aggregate	18.06%
5	Aggregate crushing value	16.6%
6	Flakiness of coarse aggregate	36.8%
7	Elongation of coarse aggregate	48.9%

TABLE: RESULTS OF ALCCOFINE TESTS

S.NO	TESTS ON ALCCOFINE	RESULTS
1	Specific gravity of alccofine	2.6
2	Water absorption of alccofine	0.82%

WORKABILTY:

Slump Cone Test:

The test was conducted for fresh concrete prepared before the moulding process. A total mix proportions of replaced concrete are prepared at different times. Workability Results from slump cone test for M30 grade of concrete is shown in table:

TABLE : WORKABILITY OF CONCRETE

S.NO	MIX DESIGNATION	SLUMP CONE (mm)
1	C0	72
2	C1O	86
3	C20	101
4	C30	112

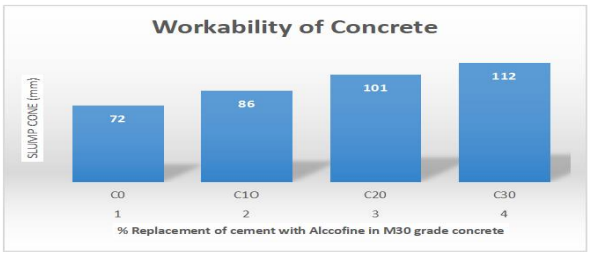
Where

Co = Conventional concrete for M30 grade.

C10 = 5% Replacement of cement with Alccofine in M30 grade concrete.

C20 = 10% Replacement of cement with Alccofine in M30 grade concrete.

C30 = 15% Replacement of cement with Alccofine in M30 grade concrete.



Graph: Workability of concrete

The above graph shows the workability of M30 grade of concrete by slump cone method. The result shows that decrease in workability of concrete by replacing cement with Alccofine with different proportions. The workability of concrete decreased with increasing the proportion of Alccofine.

Compressive strength

A total of 36 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days testing each specimen after conducting the workability tests. The results are tabulated below:

TABLE :COMPRESSIVE STRENGTH OF CONCRETE

S.NO	MIX DESIGNATION	REPLACED CONCRETE WITH ALCCOFINE (5%,10%,15%)	COMPRESSIVE STRENGTH N/mm2		
			7 DAYS	14 DAYS	28 DAYS
1.	C0	0	22.21	26.43	31.42
2.	C10	5%	25.30	28.46	33.02
3.	C20	10%	27.87	32.32	38.40
4.	C30	15%	28.02	31.76	39.18

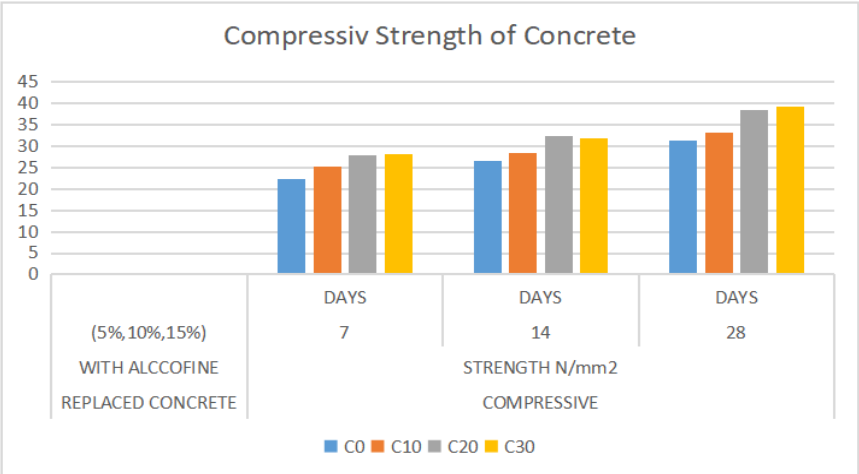
Where

C0 = Conventional concrete for M30 grade.

C10 = 5% Replacement of cement with Alccofine in M30 grade concrete

C20 = 10% Replacement of cement with Alccofine in M30 grade concrete.

C30 = 15% Replacement of cement with Alccofine in M30 grade concrete.



Graph :compressive strength for M30 grade of concrete

The above graph shows the compressive strength of M30 grade of concrete. The result shows that increase in strength of concrete by replacing cement with Alccofine with different proportions. It clearly shows that strength increased by replacing the materials compared to conventional concrete. The optimum strength is obtained for 8% and 14% replacement of Alccofine in cement and concrete.

Tensile strength

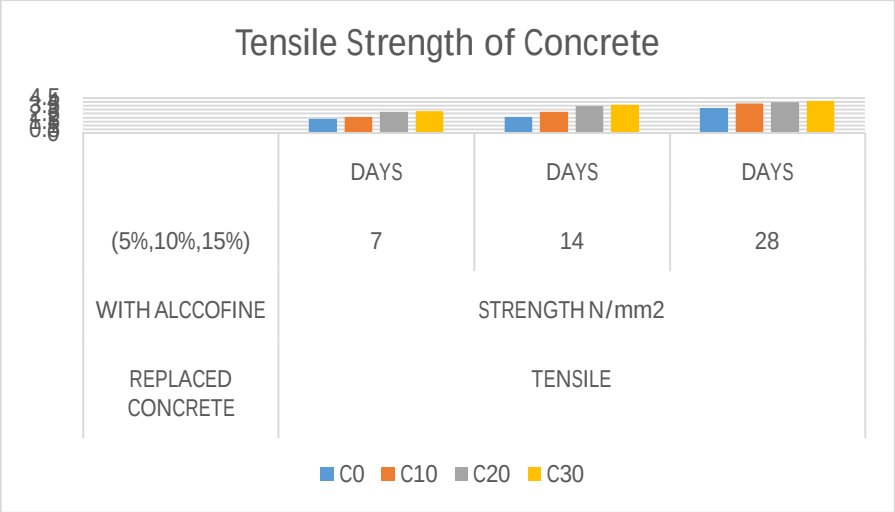
A total of 36 cylinders of size 150mm diameter and 300mm height were casted tested for 7 days, 14 days and 28 days testing each specimen after conducting the

Workability tests. The results are tabulated below:

TABLE : TENSILE STRENGTH OF CONCRETE

S.NO	MIX DESIGNATION	REPLACED CONCRETE WITH ALCCOFINE (5%,10%,15%)	TENSILE STRENGTH N/mm2		
			7 DAYS	14 DAYS	28 DAYS
1	C0	0	1.87	2.12	3.3
2	C10	5%	2.11	2.76	3.8
3	C20	10%	2.76	3.5	4
4	C30	15%	2.89	3.7	4.2

C0 = Conventional concrete for M30 grade.
C10 = 5% Replacement of cement with Alccofine in M30 grade concrete
C20 = 10% Replacement of cement with Alccofine in M30 grade concrete.
C30 = 15% Replacement of cement with Alccofine in M30 grade concrete.



Graph: Tensile Strength for M30 grade of concrete

The above graph shows the tensile strength of M30 grade of concrete. The result shows that increase in strength of concrete by replacing cement with alccofine with different proportions. It is clearly shows that strength is increased by replacing the materials compared to conventional concrete. The optimum strength is obtained for 4% and 8% replacement of Alccofine in cement and concrete.

VII. CONCLUSION

Summary

The testing of concrete specimen shows the following results

Undergoing compressive strength test, the maximum compressive strength of concrete when partially replaced by alccofine was found maximum to be at 15% for both 7 days,14 days and 28 days.

There was not a big nominal change when cement was replaced up to 5% but when it reached 15% the compressive value recorded was maximum, then on further addition of alccofine the compressive strength values goes on decreasing.

The increase in percentage of compressive strength for 7 days, 14 days and 28 days curing was found to be maximum at 15% replacement.

Alccofine when added in concrete mix exhibits nice permeability parameters which results in resistance against corrosion.

CaO present in alccofine when combines with water under mix, provides high resistance against chemical and acid attacks.

VIII. SCOPE FOR FUTURE STUDY

1) Objective : Investigate the effect of partial replacement of coarse aggregate with alccofine on the properties of concrete (e.g, Workability , Compression Strength , Durability)

2) Scope : Replacement a specific percentage of cement with alccofine compare the concrete's performance against a control mix.

To study the behaviour of coconuts shell with various volume fraction of steel fibre in concrete was studied through the following methodology.

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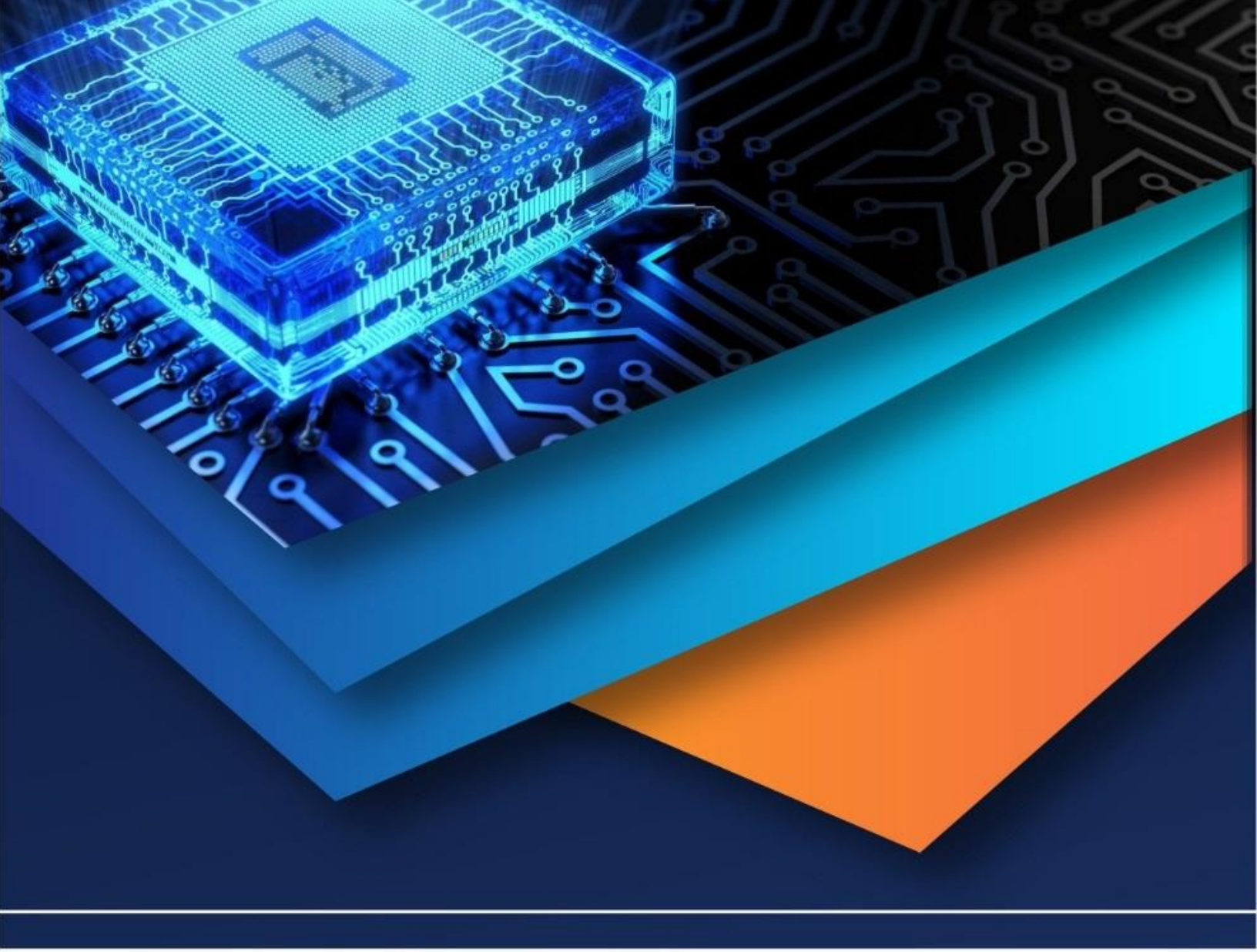

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