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Durability Study of Self Compacting Concrete Containing Fly Ash, Lime Stone and Sugarcane Bagasse

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Abstract: Self-compacting concrete (SCC) is a unique kind of concrete that can flow and fill form work or moulds under its weight without the aid of vibration or mechanical compaction. SCC is accomplished using a specifically formulated mix that contains high-range water-reducing admixtures (super-plasticizers) and viscosity-modifying agents. Excellent workability, great flowability, and the capacity to pass through densely packed reinforcement without segregation are just a few of SCC's special qualities. SCC has many advantages, including increased construction efficiency, lower labor costs, improved durability, and better surface polish. The present study focuses on the durability properties of concrete mixes, which were designed using control, binary, and ternary cementitious systems. In the environment, wastes such as Fly Ash (FA), limestone (LS), and agro-industrial waste such as sugarcane bagasse ash (SCBA) are used as partial replacements for cement. Optimum replacement of cement with a combination of FA (30%), SCBA (10%,15%&20%), and limestone (10%,15%&20%). The durability properties of the different mixes were also assessed using tests for sulphate resistance, sorptivity, water absorption, water impermeability, and porosity. Based on the results, the optimal mix proportion was identified as 10%SBA +15%L, with 75% OPC.
Keywords: SSC, Sugarcane Bagasse, M-sand, Conplast SP430, Fly Ash, Limestone

I. INTRODUCTION

Self-compacting concrete (SCC) is an innovative and versatile material in the field of construction. Unlike traditional concrete, SCC doesn't require the use of mechanical vibration to eliminate air voids and ensure proper compaction. It possesses exceptional flow-ability, allowing it to effortlessly fill intricate formwork and reach even densely reinforced areas. SCC's self-consolidating properties not only make construction processes more efficient but also result in smoother and aesthetically pleasing surface finishes.Super-plasticizers play a crucial role in the formulation of Self-Compacting Concrete (SCC), enhancing its unique properties. These high-range water-reducing admixtures are employed to significantly improve the workability and flowability of SCC without compromising its strength or durability. Superplasticizers effectively disperse the cement particles and reduce the water content required for the mix, resulting in a more fluid and self-consolidating mixture. This not only enables SCC to effortlessly flow into complex formwork and densely reinforced areas but also helps in achieving a more uniform and high-quality concrete with reduced voids. Superplasticizers are essential for tailoring the rheological properties of SCC, allowing for precise adjustments to meet the specific needs of a project. They are a fundamental component in creating SCC that is both easy to handle during construction and maintains its structural integrity, making it an invaluable tool in modern construction practices.This specialized concrete is widely used in a range of construction applications, such as high-rise buildings, precast concrete production, bridges, and infrastructure projects. It offers the advantage of reduced labor intensity, improved concrete quality, and a more comfortable and eco-friendly construction environment due to its noise and vibration reduction properties. SCC has become a preferred choice for modern construction, contributing to the efficiency and durability of structures.

II. MATERIALS USED

The materials that are used in the production of self compacting concrete are cement, fly ash, fine and coarse aggregate, limestone, sugarcane bagasse and super plasticizer. Using agricultural waste like sugarcane bagasse as a partial replacement for cement in construction materials is a concept related to sustainable and ecofriendly construction practices. This approach aims to reduce the environmental impact of cement production and disposal of agricultural waste while also potentially improving the material properties.Sugarcane bagasse is a fibrous residue left over after sugarcane juice extraction.

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It can be processed and used as a supplementary cementitious material due to its pozzolanic properties. Pozzolanic materials react with calcium hydroxide (a byproduct of cement hydration) in the presence of water to form additional cementitious compounds, contributing to the strength and durability of the material. M-sand, or manufactured sand, is a type of fine aggregate that is produced by crushing rocks or stones to create sand-sized particles. It is an alternative to natural river sand and is primarily used in the construction industry for various applications like concrete production, plastering, and masonry work. M-sand has a consistent particle size and shape, which can lead to improved workability and strength in concrete compared to natural sand.

The fine aggregate used in this study isM sand (passing through 4.75 mm sieve). Fine aggregate is conformed to the grading zone II as per IS 383-2016. The gradation test results have been shown in the table I represent the gradation chart. The other physical properties of the aggregates such as specific gravity, bulk density and water absorption are determined in accordance with IS 2386-2007 and the results are tabulated in the Table I. Coarse aggregate used here are 10mm as per IS 383-2016. The physical properties of the aggregates such as specific gravity, bulk density and water absorption are determined in accordance with IS 2386-2007 and the results are tabulated in the Table II. Conplast SP430 is a type of superplasticizer, which is a chemical admixture used in concrete to improve its workability and flow characteristics while maintaining or enhancing its strength. The benefits of using fly ash as a replacement for cement in SCC are similar to those in conventional concrete, including improved strength, durability, reduced permeability, and environmental advantages. The use of limestone as an SCM can lead to improved workability, reduced heat of hydration, enhanced durability, and reduced permeability of concrete. Additionally, incorporating limestone can mitigate the need for landfill disposal of waste limestone, which is often a byproduct of various industries.

Table I Gradation test of M sand

Sieve size (mm)	% passing	Zone 2 range as per IS 383-2016
4.75	99.97	90-100
2.36	87.72	75-100
1.18	61.97	55-90
0.60	43.28	35-59
0.30	19.88	8-30
0.15	6.47	0-10

Table II Properties of Coarse aggregate

Characteristics	Coarse aggregate properties
	10mm
Specific gravity	2.68
Water absorption (%)	0.80
Bulk density (g/cc)	1.60

III. MIX DESIGNS

The European Guidelines for Self Compacting Concrete" are a cutting-edge guide for specifiers, designers, buyers, producers, and users who want to improve their knowledge of and usage of SCC. The European Project Group used the breadth of experience and expertise at its disposal to produce the Guidelines.

TABLE III Mix Ratio

MIX ID	FLY ASH (%)	SBA (%)	LIME STONE (%)	CEMENT (kg/m³)	COARSE AGGREGATE (kg/m³)	MSAND (kg/m³)	FLY ASH (kg/m³)	LIME STONE (kg/m³)	SBA (kg/m³)	SUPER PLASTICIZER (lit/m³)	WATER (lit/m³)
SSC1	30	-	-	386	784.9	841.02	165.7	-	-	3.3	196.6
SSC2	30	10	-	347.4	784.9	841.02	165.7	-	38.6	3.3	196.6
SSC3	30	-	10	347.4	784.9	841.0	165.7	38.6	-	3.3	196.6
SSC4	30	10	10	308.8	784.9	841.02	165.7	38.6	38.6	3.3	196.6
SSC5	30	15	10	289.5	784.9	841.02	165.7	38.6	57.9	3.3	196.6

IV. EXPERIMENTAL INVESTIGATION

Industrial wastes contaminate the environment, wastes such as Fly Ash (FA), lime stone (LS) and agro-industrial waste such as sugarcane bagasse ash (SCBA) are used as partial replacements for cement. Optimum replacement of cement with combination of FA (30%), SCBA (10%, 15%, 20%) and lime stone (10%, 15%, 20%). For each composition, the fresh properties of SCC are experimentally investigated by Slump cone test, L box test, J ring test & U box test. The concrete cubes were cast and cured. Some of the important tests that have to be carried out in order to satisfy the requirements of self-compacting concrete, the test procedure and result are as follows.

Table IV Permissible range for self-compacting concrete

Test	Permissible Range
V FUNNEL	8 to 12 sec
L BOX	10mm
J RING	0 to 30 sec
INVERT SLUMP	650mm to 850mm

Table V Fresh properties on concrete

Mix Id	Slump Flow	J-Ring	L-Box	V-Funnel
	RANGE 650-800(mm)	RANGE 0-30(sec)	RANGE 0-10(mm)	RANGE 8-12(sec)
SCC1	720	20	7	10
SCC2	710	22	9	12
SCC3	690	21	9	9
SCC4	700	18	6	9
SCC5	700	21	7	8

The compressive strength is measured as per the IS 516 (1959). The moulds used for the compression test is 100mm X100mm X100mm. Immediately after mixing, the concrete is filled into a cube mould. After 24 hours the cubes are removed from the mould and immersed in clean fresh water until taken out for testing.

V. RESULTS AND DISCUSSIONS

Concrete's performance is assessed based on its fresh and hardened properties. The compressive strength of concrete is the most essential property, and it is widely accepted that an improvement in concrete compressive strength will improve its mechanical properties. However, in concrete where cement is largely substituted by mineral admixtures, not all mechanical properties are directly connected with compressive strength, because effects of the same amount of different mineral admixtures on the mechanical properties of hardened concrete are not known.

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1) Slump Flow Test

Slump flow test of self compacting concrete (670mm) and cement replacement of sugarcane bagasse and lime stone (10%, 15%) concrete cube values are 720mm, 710mm, 690mm, 700mm, and 700mm the comparison among the samples are shown in the graph format in Figure 1 (a).

2) V Funnel Test

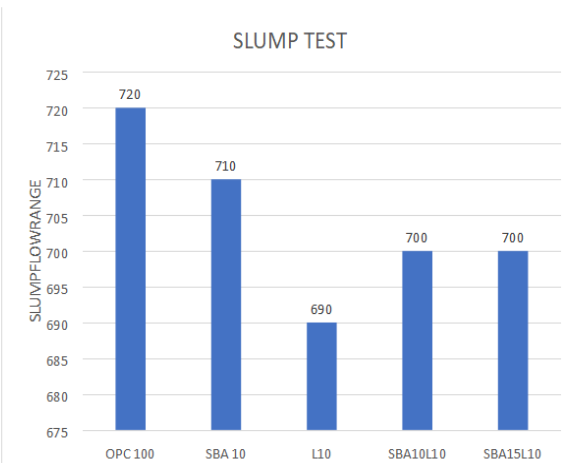
V Funnel test of self compacting concrete (10sec) and cement replacement of sugarcane bagasse and lime stone (10%, 15%) concrete cube values are 10 sec,12 sec, 9 sec, 9 sec, and 8 sec the comparison among the samples are shown in the graph format in Figure 1(b).

3) L Box Test

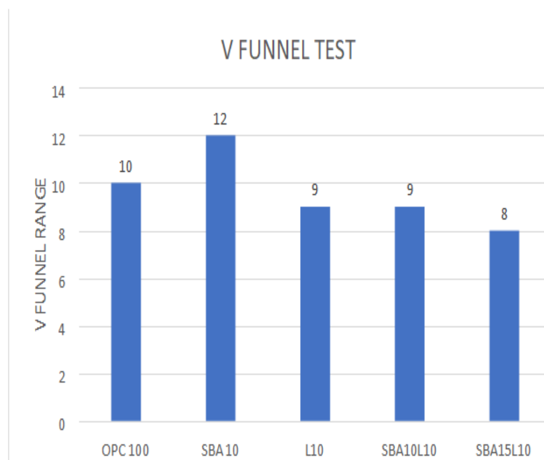
L Box test of self compacting concrete (8mm) and cement replacement of sugarcane bagasse and lime stone (10%, 15%) concrete cube values are 7mm, 9mm, 9mm, 6mm, and 7mm the comparison among the samples are shown in the graph format in Figure 1(c).

4) J Ring Test

J Ring test of self-compacting concrete (20 sec) and cement replacement of sugarcane bagasse and lime stone (10%, 15%) concrete cube values are 20 sec, 22 sec, 21 sec, 18sec, and 21sec the comparison among the samples are shown in the graph format in 1(d).



(a)



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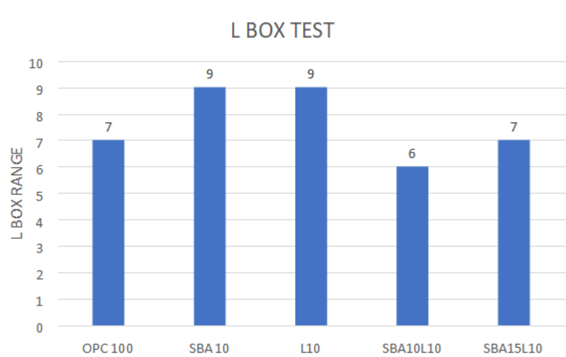

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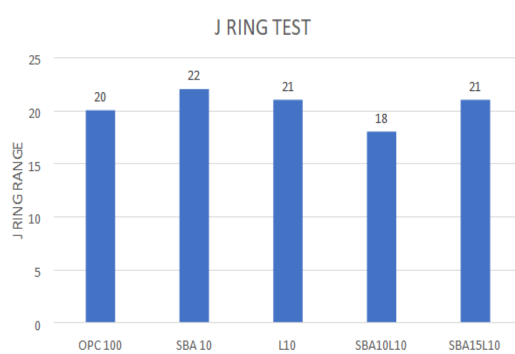

(d)

Figure 1: illustration of comparasion of (a)slump test (b) V funnel test, (c) L Box test (d) J ring test

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Table VI Compressive Strength

MIX ID	COMPRESSIVE STRENGTH (N/mm²)	
	(7th Day)	(28th day)
OPC 100	24.5	41
SBA 10	24	42.5
L10	22.5	44
SBA10L10	23.5	44.5
SBA15L10	23.5	42

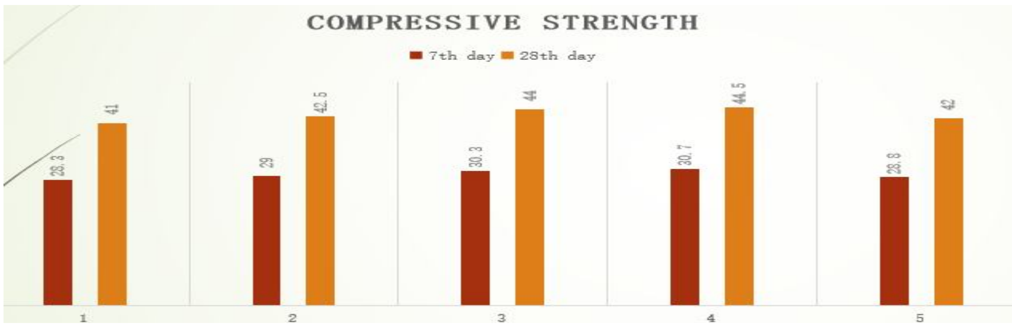
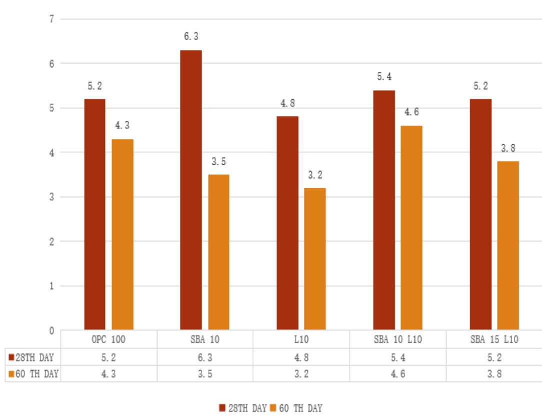


Figure 2 comparison of compressive strength

A. Tests For Durability

The durability properties of the different mixes were also assessed using tests for sulphate resistance, sorptivity, water absorption, water impermeability, and porosity. Based on the results, the optimal mix proportion was identified as 10%SBA +15%L, with 75% OPC.



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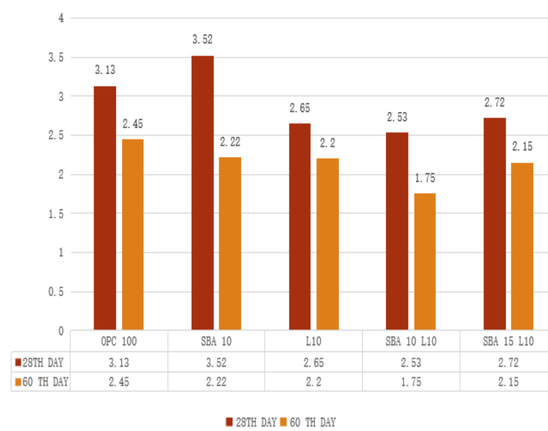
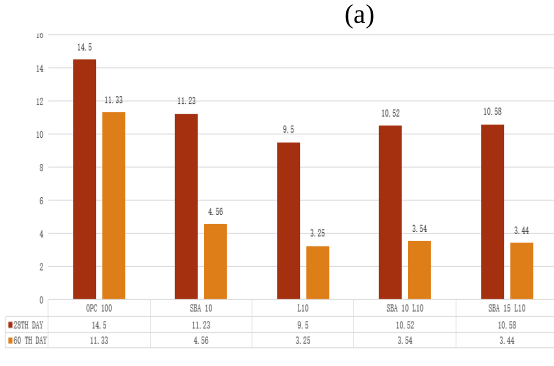


(b)



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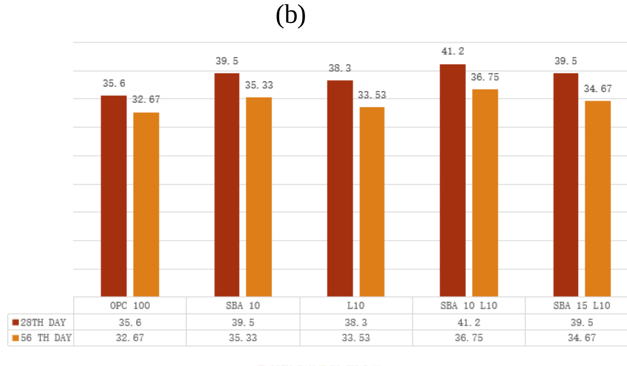

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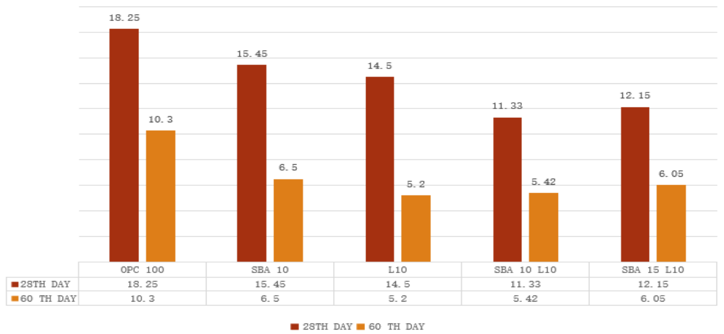

(e)

Figure 3: (a) water absorption test (b) porosity test © sorptivity test (d) sulphate resistance test (e) water impermeability test

VI. CONCLUSIONS

The concrete specimens were made out of conventional SCC, SCC with Fly ash, lime stone and sugarcane bagasse as partial replacement to cement. And based on compressive strength for 7 days and 28 days results optimization of SCC was done. The behaviour of concrete with sugarcane bagasse and limestone as partial replacement of cement is studied and the following conclusions are drawn.

1) Compressive strength results from it is evident that from 7 days and 28 days the SCC in which replacement up to 30% fly ash, 10% and 15% sugarcane bagasse, 10% limestone gives better mechanical strength than that of the conventional SCC.
2) The workability decreased with the increase in the replacement of OPC with agricultural waste (sugarcane bagasse ash). This is an effect of the agricultural waste's pozzolanic behaviour.l The addition of limestone increased the workability upto SBC15%+L10; after that, the limestone replacement did not show any change in workability. Therefore, 15% have been considered as the ideal replacement percentage in terms of workability.
3) At 7th day, the compressive strength of the 10% SBA replacement is lower than the OPC100. This indicates that the cement does not hydrate fully when SBA is used in part as a replacement. But early strength of the other ternary mixture, SBA10 L10 and SBA15 L10, increases it shows that how limestone addition assisted in the concrete's cement's early hydration.
4) The later compressive strengths of the ternary concrete are good compared to conventional concrete. The durability properties of the different mixes were also assessed using tests for sulphate resistance, sorptivity, water absorption, water impermeability, and porosity. Based on the results, the optimal mix proportion was identified as 10%SBA +15%L, with 75% OPC.

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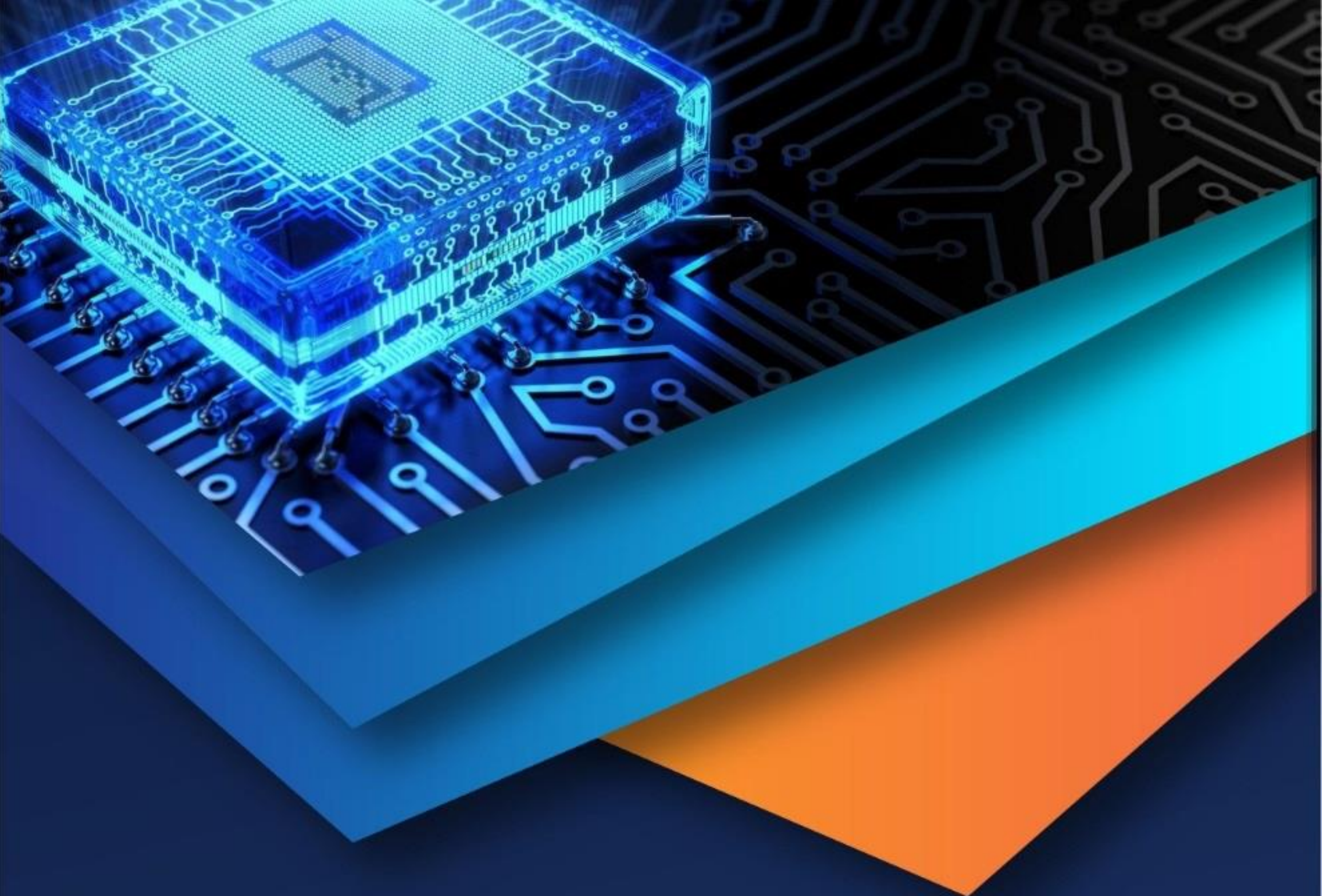

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