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An Experimental Investigation on the Strength and Durability aspect of Bacterial Self-Healing Concrete with GGBS

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Abstract: ***A construction industries are fast growing sector around the globe and Concrete is a key material for construction worldwide due to the strength and durability properties. Along with the positive, there are some lacks in the concrete that is in terms of cracking in concrete, every year millions of resource in terms of money and technology consumes. The bacterial self-healing is novel approach towards the producing durable and crack free concrete by using the Industrial waste which leads to reduce the cost of repairing the cracks by conventional methods and reduce the chances to again development of crack in concrete. For this process bacteria's such as B.subtiles, B. spharies and B. pasteurii etc. are use for self-healing the concrete cracks now a days the industrial wastes are rapidly increasing more. So utilize such material and reduce such type of waste in environment, therefore some percentage of cement will replaced by the industrial waste.***
Keywords: ***Bacterial Self-healing, Concrete, Industrial waste****.*

I. INTRODUCTION

Concrete which forms major components in the construction industry as it is cheap, easily available, and convenient to cast. But drawback of these material is it is weak in tension, which creates cracks in the concrete. Cracks occurs due to various mechanism such as shrinkage, freeze-thaw reaction and mechanical compressive and tensile forces. Cracks in concrete may also enhance the deterioration of embedded steel bars. Without immediate and proper treatment, cracks tend to expand further and eventually required costly repair. Synthetic materials like epoxies are used for remediation, but they are not compatible, costly, reduce aesthetic appearance and need constant maintenance. By introduce the bacteria in concrete it producing calcium carbonate crystals which block the micro cracks are always avoided but to some extents they are responsible to their failure in strength. The selection of the bacteria is depends on the survive capability of bacteria in the alkaline environment. Most of the microorganisms die in an environment with pH value of 10 or above. Bacteria Bacillus will be found to succeed in high alkaline environment. The bacteria survive in the high alkaline environment that formed spores. The pH of the highly alkaline concrete lower to the value in the range 10 to 11.5 where the bacterial spores becomes activated. There are many other bacteria which are survive in the alkaline environment shown in the table 1.

Table 1. Bacteria other than Bacillus which are survives in the alkaline environment.

Sr. No.	Application	Types of Bacteria
1	As a crack healer	• B.pasteurii • Deleya Halophila • B. megaterium
2	For surface treatment	• B. sphaericus
3	B.sphericus	• Bacillussubitilis • B. sphaericus • Thiobacillus

II. METHODOLOGY

The methodology of the work starts from the study on the properties of the material and the past work done from the collection of literatures for review. The bacterial properties of the GGBS to be used need to be well studies. The material used for casting the specimens were properly tested for finding the material properties. Depending on the material test mix design was prepared and casting has to be developed. The specimen will be cast for finding the engineering and durability of the bacterial self-healing concrete by the following methods.

For my experimental 3 grades of concrete is used M30, M35& M40, with 4 different mix.

Cement is replaced with GGBS 30%, 40% and 50%. Ambuja PPC cement is used for experimental study.

A. Bacteria Culturation Process

1) Bacillus Pasteurii bacterial are obtained from National Chemical Laboratory (NCL), Pune. In an agar tube. At maintained temperature of 30o C.
2) For Culturation of bacteria nutrient broth is required.
3) Nutrient Broth is prepared in a conical flask (Beef extract = 10g, NaCL = 5g, Peptone = 10g, Distilled water = 1Lit.).
4) Then conical flask is covered with thick cotton plug and made it air tight with paper and rubber band.
5) Then allow it for sterilization for 10-20minute.
6) After sterilized process 1ml of bacteria is added into the flask. And kept it into the shaker for 24 hr. at 150 – 200 RPM.
7) After 24 hr. bacterial solution was found to be whitish yellow turbid solution.
8) In this study bacterial solution is used, bacteria is diluted in to the water and prepare the bacterial solution. Refer Fig (2.1) & (2.2).

Fig 2.1 Bacillus Bacteria

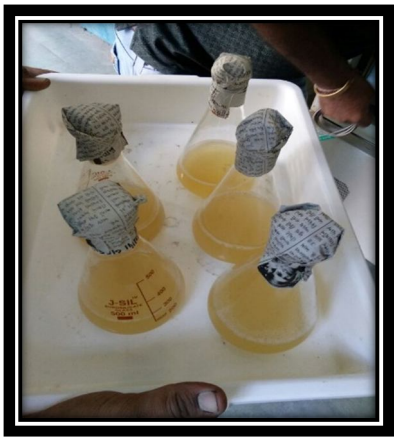

Fig 2.2 Culture Bacteria

B. Material

1) *Cement :* In this experiment Pozzolana Portland Cement (PPC) with brand name Ambuja was used for all concrete mix. The cement used was fresh and free from lumps. The testing of cement was done as per IS: 8112-1989. The specific gravity of cement was found 2.9
2) *Fine Aggregate:* The sand used for the experimental program was natural river sand (Bodeli, Gujarat) locally procured and was confining to zone –II of IS: 383-1970. The specific gravity of fine aggregate was found to be 2.60
3) *Coarse Aggregate:* Locally available coarse aggregate having the maximum size of 20mm and down as per IS: 383-1970 were used in the present work. The specific gravity of coarse aggregate was found to be 2.86
4) *Ground Granulated Blast Furness Slag:* GGBS has been shown to be an effective addition for concrete providing increased cohesion and reduce sensitivity to changes in water content. GGBS used in the experiment was obtained from Surat (Gujarat)
5) *Bacteria:* The pure culture of Bacillus Pasteurii NCL NO 2477 was obtained from National Chemical Laboratory, Pune. The sub culture of bacteria was made in laboratory of Department of Bioscience
6) *Water:* Clean water available in the laboratory, was used for the preparation of specimens and for the curing of specimens.

C. Acid Attack Test

The concrete cube specimens of various concrete mix of size 150mm x 150mm x 150mm were cast and after 28 days of water curing the specimens were removed from the curing tank and allowed it to dry for one day. The weight of concrete cube specimen

were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 91 days after 28 days of curing. HCL with ph of about 2 to 5% weight of water was added to water in which the concrete cubes were stored. The pH was maintained throughout the period of 90 days. After 90 days of immersion, the concrete cubes were taken out of acid water. Then the specimens were tested for the compressive strength. The resistance of concrete to acid attack was found by the % loss of compressive strength on immersing concrete cubes in acid water.

III. RESULTS

A. Compressive Strength

Compressive strength results of 7 days, 28 days and 91 days are shown in Fig (3.1), Fig (3.2) and Fig (3.3).

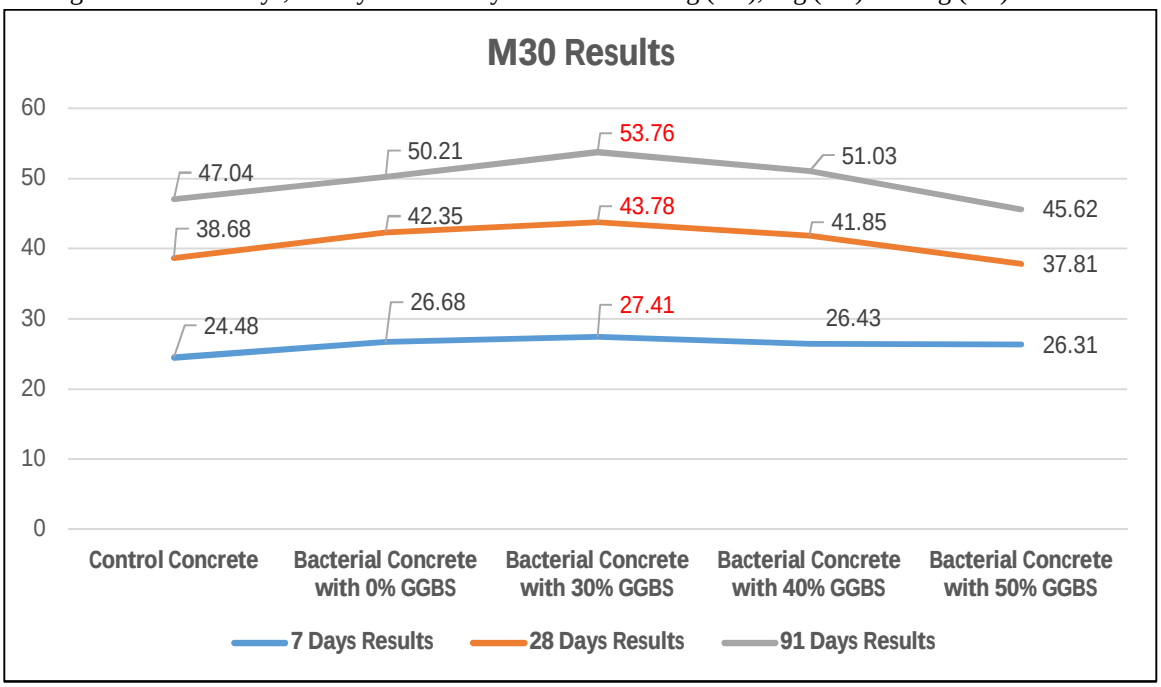

Fig 3.1 M30 Compressive Strength Results

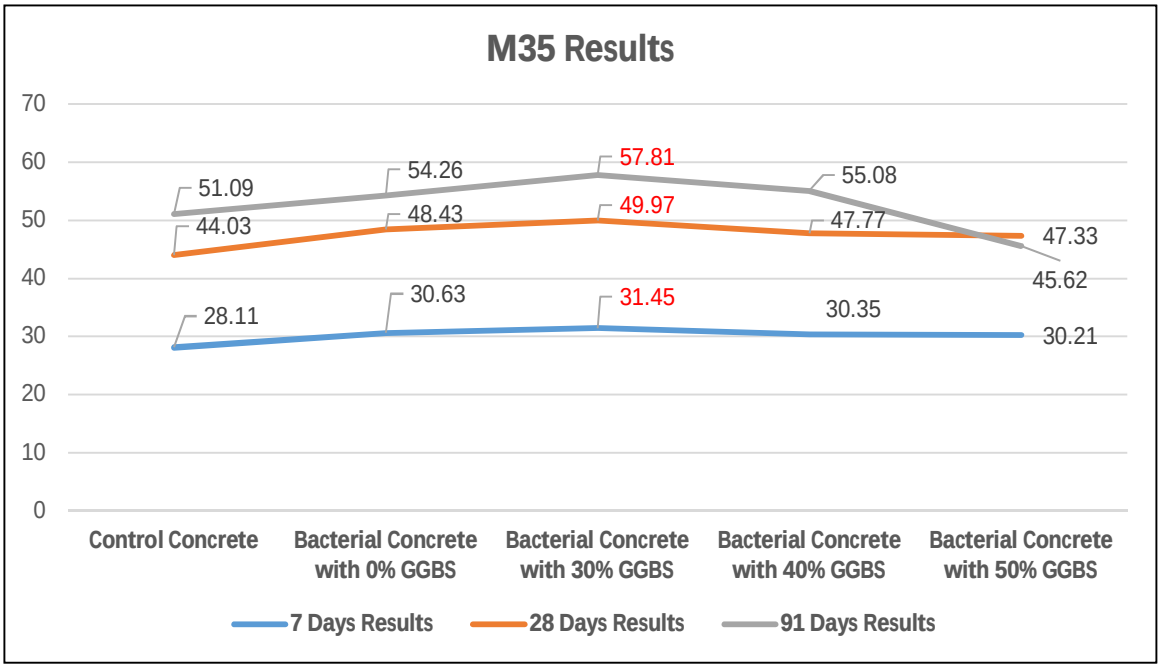

Fig 3.2 M35 Compressive Strength Results

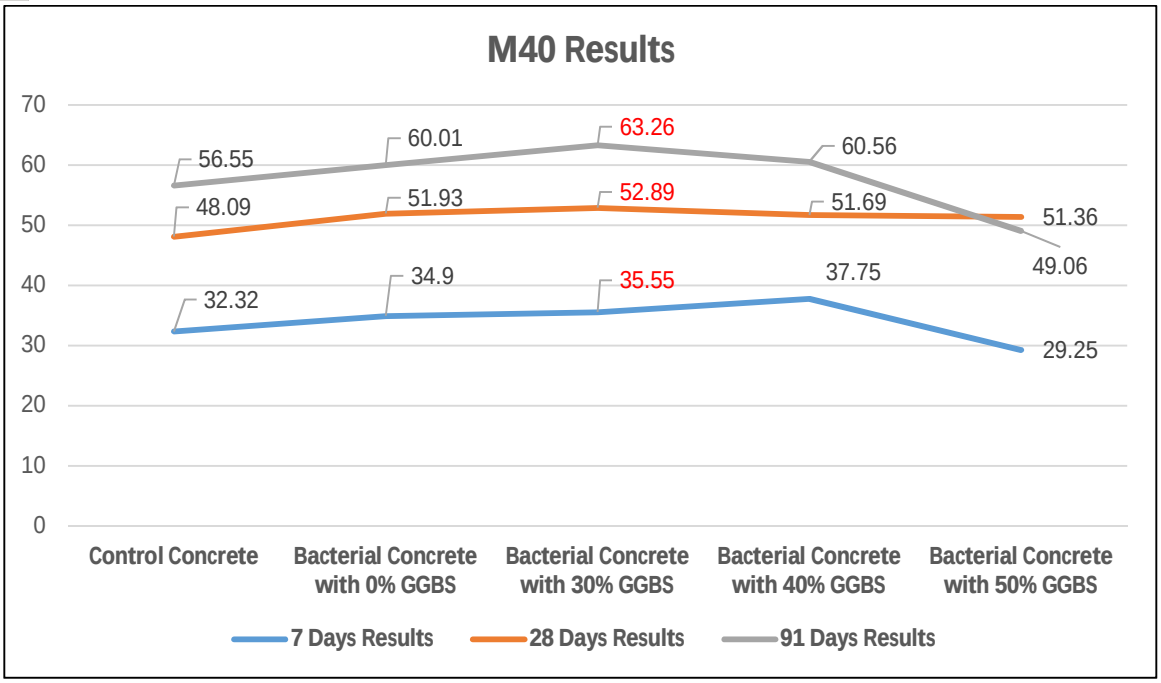

Fig 3.3 M40 Compressive Strength Results

B. Acid Attack Test

Acid attack test results of 91 days are shown in Fig (3.4), Fig (3.5) and Fig (3.6).

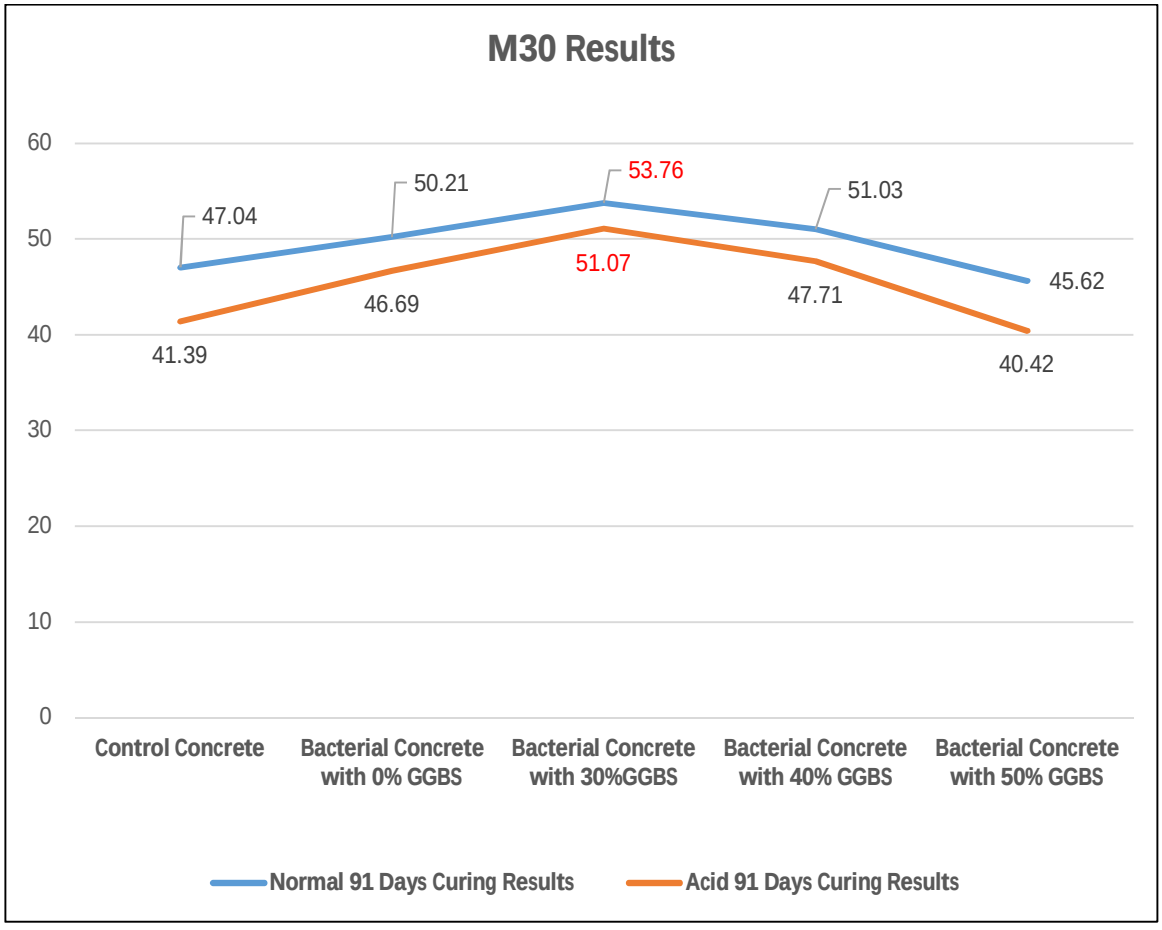

Fig 3.4 M30 Acid Attack Test Results

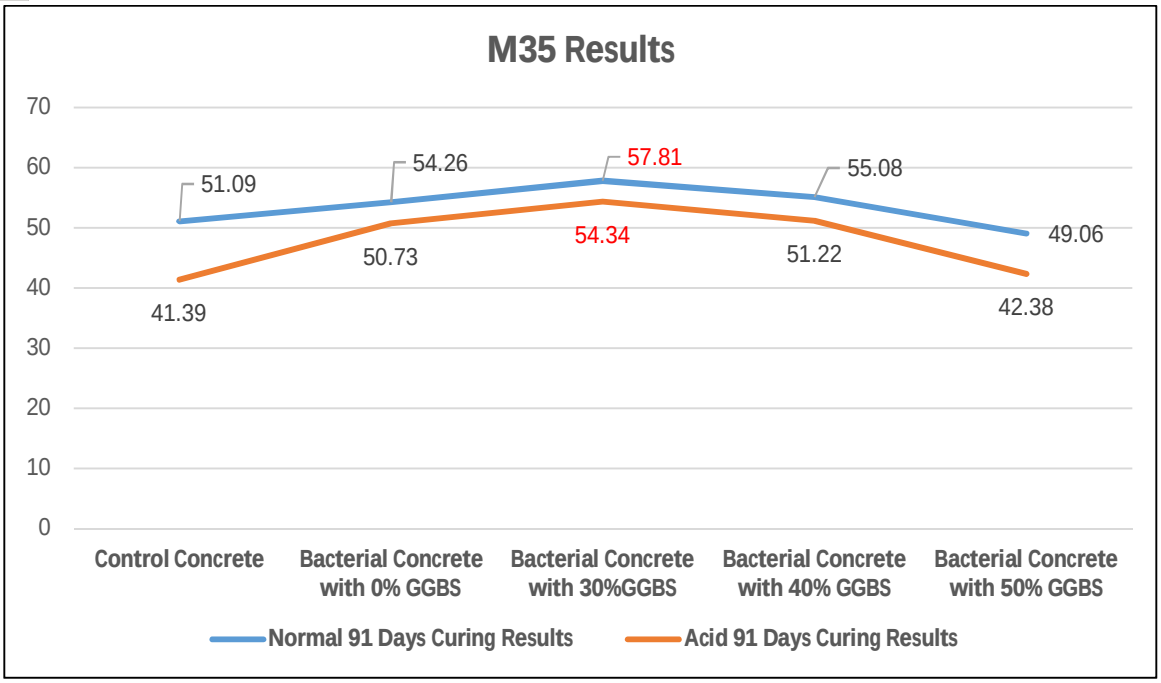

Fig 3.5 M35 Acid Attack Test Results

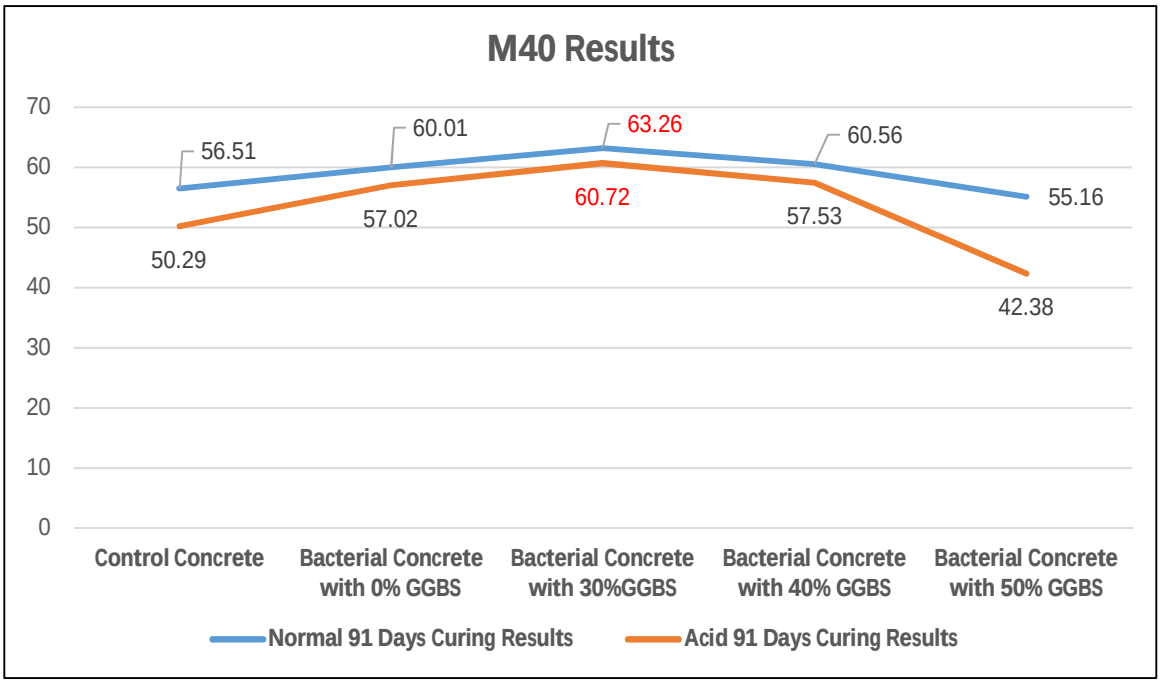

Fig 3.6 M40 Acid Attack Test Results

IV. CONCLUSIONS

A. Thus we studied the percentage increasing in compressive strength of bacterial concrete compared to control concrete.
B. It is also concluded that the maximum strength obtained at 30% replacement of GGBS.
C. Use of bacteria improve the resistance against acid attack

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V. FUTURE RESEARCH

A. Rapid Chloride Penetration Test and Mercury Porosity Test will conduct for same design mix, with same replacement.
B. Self-healing of micro crack are already in progress and would be communicate in future publication.

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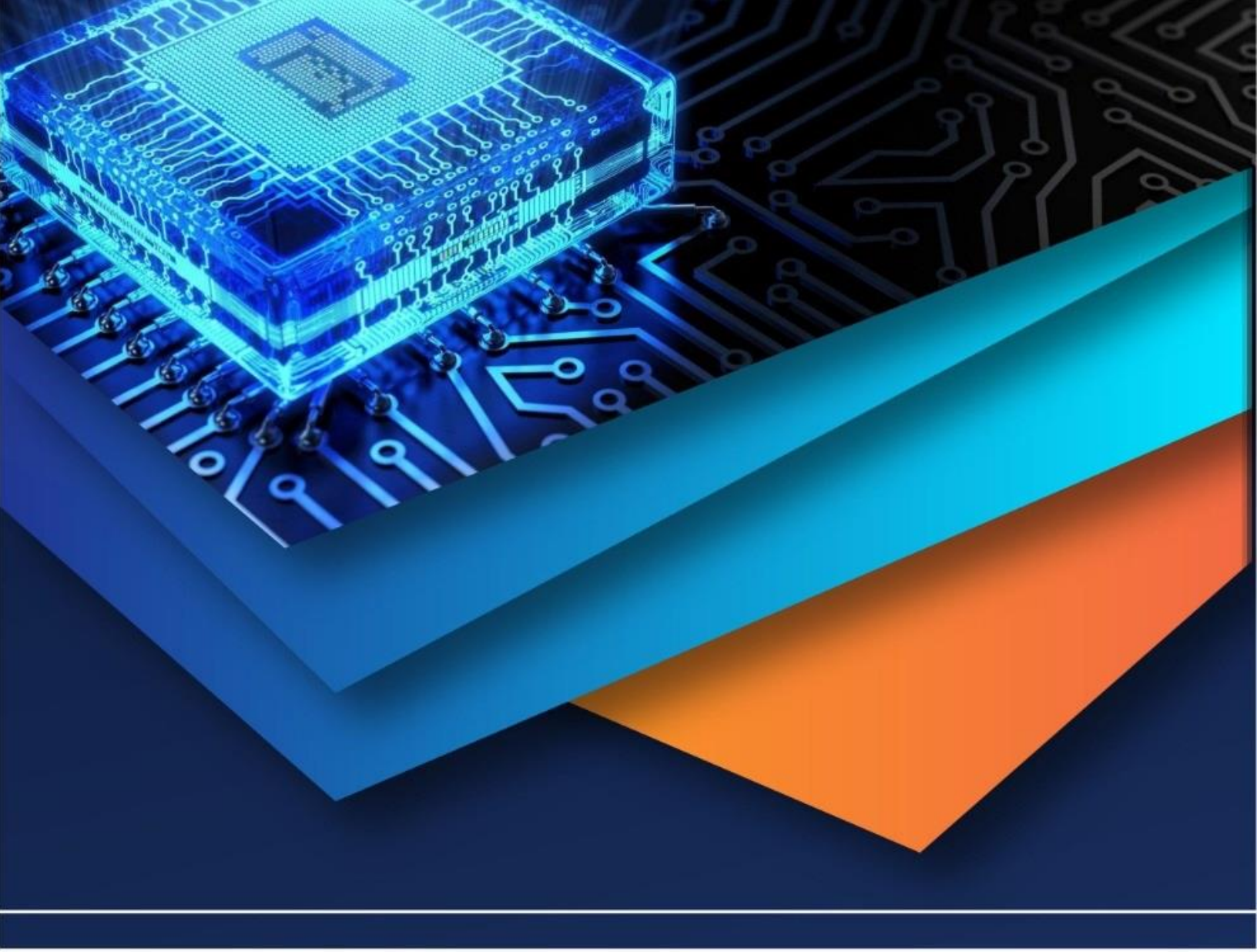

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