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A Preliminary Assessment of Marine Algae on Concrete

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Abstract: ***Increase in the developmental activities over the world, the demand for construction material is increasing exponentially. Green construction material takes an important role in sustainable development. Seaweed is pure natural material that offers numerous advantages such as, excellent heat insulation and heat capacity characteristics as well as full bio-degradability and strong carbon fixation. Our project deals with a special type of concrete –MARINE ALGAE CONCRETE. The study on marine algae concluded that, it is environmental friendly and the chemical reaction with cement makes pollution free environment. This also makes concrete more economic and at the same time there is a reduction of the problem of the waste. In this study, Marine algae were used as additive material to concrete in wet and dry form to study the strength parameters in various aspects. Finally, expected outcome of this work is to reduce void problems formed in concrete and also to address internal curing process by comparing with conventional concrete. This also addresses the strength parameters using flexural testing of marine algae concrete beams.***
Keywords: Green construction material, Dry algae, Wet algae, Carbon fixation.

I. INTRODUCTION

Concrete is a basic building material made of basic ingredients such as, Portland cement (Binding material) Fine aggregates (Filler material)**,** Coarse aggregates (Contributes to overall strength)**,** Water**.** This combination, makes a conventional mix and is poured and hardened into a durable material. In Concrete mix, Water cement ratio plays an important role which influences various properties such as workability, strength and durability. Adequate water cement ratio is required for production of workable concrete. When water is mixed with materials, cement reacts with water and hydration reaction starts. This reaction helps ingredients to form a hard matrix that binds the materials together into a durable stone-like material. In a building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements. There are various types of cement used in concrete construction based on the surrounding environment. Each type of cement has its own properties, uses and advantages. Similarly, to enhance the properties of concrete there are various types of admixtures are added in various proportions. The type of admixture is selected based on the need for the entire structure. Admixtures are classified majorly as, Mineral Admixtures, Chemical Admixture. Eco-friendly ways of producing concrete have been studied not only to overcome the practical difficulties but also to reduce the environmental impact of Concrete which leads to sustainability. Thus, our project deals with a special type of concrete-MARINE ALGAE CONCRETE, which is environmental friendly and the chemical reaction with cement reduces the heat of hydration. This also makes the concrete economic and at the same time there is a reduction on problem of waste.

II. MARINE ALGAE CONCRETE

Marine algae and plants are a diverse collection of marine life that, together with cyanobacteria, forms the main primary producers at base of the ocean food chain. Marine primary producers are important because they underpin almost all marine animal life by generating most of the oxygen and food that animals need to exist. Some algae and plants are also ecosystem engineers which change the environment and provide habitats for other marine life. Algae are an informal term for a widespread and diverse group of photosynthetic eukaryotic organisms which are not necessarily closely related and are thus polyphyletic. Unlike higher plants, algae lack roots, stems, or leaves. Marine Algae are one of the natural amicable substances. It controls the compound response of cement. Marine Algae Concrete is oneself self-consolidating concrete. Marine algae mainly fall into five categories as Green Algae, Red Algae, Brown Algae, Diatoms, and Dinoflagellate of which Brown Algae species is used for purpose of food, agriculture, research etc., Between 1,500 and 2,000 species of brown algae are known worldwide. Some species, such as Ascophyllum nodosum, Sargassum have become subjects of extensive research in their own right due to their commercial importance. They also have environmental significance through carbon fixation.

A. Properties of Marine Algae

The properties of marine algae were studied by analyzing the specimen using Scanning Electron Microscope (SEM) and are expressed in Fig 1, 2 and 3.

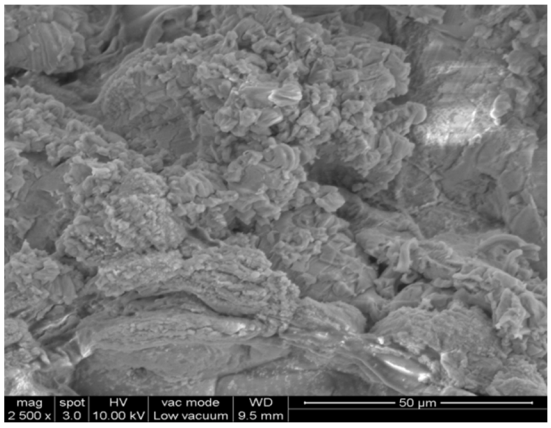

Fig. 1 SEM analysis of Marine Brown Algae (Wet State)

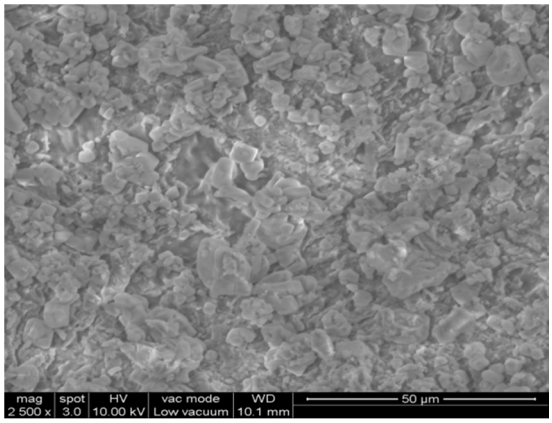

Fig. 2 SEM analysis of Marine Brown Algae (Dry State)

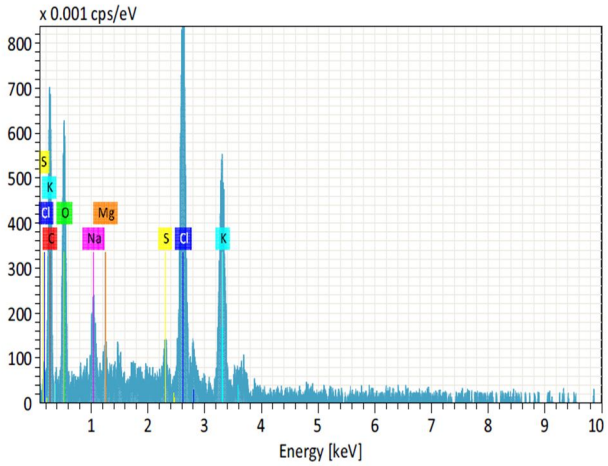

Fig. 3 Components of Marine Brown Algae

The results can be inferred as follows:

The evidence of fringes shows the reduction of voids. The presence of magnesium (Mg) proves the increase in binding nature of the component.

B. Mix Proportion

Table 1 Mix Proportion

Grade of concrete	Cement	Fine Aggre-gates	Coarse Aggreg-ates	Water-Cement Ratio
M35	1	1.62	2.54	0.45

III. OBJECTIVE OF THE STUDY

The objective of this project is to,

A. To compare algae in wet and dry state for various proportions such as 5%, 10%, 15%.
B. To study the strength parameters of Marine Algae Concrete.
C. To use seaweed as an admixture for internal curing and strengthening in concrete.
D. To stay away from the voids in concrete and decline porousness of the solid.

IV. EXPERIMENTAL STUDY

A. General

In order to study the strength parameters of marine algae concrete, the specimens of different dosages such as 5%, 10%, 15% by weight of cement are added and casted. The strength parameters are studied using the following experiments for 7 and 28 days.

B. Slump Cone Test

The Slump Cone Test on fresh concrete is done to determine the workability of concrete. The test is carried out based on *IS1199:1959 – Clause 5.1.*

C. Compaction Factor Test

The Compaction Factor Test on Fresh Concrete is done to study the compactability of Concrete and is based on the procedure recommended as per *IS1199:1959 - Clause 5.2.*

D. Compression Strength Test

Compressive strength is the capacity of material or structure to resist or withstand under compression. The test follows the recommendations of *IS516:1959-Clause 2.*

E. Split Tensile Strength Test

A method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is an indirect method of testing tensile strength of concrete. The test is followed as per *IS5816:1999.*

F. Rebound Hammer Test

To determine the compressive strength of the concrete by relating the rebound index and the compressive strength. To assess the quality of the concrete based on the standard specifications**.**

G. Impact Resistance Test

Impact strength is a durability test which measures the resistance to sudden shock or load. Impact strength is of importance in driving concrete piles, in foundations for machines exerting impulsive loading, and also when accidental impact is possible.

H. Rapid Chloride Permeability Test

Rapid chloride permeability test equipment (RCPT) is used to evaluate the resistance of a concrete sample to the penetration of chloride ions. It measures the permeability of concrete as a quality control parameter.

V. TEST RESULTS

A. *Slump Cone Test*

The table 2 and 3 shows the study on marine algae –fresh concrete. The slump pattern is observed to be true pattern.

Table 2 Slump Value on Wet Marine Algae Concrete

Grade of Concrete	Composition of Marine Algae	Slump Value (in mm)	
		Conven -tional Concrete	Wet Marine Algae Concrete
M35	Conventional	25	-
	5%	-	9
	10%	-	0
	15%	-	0

Table 3 Slump Value on Dry Marine Algae Concrete

Grade of Concrete	Composition of Marine Algae	Slump Value (in mm)	
		Conven -tional Concrete	Dry Marine Algae concrete
M35	Conventional	25	-
	5%	-	22
	10%	-	14
	15%	-	11

B. *Compaction Factor Test*

The table 4 and 5 shows the compaction factor value for various compositions of Marine Algae.

Table 4 Compaction Factor Value of Wet Marine Algae Concrete

Grade of Concrete	Composition of Marine Algae	Compaction Factor	
		Conven -tional Concrete	Wet Marine Algae Concrete
M35	Conventional	0.89	-
	5%	-	0.899
	10%	-	0.912
	15%	-	0.94

Table 5 Compaction Factor Value of Dry Marine Algae Concrete

Grade of Concrete	Composition of Marine Algae	Compaction Factor	
		Conven -tional Concrete	Dry Marine Algae Concrete
M35	Conventional	0.89	-
	5%	-	0.93
	10%	-	0.92
	15%	-	0.948

On comparing the compaction factor value of Wet and Dry Marine Concrete, the Dry Marine Algae Concrete tends to have higher compaction factor value. Hence it has high ease of compaction.

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C. Non-Destructive Testing

To study the Compression Strength of the hardened concrete, the Rebound Hammer Method of NDT is done. The testing is done as shown in the Fig 4.

Fig 4 NDT method of Testing

Based on the Rebound Number observed the Compressive Strength is determined and tabulated as in table 6.

Table 6 Compressive Strength by Rebound Hammer

Shape of the Specimen	State of marine algae	Compressive Strength (in N/mm^2)			
		Conv.	5%	10%	15%
Cube	Wet	28	40	40	34
	Dry		38	34	28
Cylinder	Wet	24	32	30	28
	Dry		32	30	24

The compressive strength tends to decrease with increase in marine algae content by NDT method of testing.

D. Compression Strength Test

The Compression Strength of the hardened concrete is tested by Compression Testing Machine of capacity 2000KN. The table 7 and 8 shows the Compression Strength values of 7 and 28 days specimen respectively. The Compression Test is carried out in the cube specimen of size 150x150x150mm.

Table 7 Mean Compressive Strength on 7th day

No. of Days	State of Marine Algae	Mean Compressive Strength (in N/mm^2)			
		Conv.	5%	10%	15%
7 days	Wet	16.5	19.9	22.9	11.065
	Dry		18.5	8.89	5.11

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Table 8 Mean Compressive Strength on 28th day

No. of Days	State of Marine Algae	Mean Compressive Strength (in N/mm^2)			
		Conv.	5%	10%	15%
28 days	Wet	33.24	36.865	40.7	34.97
	Dry		37.505	35.46	34.58

From the above table, it may be observed that by addition of marine algae upto 10% increases the strength and further increase in composition of marine algae tends to affect the strength parameters in both 7th and 28th day of testing. The comparison of strength parameters are expressed graphically in which x-axis represents composition of Marine Algae (in %) and y-axis represents the Compression Strength (in N/mm^2) in Fig 5 and 6 for 7 and 28 days respectively.

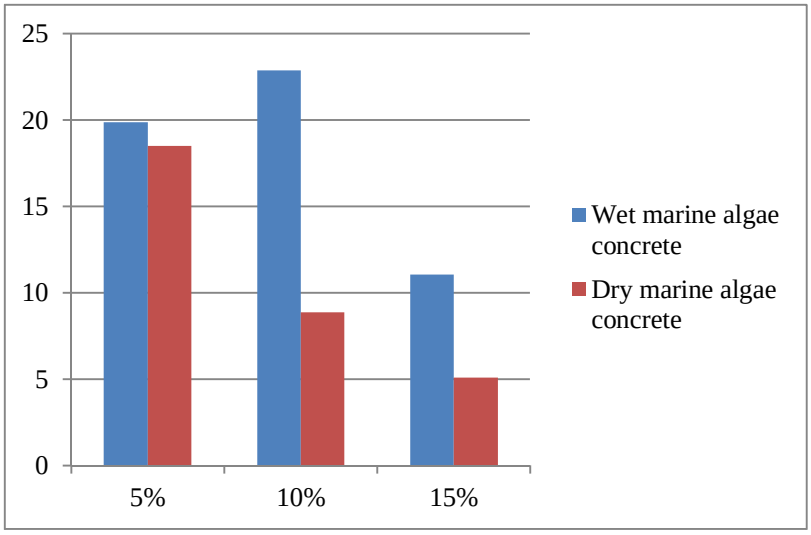

Fig 5 Comparison of 7th day Compressive Strength

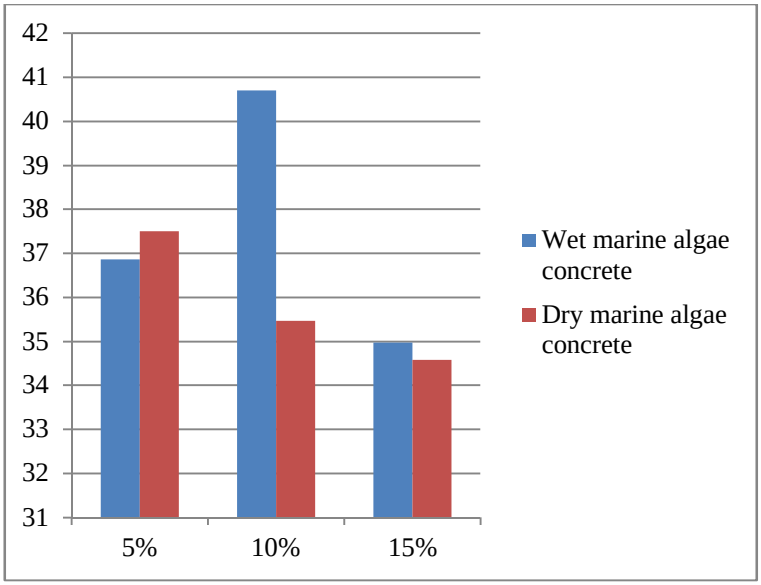

Fig 6 Comparison of 28th day Compressive Strength

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E. Split Tensile Strength Test

The Tensile Strength of the hardened concrete is an indirect measure, which is done by placing the cylindrical specimen longitudinally. A cylinder of diameter 150mm and 300mm length is casted and cured for 7, 28 days and tested. The tensile strength values are discussed in table 9 and 10 for 7 and 28 days respectively.

Table 9 Mean Tensile Strength on 7th day

No. of Days	State of Marine Algae	Mean Tensile Strength (in N/mm^2)			
		Conv.	5%	10%	15%
7 days	Wet	1.4	2.38	1.94	2.18
	Dry		1.855	1.25	1.651

Table 10 Mean Tensile Strength on 28th day

No. of Days	State of Marine Algae	Mean Tensile Strength (in N/mm^2)			
		Conv.	5%	10%	15%
28 days	Wet	2.47	3.625	2.455	1.65
	Dry		1.272	1.69	1.06

It is observed that, with addition of 5% of wet marine algae, the Tensile Strength tends to increase and further addition of marine algae decreases the Tensile Strength. The comparison of Tensile Strength is represented in Fig 7 and 8 for 7 and 28 days respectively.

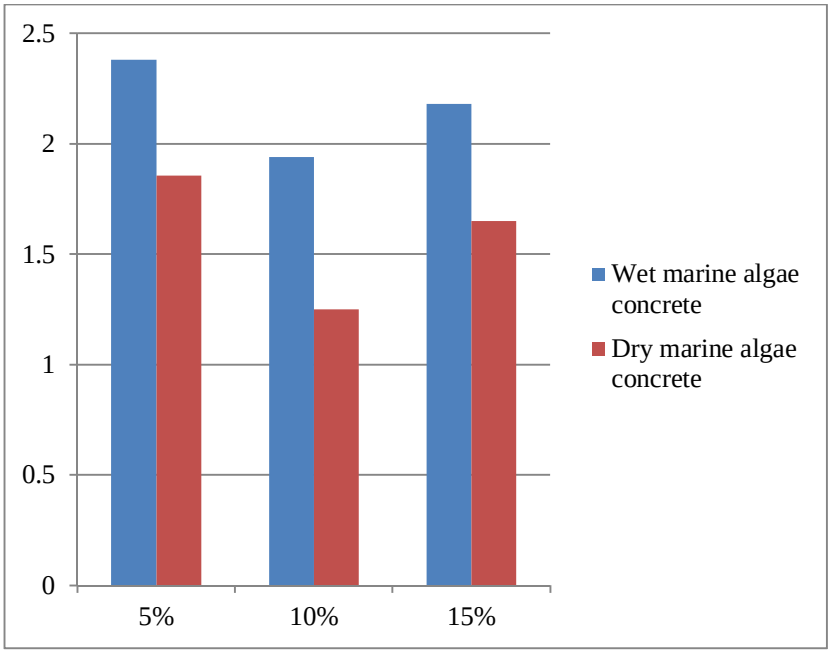

Fig 7 Comparison of 7th day Tensile Strength

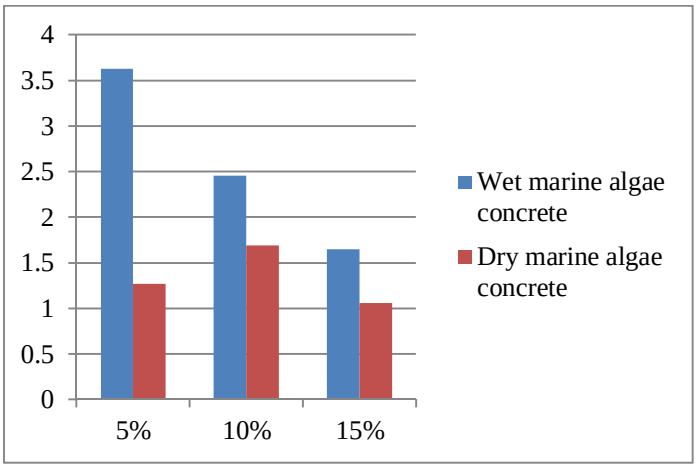

Fig 8 Comparison of 28th day Tensile Strength

F. Impact Resistance Test

The Impact Resistance test is carried out in cylindrical specimen of diameter 163mm and 50mm length. The test is performed using dead weight loader of hammer weight 4.65Kg with the height of fall 600mm. The test apparatus is shown in the Fig 9.

Fig 9 Impact Resistance Test

The test result is predicted as per the number of blows that the specimen withstands. The initial blow is counted as cracking starts and the final blow is the count when the specimen is completely deformed. The test result is shown in table 11.

Table 11 Impact Resistance on Concrete

Composition of Marine Algae	Initial Blow		Final Blow	
	Wet Marine Algae	Dry Marine Algae	Wet Marine Algae	Dry Marine Algae
5%	7	3	9	5
10%	5	2	6	4
15%	3	2	3	5

G. Rapid Chloride Permeability Test

It is a measure of durability test as it measures the concrete resistance to chloride attack. A potential difference of 60volts is given and the charge passed (in mA) through the specimen is studied by the indicator for every 30 minutes interval. The total charge passed is calculated by the following formula,

$Q=900(I_0+2\{I_{30}+I_{60}+I_{90}+I_{120}+I_{150}+I_{180}+I_{210}+I_{240}+I_{270}+I_{300}+I_{330}\}+I_{360})$

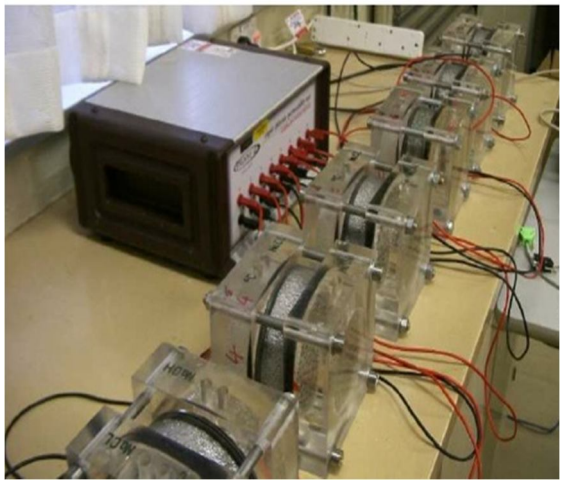

Fig 10 RCPT on Concrete

Fig 10 represents the setup for RCPT Testing. The RCPT rating is performed as per ASTM C1202. The chloride permeability and its respective ratings are tabulated in table 12.

Table 12 Chloride Permeability Ratings

Composition of Marine Algae	Charge Passed (in mA)		Chloride Permeability	
	Wet Marine Algae	Dry Marine Algae	Wet Marine Algae	Dry Marine Algae
5%	2703	3043	Moderate	Moderate
10%	1805	2992	Low	Moderate
15%	2920	3207	Moderate	Moderate

Thus, it is observed that the level of chloride permeability is moderate. Concrete of 10% Wet Marine Algae is of low rating, which means it has comparatively higher permeability.

VI. CONCLUSION

Recent studies on concrete mostly focuses on increasing the strength of concrete but no study has focused on how seaweed can increase the strength of the concrete and usage of seaweed as an internal curing agent. The algal precipitate is a rich source of magnesium, silica and carbonate materials. The compressive strength of the test specimens of 10% and 15% cement replacement with algae precipitate was found to increase as compared to the conventional concrete. It is a completely new study in the field of GREEN CONSTRUCTION MATERIAL. From the various tests that have been performed with the replacement of cement by algae in composition of 5% 10% and 15%, it may be concluded that, with the increase in the composition of wet marine algae upto 10% the strength parameters such as Compression Strength, Tensile Strength tends to increase. Addition beyond 10%, leads to decrease in strength. Thus the optimum percentage of algae to be added to the concrete is 10% by the weight of cement, which decreases the cement content to certain level. Wet Marine Algae Concrete shows increased strength on compared to Dry Marine

Algae Concrete because, as per SEM Analysis, the evidences of fringes are studied in Wet State of Marine Algae, which tends to reduce the voids formed in the structure of concrete and increase in binding property. Hence, Marine Algae species which belongs to natural sea waste can be used in construction industry by studying its complete properties. This type of construction sounds economical and there is also an added advantage of reduction in problem of waste.

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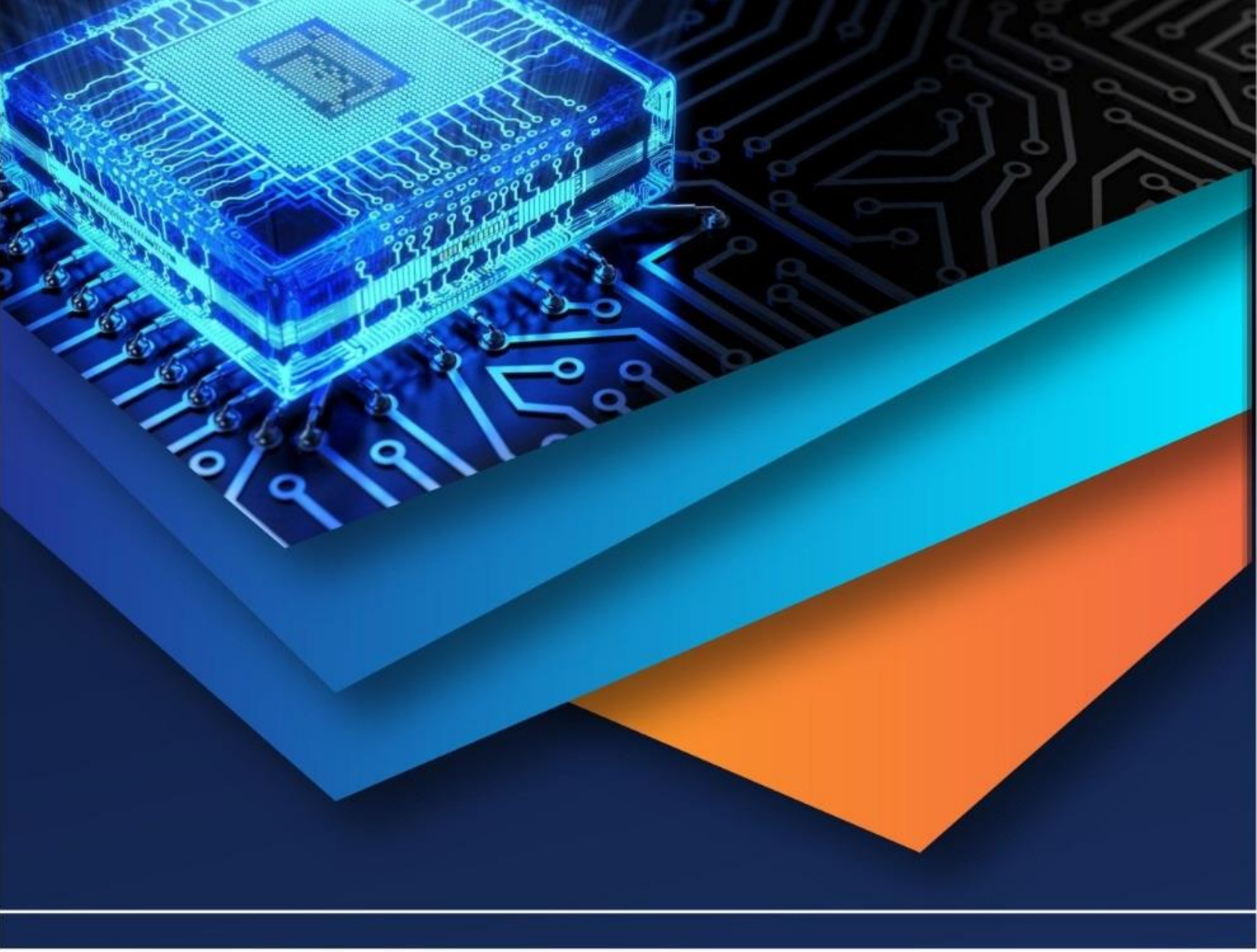

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