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Experimental Study on Partial Replacement of Cement by Fly Ash with Glass Fiber Reinforcement

Shwetha P C [1], Praveena K [2], Ajith B.T [3]. , Chandrashekara A [4]
[1] P G Student, K.V.G, College of Engineering, Sullia, India
[2]Assistant professor Dept. Of Civil Engineering, Sullia, India
[3] Assistant professor Dept. of Civil Engineering, Sullia, India
[4] HOD. Dept. Of Civil Engineering, Sullia, India

***Abstract**: Fly ash has been used as a mineral admixture in cement and concrete. Using it provides several advantages, such as improved strength and workability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions. Alkali Resistant glass fibers are used as additional reinforcement of constant 0.17% by weight of cement. Glass fibers acted as good crack arrester and increases split and flexural strength not increase in compressive strength. M40 grade of concrete is used for this study. The main objective of this work is to study the suitability of the fly ash as a mineral admixture for cement replacement and additional reinforcement of glass fibers in concrete. Fly ash as partial replacement of cement and glass fibers are used as additional reinforcement, which satisfies the various structural properties of concrete like compressive, split and flexural strength. From the entire study it is concluded that mix M3 (15%FA+0.17%GF) is the best combination among all mixes, which gives maximum, tensile, flexure strength and mix M3 (15%FA) is the best combination among all mixes, which gives maximum compressive strength over normal concrete.*
Keywords: Fly Ash (FA), AR Glass Fiber (GF), Workability, Compressive Strength, Split Tensile Strength, Flexural Strength.

I. INTRODUCTION

Sustainable development and produce a greener concrete material in the construction industry requires the utilization of industrial and agricultural waste materials. Now a days, for a number of reasons, the concrete construction industry is not sustainable. Mainly, it requires very large amount of virgin materials which can again require for next generations. Secondly, the main binding material in concrete is Portland cement, in the production of Portland cement produces huge amount of Carbon dioxides, this is a main reason to green house gas effects, emissions of carbon dioxides in manufacturing of Portland cements are causing global warming and climate change. Then another important criteria is, so many concrete structures suffer from durability problems which may waste the natural resources. So, implementing a solution to use a industrial and agricultural waste products for partial replacement of the port land cement, It seems to be suitable solution for sustainable development for present and future days. Recycling and reuse of waste materials contribute to energy savings in cement manufacturing, natural resources protection, and to protection of the environment from green house gas effect from minimises the emissions of cordon dioxide. Then other reasons are, the proper utilization of other certain components which are potentially pozzolanic reactivity can significantly improves the certain properties of concrete. One of the most important and suitable resource of mineral admixture among the industrial waste material is fly ash, as it is available in large quantities and it relatively contains a huge amount of silica. In an ancient time of construction, construction activities were carried out with the help of mudstones from mudstone industry. When the coal is burned in high temperature from thermal plants finally get a finely divided particles of fly ash, fly ash is byproduct of coal. Fly Ash is a by-product of burned coal from power station some efforts are being taken all over the world to proper utilize of industrial, agricultural waste and mineral byproducts as supplementary cementetious component to improve the strength, workability and other various properties of concrete. Fly ash is a mineral byproduct of thermal power station and its finely divided particles. Fly ash exhibits pozzolanic properties same as to naturally available pozzolanic materials. Fly ash contain concrete offers economical as well as technical benefits to the structural concrete and also fly ash concrete provide social benefits to the society to decrease the fly ash directly dispose to the environment and minimize the emission of carbon dioxide to the environment. Class F fly ash is used in this experimental investigation collected from Udupi power corporation limited Padubidre in Udupi District. Fiber reinforced concrete is a mixture of mainly port land cement, fine aggregate, coarse aggregate, water and addition of fibers. Fiber reinforced concrete is relatively new material, in fiber reinforced concrete, small length of fibers are dispersed randomly throughout the mix. The variety number of natural and artificial types of

fibers is available in market the artificial fibers are mainly glass fiber, steel fibers, recrons and organic polymers etc. When the fibers are present in concrete mixes it will acts as crack arresters and improves the tensile and flexural strength of fibers. Compared to the normal concrete mixes means, concrete having only cement, fine aggregate, coarse aggregate and water, fiber reinforced concrete increases the strength in terms of flexure and tensile strength.

II. OBJECTIVES.

The main objectives of this experimental investigation are as follows.

A. To study the various properties of fly ash used as mineral admixture for partial cement replacement and glass fiber is used as additional reinforcement.

B. To study the workability properties of concrete when cement is partially replaced with fly ash and increase the percentage of glass fibers in concrete.

C. To study the various mechanical properties of concrete such as compressive, split tensile and flexural properties of this study.

D. Use of industrial waste in use full manner to reduce the disposal problem in present and future days and significantly reduce the CO2 emission and also avoid adverse effect environment, provide economic construction material to the construction industry .

III. LITERATURE REVIEW

Saiful M, et al. (2010), This paper reports the results of an experimental investigation carried out to study the effects of fly ash on strength development of mortar and the optimum use of fly ash in mortar. Cement was partially replaced with six percentages 10%, 20%, 30%, 40%, 50%and 60% of fly ash by weight. Test results were shows that strength increases with the increase of fly ash up to an optimum value, beyond which, strength values started decreasing. Among the six fly ash mortars, the optimum amount of cement replacement in mortar was about 40%, which provides 14% higher compressive strength and 8% higher tensile strength as compared to OPC mortar. (1)

Srinivasa R, et al. (2010), In this experimental work glass fiber was added to the concrete at 0.03% by concrete volume. Comparison study was carried out to show the effectiveness of with and without glass fibers. The increase in compressive strength for all the grades of concrete mixes was varied from 20 to 25% when compared with 28 days strength. The flexural and split tensile strength for all the grades of concrete mixes was varied from 15% to s20% when compared with 28 days strength. (2)

Pitroda J, et al. (2012), The cement has been replaced by fly ash accordingly in the range of 0% 10%, 20%, 30% & 40% by weight of cement for M-25 and M-40mix. Result was indicated that FA can be used as cement substitute at 10% replacement at 28 days curing age Compressive strength reduces when cement replaced fly ash. As fly ash percentage increases compressive strength and split strength decreases. (3)

Shamsuddin H, et al. (2012), In this experimental work glass fiber was added to the concrete at 0.03% by concrete volume. Comparison study was carried out to show the effectiveness of with and without glass fibers. It has been observed that the workability of concrete decreases with the addition of Glass Fibres. Flexural strength, Split tensile strength for M-20, M-30 and M-40 grade of concrete at 3, 7 and 28 days are observed to be 20% to 30%, 25% to 30% and 25% to30% respectively when compared with 28 days strength of Plain Concrete. (4)

Kartikey T, et al. (2013), He suggested that when the cement is partially replaced with fly ash, fly ash improves the properties of structural concrete. In this work characteristic strength and properties of various grades of concrete were studied, the various grades were M15, M20 and M25 for all this grades fly ash was used with cement at 20%, 40% and 60%. When the cement is partially replaced with fly ash workability of concrete was increased with increased percentage of fly ash. For each grade of concrete three cubes were tested for compressive strength. The optimum strength was obtained for M15 grade was 14.48 N/mm^2 for 20% replacement, 14 N/mm^2 for M20 grade at 20% replacement level and 14.05 N/mm^2 for M25 grade at 20% replacement. From this work finally concluded that fly ash replacement up to 20% shows greater strength than 40% and 60% for all three grades at 28 days of curing period. (5)

IV. MATERIALS AND PROPERTIES

A. Cement

Ordinary Portland cement of 43 grade (Ramco) conforming to IS 8112-1989 was used. Table 1 shows the test results of basic properties of cement.

Table 1: Basic Properties of Cement

Properties	Cement
Specific gravity	3.1
Standard consistency	31%
Initial setting time	38min
Final setting time	480min
Fineness	5.3%

B. Fine Aggregate

Natural river sand of size below 4.75mm conforming to zone II of IS 383-1970 was used as fine aggregate. Table 2 shows the test results of basic properties of fine aggregates.

Table 2: Basic Properties of Fine Aggregates

Properties	Fine Aggregate
Specific gravity	2.62
Water absorption	1.45%

C. Coarse Aggregate

Natural crushed stone with 20mm down size was used as coarse aggregate. Table 3 shows the test results of basic properties of coarse aggregates.

Table 3: Basic Properties of Coarse Aggregates

Properties	Coarse Aggregate
Specific gravity	2.65
Water absorption	0.39%

D. Fly Ash

Class F fly ash was used in this study and it was collected from Udupi Power Corporation Limited, Padubidre, Udupi District, Karnataka. Table 4shows the test results of basic properties of fly ash

Table 4: Basic Properties of Fly Ash

Properties	Fly Ash
Specific gravity	2.5
Water absorption	2.28%

E. Glass Fiber

AR Glass fibers of 12mm length fibers are usually round and straight with diameters of 0.014 mm. They could also be bundled together to produce glass fibers bundles with bundle diameters up to 1.3 mm. The Glass fibers used in the present experimental investigation is High Dispersion Cem-FIL AR fibers collected from Sanjay Impex Bangalore.

Table 5: Basic Properties of Glass fiber

Properties	Coarse Aggregate
Specific gravity	2.68
Modulus of Elasticity	*72 GPA*

F. Water

Ordinary portable water was used in this investigation both for mixing and curing.

G. Superplasticizer (SP)

Conplast SP430 is used as a super plasticizer. It is a chloride free, chemical admixture. It is used to maintain w/c ratio and enhance the workability of concrete mixes.

H. Concrete Mix Design

Mix proportion used in this study is 1:1.61:2.65 (M40) with water-cement ratio of 0.4 and super plasticizer of 0.75%.

I. Batching and Mixing of Materials

Weight batching and machine mixing are adopted in this experimental work. The percentage replacement of ordinary cement by FA and addition of glass fiber and their material weight are shown in Table 6

Table 6: Mix Proportion per Cubic Meter

Mix Names	GF (gm)	FA (kg)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (w/c 0.4) (liters)	0.75% SP (liters)
M	-	0	425	684.25	1126.25	170	3.187
M1	-	21.25	403.375	684.25	1126.25	170	3.1875
M2	-	42.5	482.5	684.25	1126.25	170	3.187
M3	-	63.75	361.25	684.25	1126.25	170	3.187
M4	-	85	340	684.25	1126.25	170	3.187
M5	-	106.2	318.75	684.25	1126.25	170	3.187
M6	-	127.5	297.5	684.25	1126.25	170	3.187
M7	0.722	0	425	684.25	1126.25	170	3.187
M8	0.722	21.25	403.375	684.25	1126.25	170	3.187
M9	0.722	42.5	382.5	684.25	1126.25	170	3.187
M10	0.722	63.75	361.25	684.25	1126.25	170	3.187
M11	0.722	85	340	684.25	1126.25	170	3.187
M12	0.722	106.2	318.75	684.25	1126.25	170	3.187
M13	0.722	127.5	297.5	684.25	1126.25	170	3.187

IV. METHODOLOGY

A. The main aim of this present work is to study the effects of fly ash as mineral byproduct for partial replacement of cement and glass fiber is additional reinforcement by weight of cement in present investigation. Thus it is an expected that use of fly ash and glass fiber in concrete shows better strength and other properties of concrete.

B. Class F fly ash is collected from udupi power corporation limited, Padubidre in Udupi district and AR glass fiber is collected from Sanjay Impex Bangalore. Various basic property tests are conducted on fly ash during the progress of the work.

C. Mixing is done by mechanically operated concrete mixer. During the process of mixing first wet the mixer with ordinary portable water, Super plasticizer added to measured water and stirred well then mixing is done by added aggregate to mixing drum first, after that adding 25% of total water and super plasticizer to the mixer to prevent cement sticking to blades or at the bottom of the drum. Then sand is added, with 25% of water and super plasticizer again. After through mixing of aggregates, cement with admixtures if any is added and remaining 50% of water and super plasticizer is added and then AR glass fibers are added to the wet mix.

D. For each mix slump test is conducted to measure workability. For each proportion 12 cubes of size 100*100*100mm, 3 cylinder of 100mm dia and 200mm in height and 3 beams of 100*100*500mm are casted.

E. Totally 168 cubes, 42 cylinder and 42 beams are casted. After casting concrete is filled into moulds and compacted on vibration table. Demoulding was done after 24 hours of casting. Specimens are cured in curing tank. Water immersion method of curing is adopted.

F. Every proportion cubes, cylinders, beams are casted and tested for compressive, tensile and flexural strength in the compressive testing and flexural testing machine. Figure 1 show the concrete placed in moulds.

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Fig 1: Moulds filled with concrete

A. Testing of Specimen

Compressive strength test were carried on cubes, split tensile strength test on cylinders and flexural strength test on beams as shown in figure.

Fig 2: Compressive Strength Test

Fig 3: Split Tensile Strength Test

Fig 4: Flexural Strength Test

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V. RESULTS AND DISCUSSIONS

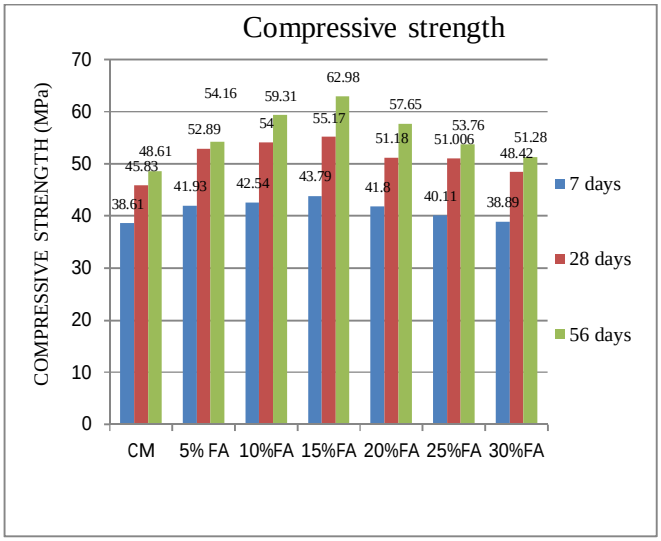

Fig 5: 7, 28, 56 Days Compressive Strength of fly ash mix

The figure 5 represents the compressive strength of concrete with partial replacement of cement by fly ash with different percentages. Compressive strength of fly ash is increased than corresponding control concrete mix. Compressive strength increased upto 15% replacement of fly ash, after that it gets start to decreasing.

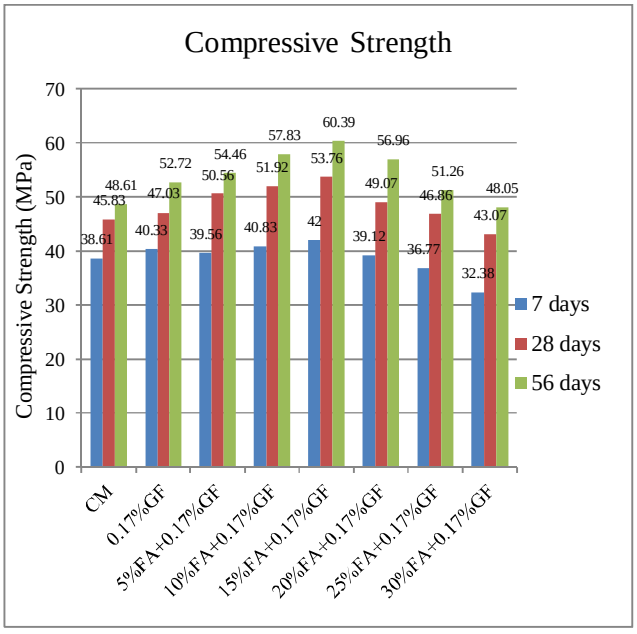

Fig 6: 7, 28, 56 Days Compressive Strength of FA+GF mix

The above figure 6 shows the compressive strength of concrete with partial replacement of fly ash and addition of glass fiber reinforcement by weight of cement. Compressive strength of FA+GF concrete is higher than control concrete. The optimum percentage was obtained at 15% replacement of FA and constant of 0.17% GF.

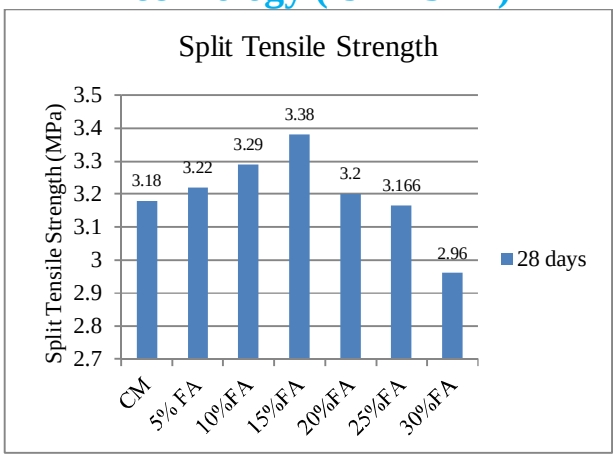

Fig 7: 28 Days Split Tensile Strength of FA mix

The above figure 7 shows the 28 days split tensile strength of concrete with partial replacement of fly ash. Split tensile strength of concrete is found to be increased than that of control mix split tensile strength. The Maximum split tensile strength was observed at 15% fly ash replacement.

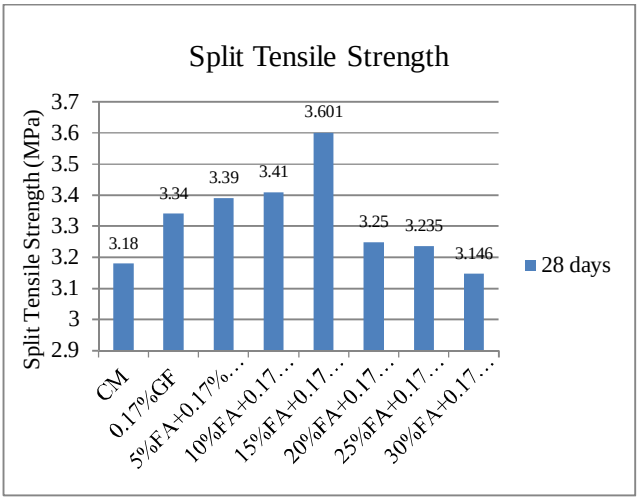

Fig 8: 28 Days Split Tensile Strength of FA+GF mix

From the above graph 8 we can observe that fly ash mixes and addition of glass fiber reinforcement shows greater strength than the strength compared to control mix and fly ash mix concrete. Their after strength gets start to decreasing. However, the maximum tensile strength of this mix is obtained at 15%FA + 0.17%GF combinations.

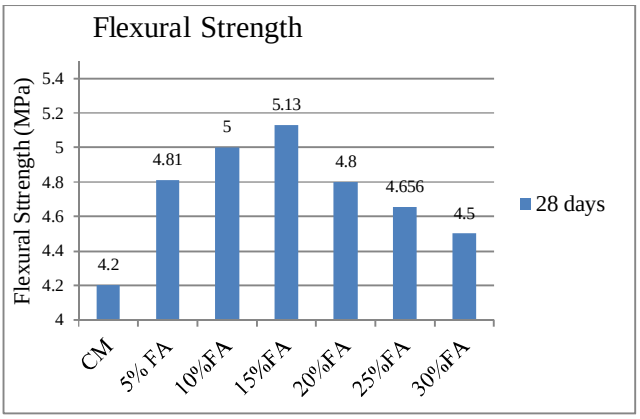

Fig 9: 28 Days Flexural Strength of FA mix

The above graph 9 represents the flexural strength of fly ash concrete at 28days. It is observed that flexural strength of fly ash

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concrete is greater than that of corresponding control mix. At 15% FA mix shows maximum flexural strength than control mix.

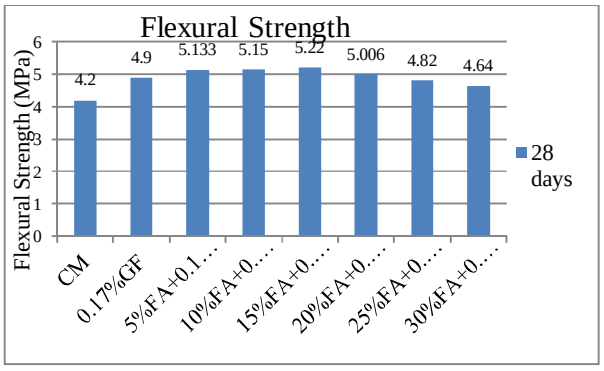

Fig 10: 28 Days Flexural Strength of GF+FA mix

From the graph 10 we can conclude that FA + GF combination mixes gives optimum strength than control mix and fly ash combination mix. Flexural strength is found to be increased at 15% FA + 0.17%GF combination mixes.

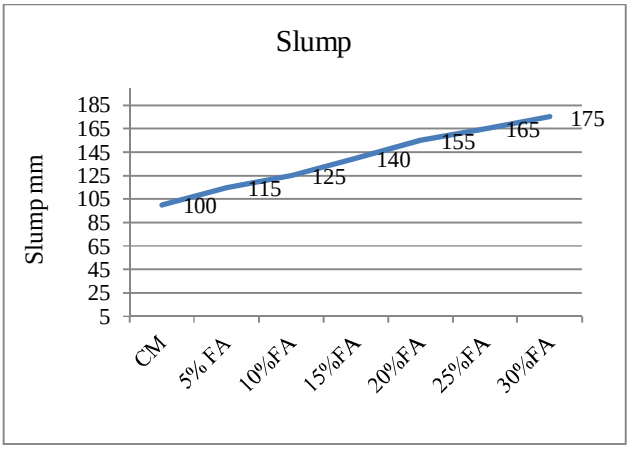

Fig 11: Workability of fly ash concrete mix.

From the above fig we can concludes that workability of fly ash mix concrete goes on incresed as the fly ash content increased in concrete mix, because fly ash having more finer particles than cement.

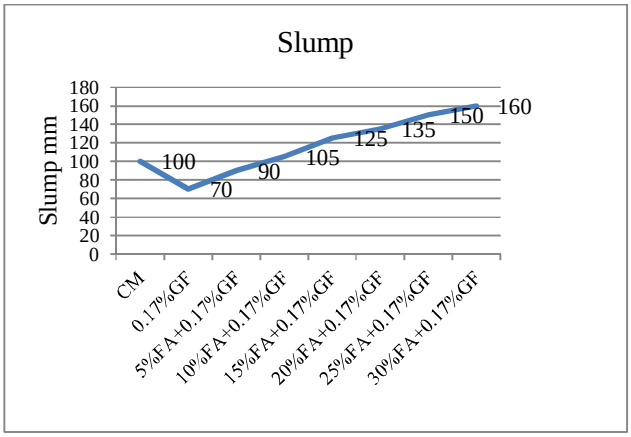

Fig 12: Workability of fly ash and glass fiber concrete mix.

From the graph we can observe that workability of mixes reduced compared with fly mix and control mix, because glass fibers absorbs more water content.

VI. CONCLUSION

Based on experiments and test results on fresh & hardened concrete the following conclusions are drawn

A. Fly ash content increased in the concrete mix workability of concrete is also increased and FA+GF combination mixes reduces the workability of mixes compared to the fly ash concrete mixes.

B. The rate of gain in strength of fly ash concrete specimens is observed to be higher than the corresponding conventional concrete.

C. Fly ash concrete having various cement replacement level up to 15% exhibited satisfactory results for both compressive, flexural and tensile strength.

D. 15% FA and 0.17% GF combination gives good tensile and flexural strength than corresponding control mix and fly ash concrete mixes.

E. Use of fly ash reduces the amount of cement content as well as heat of hydration in a concrete mix. Thus, the construction work with fly ash concrete becomes environmentally safe and also economical.

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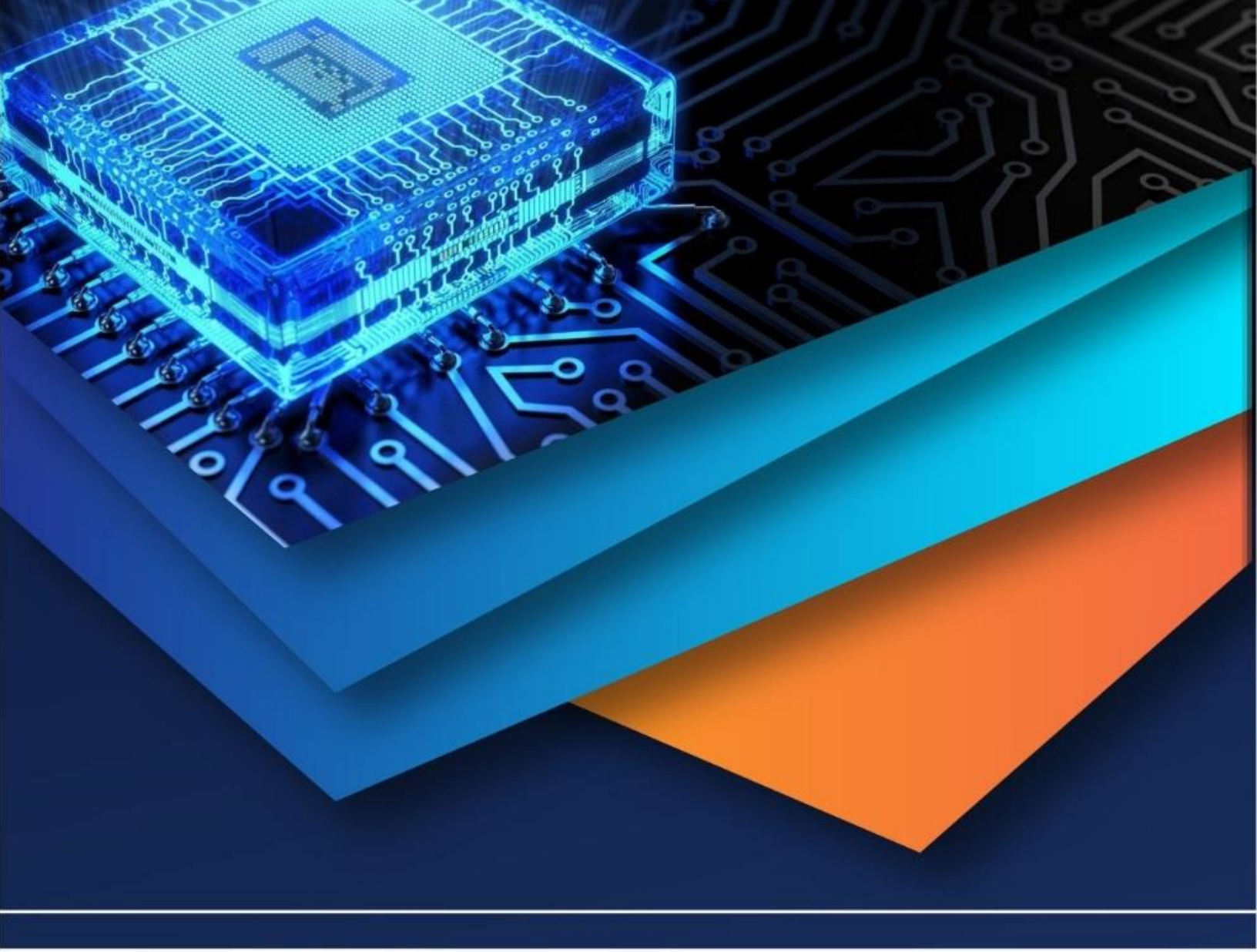

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