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An Experimental Investigation on Partial Replacement of Cement by Silica Fume and Coarse Aggregate by Over Burnt Bricks on M25 Grade Concrete

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Abstract: The mechanical properties of M25 grade concrete, with partial replacement of cement by Silica fume and coarse aggregate by over burnt bricks. Various concrete mixtures were prepared by replacing cement with Silica fume at varying percentages (0%, 8%, 9%, 10%, 11%, and 12%) and over burnt bricks replacement by coarse aggregate at varying percentage (0%, 15%, 20%, 25%, 30% and 35%) while maintaining the same water-cement ratio. The results shows that the inclusion of Silica fume improves the compressive strength and flexural strength due to the pozzolanic reaction and pore refinement, whereas the replacement of coarse aggregate with overburnt bricks reduces the density but maintains same strength.This study concludes that a combination of 10% Silica fume and 25% overburnt bricks aggregate provides an eco-friendly and cost-effective alternativefor sustainable concrete production without reducing the strength requirements of M25 grade concrete.
Keywords: Cement, Fine aggregate, Coarse aggregate,Silica fume,overburnt bricks,Compressivestrength, Flexural strength.

I. INTRODUCTION

Concrete is commonly used construction material across the world and widely used in civil engineering works, including infrastructure, low and high rise buildings.When the bricks get burnt at high temperature bricks changed their shape and colour, such bricks can't be used for construction. This waste bricks can be used as recycled coarse aggregate. The ordinary Portland cement is one of the materials commonly used for construction purpose. While cement production environmental problems cause such as CO_2 gas released into the atmosphere. so, to reduces this problem we used alternate materials such as fly ash, Silica fume, slag rice husk ash, metakaolin. Silica fume is a mineral admixture and a pozzolan and it gives high strength and durability.

II. LITERATURE REVIERW

Rachit Vyas, Deepak Garg, Prathmesh Rai[1] The study shows that economical and eco-friendly concrete done by partially replacement of cement with brick powder and combined with Silica fume. Cement was partial replaced with brick powder at percentages 5%, 10%, 15%, and 20% brick powder, while Silica fume was kept constant at 10% replacement of cement. Tests were conducted on workability, compressive, tensile, split tensile and flexural strength. Results showed that workability decreased with higher brick powder content, while the optimum percentage of brick powder was achieved at 5% replacement. Split tensile and flexural strengths also decreased slightly at higher replacements. The study concludes that using 5–10% brick powder with Silica fume can produce strong, durable, and sustainable concrete, reducing environmental pollution, waste disposal issues, and cement consumption.

Rochak Pandey, Preeti Singh[2] The study investigates the mechanical and durability performance of M20 concrete, when cement is partially replaced with ceramic waste powder (10%,20%,30%) and metakaolin (10%,15%,20%), while fine aggregate is fixed at 25% brick dust replacement. Tests were conducted for compressive, split tensile, and flexural strength, as well as chlorine diffusion and capillary water absorption. Results showed that 20% ceramic powder and 15% metakaolin replacements give the best performance, improving compressive and flexural strength anddurability is reducing by chloride penetration and water absorption.

S Kanchidurai, G Bharani and K Saravana Raja Mohan,[3] This study investigates the use of over-burnt brick bat (OBB) waste as a partial and full replacement for coarse aggregate in M20 grade concrete. OBB were produced from bricks when overheated beyond 1600°C, such bricks were used inproportions of 0%, 25%, 50%, 75%, and 100%. Tests were conducted for compressive strength, flexural strength.Results showed that 25% replacement of OBB optimum percentage for compressive strength while compare to conventionalconcrete. Higher replacements (≥50%) reduced strength significantly.

The study concludes that using 25–50% OBB waste is effective for non-structural and mass concrete applications, promoting sustainability and reducing natural aggregate consumption.

III. EXPERIMENTAL INVESTIGATION

A. CONCRETE PROPERTIES

This concrete contains Ordinary Portland cement 43 grade, fine aggregate with fineness modulus 2.78 confirming to zone-2, coarse aggregate with a maximum size of 20mm, water-cement ratio of 0.49 for M25.The aim of this research is to use Silica fume and over burnt bricks as replacement of cement and coarse aggregate respectively. The concrete cubes were casted withSilica fume for 0%, 8%, 9%, 10%, 11% and 12% and tested for 7 and 28 days for compressive strength test to obtain optimum percentage of Silica fume, by taking optimum percentage remaining cubes and beams were casted for 56 and 90 days for compressive strength and 7, 28, 56 and 90 days forflexural strength. Then maintain the same percentage of Silica fume and over burnt bricks is replaced with coarse aggregate of percentage 15%, 20%, 25%, 30% and 35%, the cubes were casted for 7days for compressive strength test to obtain optimum percentage of over burnt bricks, by taking optimum percentage, remaining cubes and beams were casted for 28, 56 and 90 days for compressive strength and 7, 28, 56 and 90 days for flexural strength.

B. MIXDESIGN

Mix design is done according to IS 10269-2016 method and trial mixes wereconducted to obtain the target strength of M25 grade concrete. Once the target strength obtained, it is used to cast concrete with 0%, 8%, 9%, 10%, 11% and 12% replacement of cement with Silica fume and maintaining the optimum percentage of Silica fume, it is used for cast concrete with 0%, 15%, 20%, 25%, 30% and 35% of over burnt bricks is replaced with coarse aggregate. This concrete is casted to find compressive strength and flexural strength. The mix proportion is shown in below table.

Grade	Cement	Fine aggregate	Coarse aggregate	Water
M25	320	716	1222	157
	1	2.24	3.82	0.49

IV. RESULTS AND DISSCUSIONS

A. COMPRESSIVE STRENGTH TEST

Compressive test is carried out on specimen of cubical size 150mm x 150mm x 150mm. compressive test is confirming to IS:516-1959.

Formula Compressive strength = $\frac{failure\ load}{cross\ section\ area}$

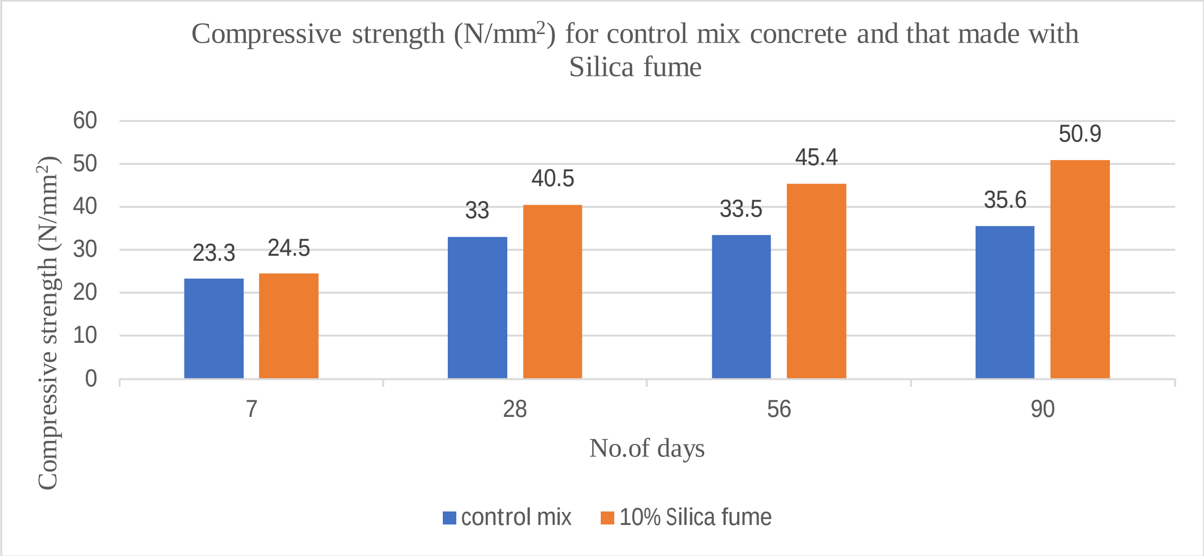

Fig1:Variation of compressivestrength for control mix concrete and that made with 10% Silica fume is replaced with cement and cured for 7, 28, 56 and 90 days

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The bar chart shows the compressive strength of control mix concrete and 10% Silica fume concrete. For7days curing we found 23.3 N/mm^2 in control mix and 24.5 N/mm^2 in 10% Silica fume concrete. Similarly for maximum curing 90 days we found 50.9 N/mm^2 in 10% Silica fume concrete.

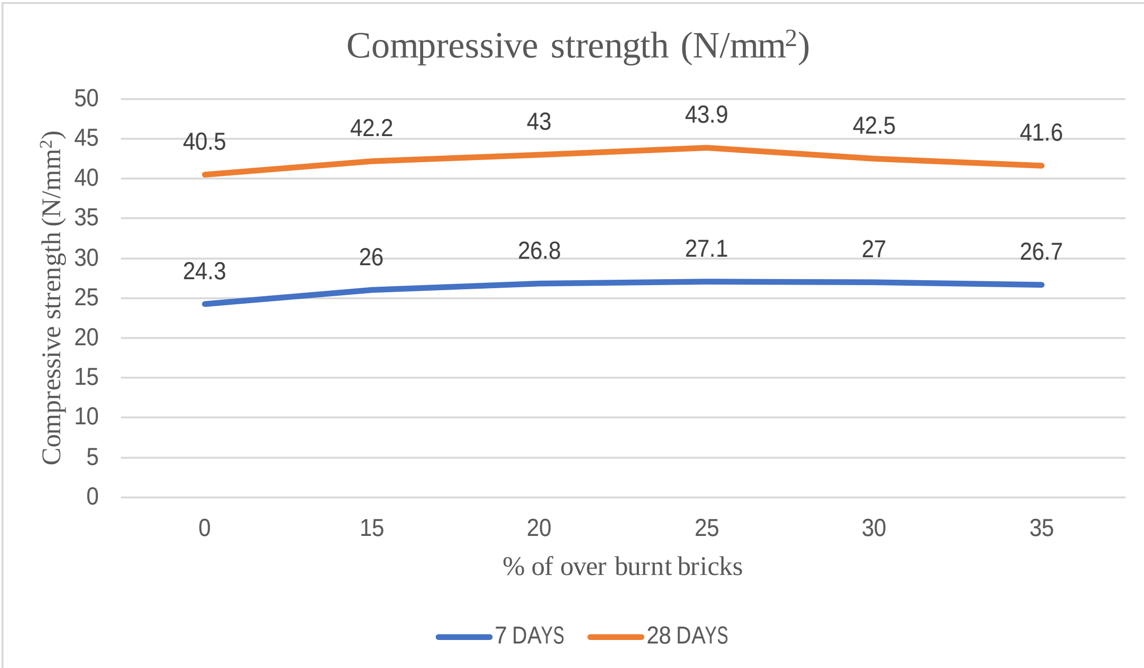

Fig 2:Compressive strength of Concrete at Optimum of Silica fume and Various Percentage of over burnt bricks at 7 and 28 days

The above bar chartshows the compressive strength of concrete with10% Silica fume and different percentage of over burnt bricks, by maintaining Silica fume percentage for all different percentage of over burnt bricks. At 25% percentage mix it shows the optimum percentage of over burnt bricks.

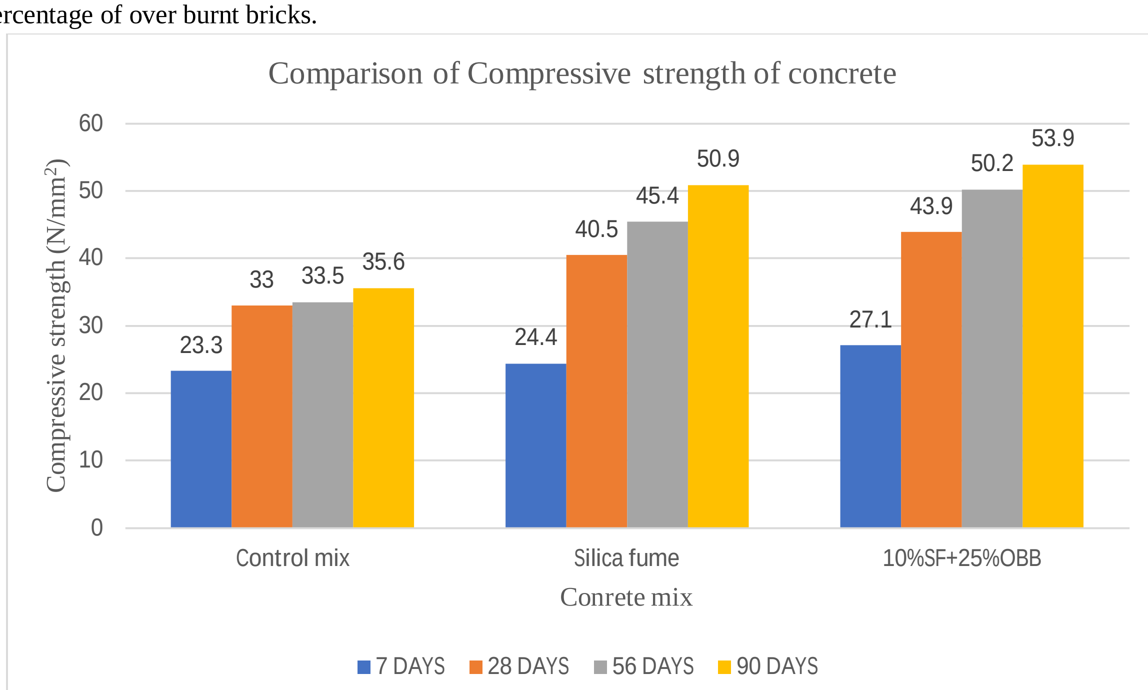

Fig3:Comparison of Compressivestrength of concrete with control mix, 10% Silica fume and 25% over burnt bricks at 7, 28, 56 and 90 daysofcuring.

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B. FLEXURAL STRENGTH TEST

The flexural strength can be determined by standard test method of two point loading. Flexural strength is crucial in concrete because it indicates the concrete ability to resist bending flexural stress. The beam of size 150mm x 150mm x 700mmwas used to find flexural strength.

Formula: MR=$\frac{PL}{bd^2}$

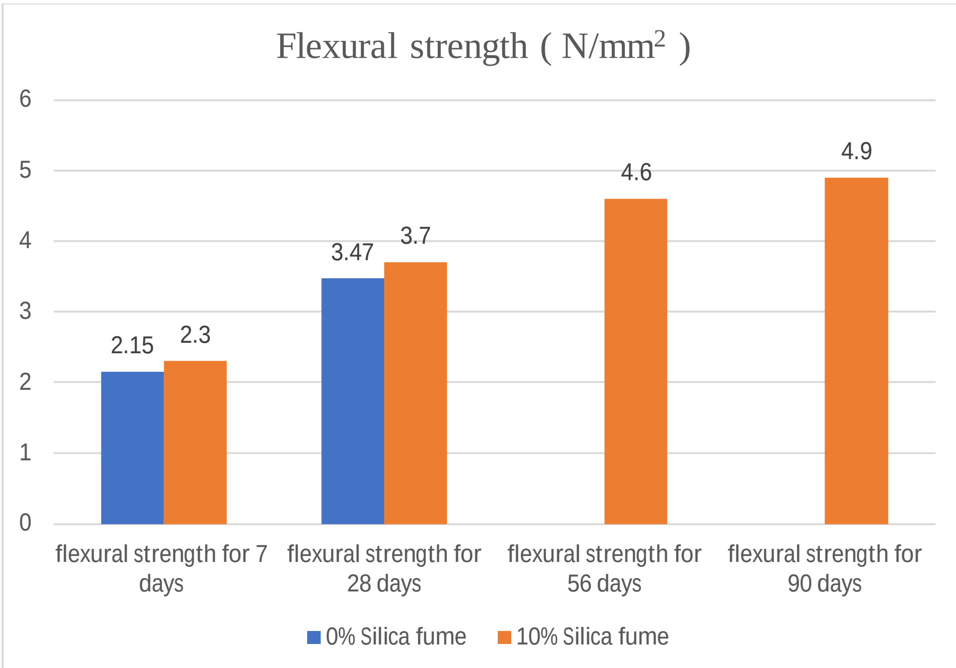

Fig4: Flexuralstrengthat 7, 28, 56 and 90 daysofcuring with 0 and 10% Silica fume

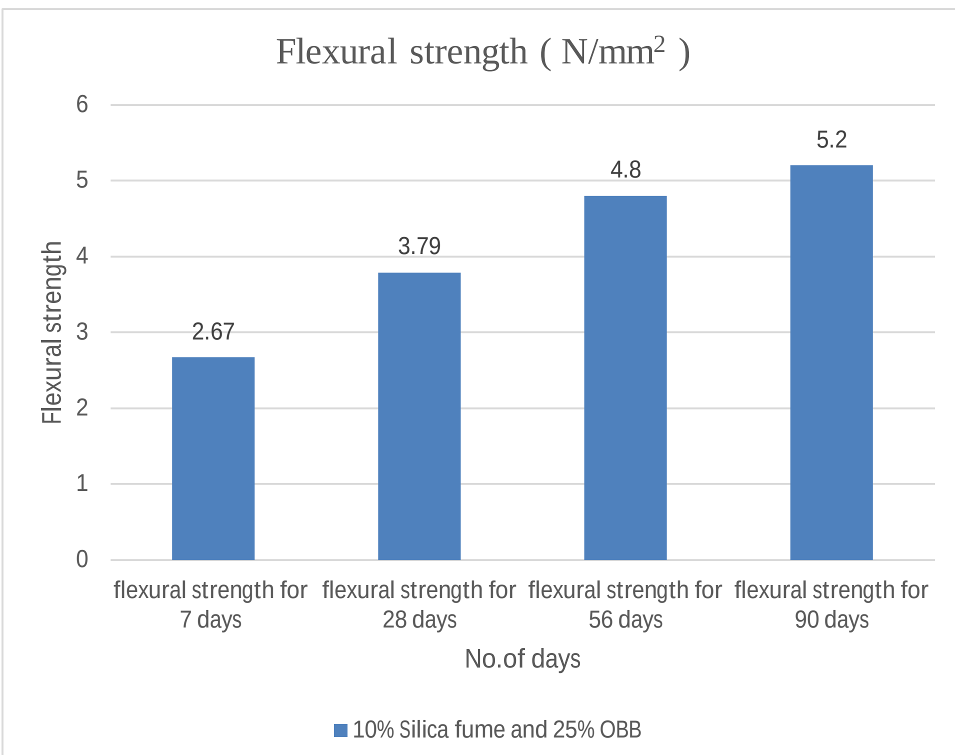

Fig5:Flexuralstrength of concrete with 10% Silica fume and 25% over burnt bricks

The experimental results indicate that partial replacement of cement with 10% silica fume significantly enhances both compressive and flexural strengths of M25 grade concrete due to its pozzolanic reaction and ability to refine pore structure. The optimum replacement of coarse aggregate with 25% over burnt bricks yielded comparable strength to conventional concrete while reducing density, making it a lightweight and sustainable option. By combination of both 10% silica fume and 25% over burnt bricks, showing a better improvement than the control mix. Overall, the combination of 10% silica fume and 25% over burnt bricks presents an eco-friendly and high-performance alternative for sustainable concrete applications.

V. CONCLUSION

1) This investigation shows that results, can be use Silica fume and over burnt bricks.
2) The compressive strength of concrete with 10% Silica fume in cement, increases the strength up to 35% when compared to normal concrete at 28 days.
3) The compressive strength of concrete with 10% Silica fume and 25% over burnt bricks increases the strength up to 46% when compared to normal concrete at 28 days.
4) The flexural strength of concrete contains 10% Silica fume increases the strength up to 8.6% when compared to normal concrete.
5) The flexural strength of concrete contains 10% Silica fume and 25% over burnt bricks increases the strength up to 8.6% when compared to normal concrete.

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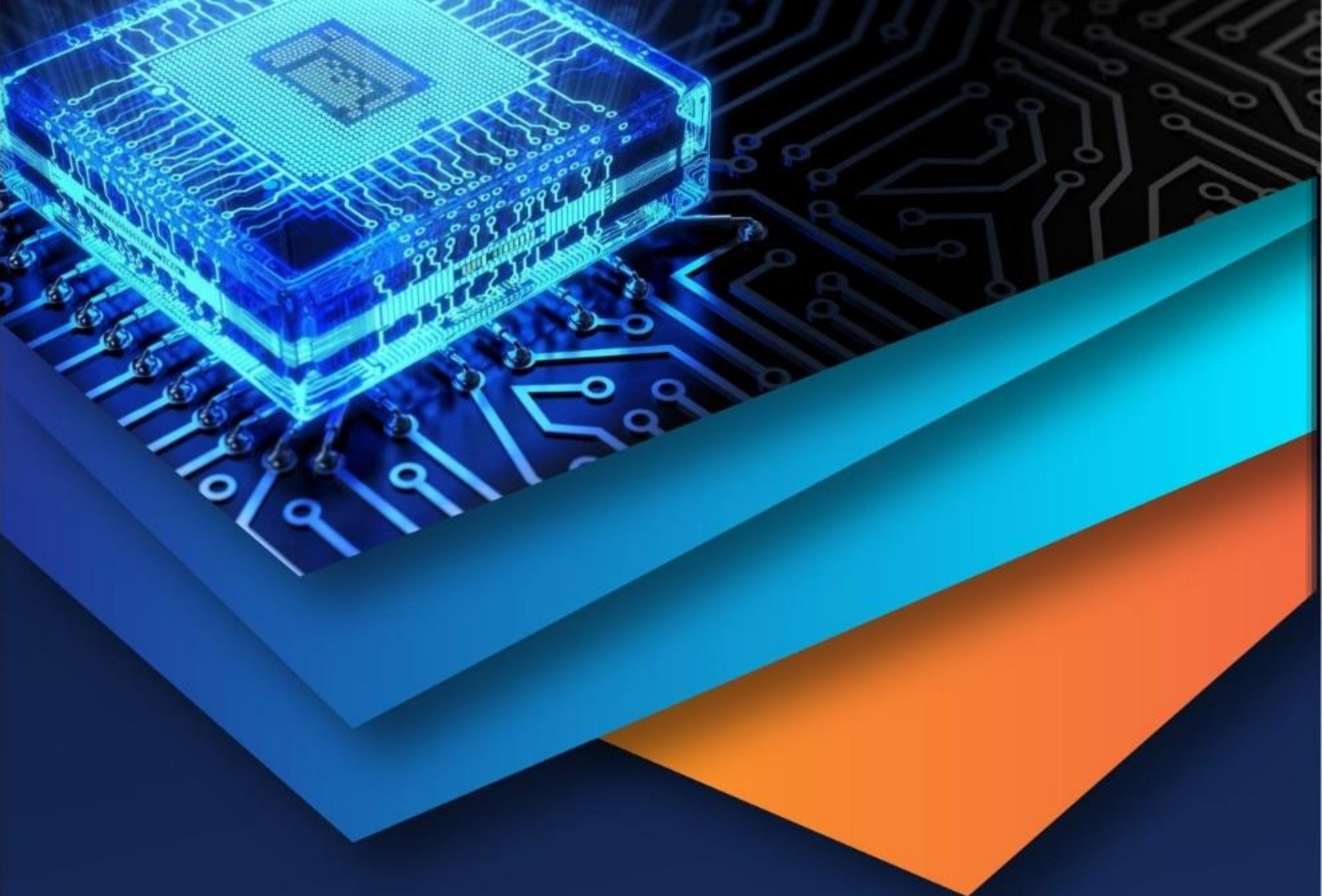

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