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Comparison Study of Basalt Fiber and Steel Fiber as Additives to Concrete

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Abstract: ***It is now well established that one of the important properties of Basalt fiber and steel fiber concrete is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fiber composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibers are able to hold the matrix together even after extensive cracking. In this paper, the mechanic properties, technologies, and applications of basalt fiber and steel fibers are discussed. Experimental investigation was done using M40 grade concrete mix and tests were carried out as per recommended procedures by relevant codes. Based on the laboratory experiments on cubes, beams and cylindrical specimens have been designed with addition of basalt and steel fiber concrete containing (0%, 0.25%, 0.5%, 0.75%, 1% and 1.25%). A result data obtained has been analyzed and compared with a control specimen (0% Fiber) and also finally the test results for basalt and steel fiber were compared. A relationship between Compressive strength, Flexural strength and Tensile strength with Age i.e. 7days and 28 days represented graphically.***
Key words: Concrete, fiber reinforce, basalt fiber, steel fiber, Compressive, split tensile & flexural strengths

I. INTRODUCTION

Fiber Reinforced Concrete plays a very important role in structural engineering applications. Concrete is subjected to high temperature during fire accidents, natural disasters. Even though concrete is the most available material for construction. It has some limitations like loss in strength, loss of weight, shrinkage, expansion, etc.

Basalt rock is a volcanic rock and can be divided into small particles then formed into continues or chopped fibers. Basalt originates from volcanic magma and flood volcanoes, a very hot fluid or semi-fluid material under the earth crust, solidified in the open air. Basalt is the name given to a wide variety of volcanic rock, which is gray. Brown or dark in color, formed from volcanic lava after solidification. Basalt fiber has a higher working temperature and has a good resistance to chemical attack, impact load, and fire with less poisonous fumes.

II. LITERATURE REVIEW

A.Meher Prasad and Devdas Menon mentioned Glass fiber reinforced gypsum (GFRG) wall panel is made essentially of gypsum plaster reinforced with glass fibers. The panels are hollow and can be used as load bearing walls.

C. Selin Ravikumar and T.S. Thandavamoorthy, The study there has been a significant increase in the use of fibers in concrete for improving its properties such as tensile strength and ductility. The fiber concrete is also used in retrofitting existing concrete structures. Among many different types of fibers available today, glass fiber is a recent introduction in the field of concrete technology.

Deshmukh S.H., Bhusari J. P, Zende A. M Concrete is a tension weak building material, which is often crack ridden connected to plastic and hardened states, drying shrinkage, and the like. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking.

A. Matthys S: (2011)

Basalt fiber as a new material in infrastructure engineering as compared to carbon, glass and aramid for strengthening. He has tested the confinement of columns by FRP and has reported that basalt fibers show comparatively good properties to glass fibers. The basalt fibers are chemically inert.has died the Concrete is most widely used construction material in the world. Fibereinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The fibers used in FRC may be of different materials like steel, G.I., carbon, glass, aramid, asbestos, polypropylene, jute etc.

B. Singaravadivelan et al :(2012)

The concrete strength increased by 25% on addition of basalt fiber. This literature survey reveals that fibers are truly corrosive resistance, environment friendly. Basalt fibers have property to resist high impact load and temperature loads. Basalt requires less energy in manufacture and row material is widely available in all over world. Basalt fibers cheaper than other fibers like carbon, basalt but their mechanical and physical properties gives impressive results so it becomes a beneficial solution in structural engineering.This paper present efficiency of basalt fiber concrete on cubes, cylinder and beams under compression, flexural and split tensile test.

C. Ranjitsinh K. Patil, D. B. Kulkarni :(2012)

The fibers were placed in concrete randomly by (0.25%, 0.5%, 0.75%, 1%) of its total volume of concrete. For each percentage of fiber total three cubes and three beams were casted to take average results. Finally comparative results are shown for each percentage and for these three fibers.

D. G.K.Geethanjali :(2012)

In this, the effect of inclusion of basalt fibers and SPs on the compressive, flexural strength of fiber reinforced concrete was studied. The experimental test results demonstrated at considerable increases in compression, flexural of specimen at 3, 7 and 28 days with addition of basalt fibers and SPs. NDT test like Rebound Hammer test and Ultrasonic Pulse Velocity (UPV) test on concrete mixtures under different stress conditions are seen.

E. Raghunath and k.suguna

has worked on Flexural behavior of high strength steel fiber reinforced concrete beams by In this study total 4 beams of 3m length and 150mmx250mm in cross section were casted and tested in laboratory. Three different steel fibers volume were taken i.e. 0.5%, 1% and 1.5%. All beams were tested under two point load condition in a loading frame of 750kn capacity.

F. Nayan Rathod, Mallikarjun Pujari, Mukund Gonbare: (2013)

In this study trial test for concrete with basalt fiber and without basalt fiber are conducted to show the difference in compressive strength and flexural strength by using cubes and concrete beams. Various application of BFRC shown in the study, the experimental test result, Techno-financial comparison with other type presented, indicate the tremendous potential of BFRC as an alternative construction material.

III. MATERIALS AND ITS PROPERTIES

A. Cement

Ordinary Portland cement 53 grade brand conforming to I.S.I standard is used in the present investigation. The cement is tested for its various properties as per IS code

Table 1: Physical properties of cement

S. No	Property	Test results
1	Normal consistency	29%
2	Specific gravity	3.13
3	Initial setting time	92 minutes
4	Final setting time	195 minutes

1) *Fine Aggregate:* The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386-1963(28). Grain size distribution of sand shows that it is close to the zone-I of IS 383-1970(29).
2) *Coarse Aggregate:* Machine crushed angular granite metal from local source is used as coarse aggregate. It is from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties.
3) *Basalt Fiber: The* basalt is mainly used in that various application. Also fiber glass polythene fibers, carbon fibers, polyamide fibers are now developed and also used in construction, industrial and infrastructure development. In that list new one fiber is added, called, as basalt rock fibers. Basalt originates from volcanic magma and flood volcanoes, a very hot fluid or semi-fluid material under the earth crust, solidified in the open air. Basalt is the name given to a wide variety of volcanic rock, which is

gray. Brown or dark in color, formed from volcanic lava after solidification. It has better strength characteristics of good hardness and thermal properties. Basalt rock fibers give high strength and low cost high performance to solve the problem in the large project like cracking, structural failure of concrete.

Fig 1 Basalt rock

Fig 2 Basalt fiber

The typical diameter lies in the range of 0.6 to 0.1 mm basalt fibers are being used in this project. Length of these basalt fibers is 12 mm and Density of basalt fiber is 2650 kg/cu.m.

Table.2 : Chemical composition of basalt fiber

Chemical	%W	Chemical	%W
SiO_2	52.8	K_2O	1.46
Al_2O_3	17.5	TiO_2	1.38
Fe_2O_3	10.3	P_2O_5	0.28
MgO	4.63	MnO	0.16
CaO	8.59	Cr_2O_3	0.06
Na_2O	3.34		

4) *Steel Fibers:* In this experimentation defferent types of Steel fibres were used. Steel fibres are short, discrete lengths of steel with an aspect ratio from about 30 to 150, and with any of several cross sections. Some steel fibres have hooked ends to improve resistance to pullout from a cement-based matrix. These are most commonly used fibre. Their shape will be Round of diameter 0.25 to 0.75mm. They Enhances flexural, impact and fatigue strength of concrete

An Experimental study is conducted to find out the Compressive, Flexural strength and Split tensile strength of concrete at 7 and 28 days.

M40 Grade Conventional Concrete.

Normal cement concrete + 0% Basalt fiber
Normal cement concrete + 0% steel fiber
Normal cement concrete + 0.25% Basalt fiber
Normal cement concrete + 0.25% stee fiber
Normal cement concrete + 0.5% Basalt fiber
Normal cement concrete + 0.5% stee fiber

Normal cement concrete + 0.75% Basalt fiber
Normal cement concrete + 0.75% stee fiber
Normal cement concrete + 1% Basalt fiber
Normal cement concrete + 1% stee fiber
Normal cement concrete + 1.25% Basalt fiber
Normal cement concrete + 1.25% stee fiber
Normal cement concrete + 1.5% Basalt fiber
Normal cement concrete + 1.5% stee fiber

IV. RESULTS AND DISCURSIONS

A. Compressive Strength

The compressive strength of the concrete was done on 150 x 150 x 150 mm cubes. Testing of the specimens was done at 7 days and 28 days at the rate of three cubes for each mix on that particular day. The average value of the 3 specimens is reported as the strength at that particular age. The compressive strength test was conducted for all the mixes and the results are shown in the table below.

Table 3: Compressive strength test results for basalt fiber concrete.

S.NO	% of basalt fiber	Compressive strength(N/mm^2)	
		7 days	*28 days*
1	0	33.9	49.12
2	0.25	34.5	50.23
3	0.5	35.9	53.2
4	0.75	37.16	54.9
5	1	35.14	52.1
6	1.25	33.95	50.6

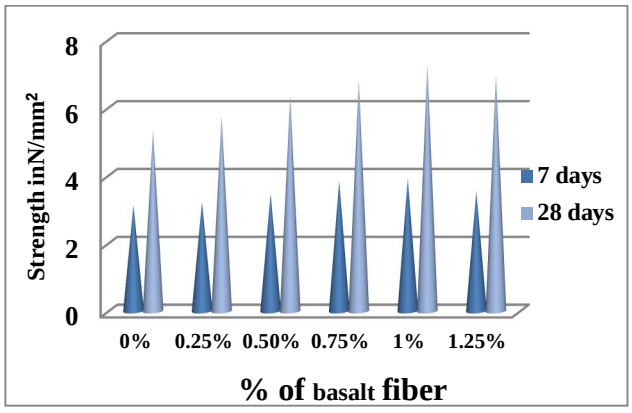

Fig. 3 Compressive strength Vs % of basalt fiber

Table 4: Compressive strength test results for steel fiber concrete

S.NO	% of steel fiber	Compressive strength (N/mm^2)	
		7 days	*28 days*
1	0	33.9	49.12
2	0.25	32.6	49.96
3	0.5	35.26	52.3
4	0.75	37.82	53.18
5	1	35.34	48.24
6	1.25	32.12	47.92

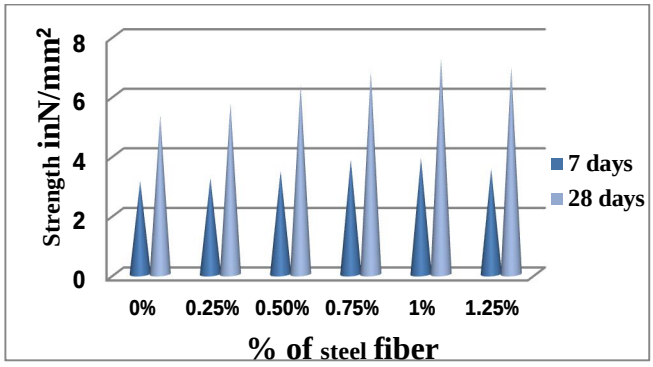

Fig. 4 Compressive strength Vs % of steel fiber

It was observed that the compressive strength basalt fiber concrete of 0%, 0.25%, 0.5%,0.75%,1.0% and 1.25% at the age of 28 days has reached its target mean strength however it was observed that the compressive strength increased by 2.26%, 8.31%, 11.76%, 6.07% and 3.01 respectively when compared with NCC.

In this parameter up to 0.75% has been observed the compressive strength in increasing manner. Beyond the values are decreased within the comparison of basalt fiber concrete.

The compressive strength of steel fibre is increased by 1.7%, 6.47%, and 8.26% with the addition of steel fiber in concrete by 0.25%, 0.5% and 0.75% respectively. But the remaining addition of steel fibres to concrete is not reached to the target mean strength.

1) *Split Tensile Strength:* The indirect tensile strength was measured on 150 x 300 mm cylinders and the results were shown below.

Table 5: Split tensile strength test results for basalt fiber concrete

S.NO	% of basalt fiber	Split tensile	
		7	*28*
1	0	2.1	4.79
2	0.25	2.46	5.04
3	0.5	2.8	5.48
4	0.75	2.94	5.9
5	1	2.72	5.24
6	1.25	2.26	5.08

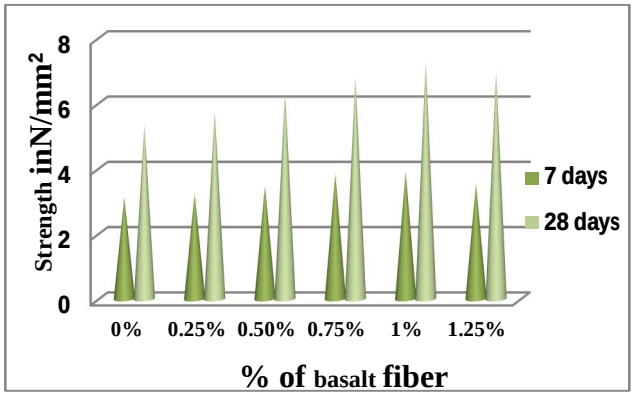

Fig. 5 Tensile strength Vs % of basalt fiber

Table 6: Split tensile strength test results for steel fiber concrete

S.NO	% of steel fiber	Split tensile strength (N/mm^2)	
		7 days	*28 days*
	0	2.1	4.79
2	0.25	2.32	4.88
3	0.5	2.44	4.98
4	0.75	2.69	5.08
5	1	2.9	5.36
6	1.25	2.54	4.9

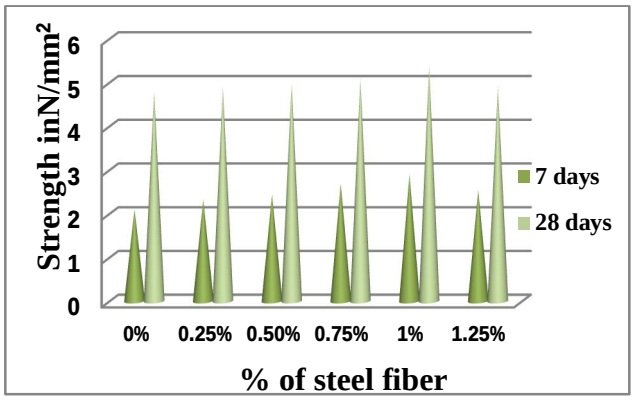

Fig. 6 Tensile strength Vs % of steel fiber

It was observed that the split tensile strength basalt fiber concrete of 0%, 0.25%, 0.5%,0.75%,1.0% and 1.25% at the age of 28 days has reached its target mean strength however it was observed that the split tensile strength increased by 5.21%, 14.40%, 23.17%, 9.39% and 6.05respectively when compared with NCC.

In this parameter up to 0.75% has been observed the split tensile strength in increasing manner. Beyond the values are decreased within the comparison of basalt fiber concrete.

The split tensile strength of steel fiber is increased by 1.88%, 3.97%, 6.05% and 11.89% with the addition of steel fibre in concrete by 0.25%, 0.5%, 0.75% and 1% respectively. But at the addition of 1.25% steel fibres, the strength of concrete decreased by 2.29%.

1) *Flexural Strength:* Flexural strength of the concrete was determined from modulus of rupture test on beam specimens of 150 x 150 x 750 mm size.

Table 7: flexural strength test results for basalt fiber concrete

S.NO	% of basalt fiber	Compressive strength (N/mm^2)	
		7 days	*28 days*
1	0	3.12	5.32
2	0.25	3.45	6.98
3	0.5	3.92	8.96
4	0.75	3.72	8.22
5	1	3.46	7.44
6	1.25	3.28	6.76

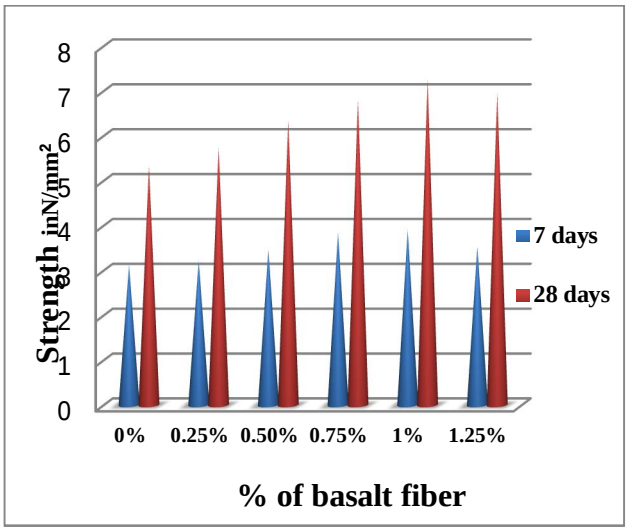

Fig. 7 Flexural strength Vs % of basalt fiber

Table 8: flexural strength test results for steel fiber concrete

S.NO	% of steel fiber	Compressive strength (N/mm^2)	
		7 days	*28 days*
1	0	3.12	5.32
2	0.25	3.22	5.73
3	0.5	3.46	6.34
4	0.75	3.84	6.8
5	1	3.9	7.25
6	1.25	3.53	6.95

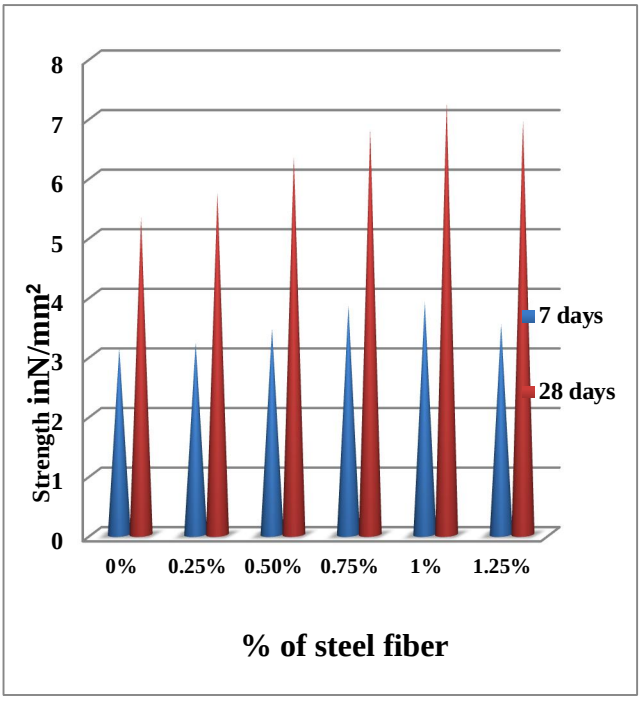

Fig. 8 Flexural strength Vs % of steel fiber

It was observed that the flexural strength basalt fiber concrete of 0%, 0.25%, 0.5%, 0.75%,1.0% and 1.25% at the age of 28 days has reached its target mean strength however it was observed that the split tensile strength increased by 31.20%, 68.42%, 54.51%, 39.84% and 27.06respectively when compared with NCC.

In this parameter upto 0.75% has been observed the flexural strengthen increasing manner. Beyond the values are decreased within the comparison of basalt fiber concrete.

The flexural strength of steel fibre is increased by 7.71%, 19.17%, 27.82% and 36.28% with the addition of steel fibre in concrete by 0.25%, 0.5%, 0.75% and 1% respectively. But at the addition of 1.25% steel fibres, the strength of concrete decreased by 30.64%.

IV. CONCLUSION

When the compressive strength, split tensile and flexural strength of concrete with 0%, 0.25%, 0.5%, 0.75%, 1% and 1.25% weight addition of concrete with basalt and steel fiber cured in Normal Water for 28 days.

The target mean strength has been increased up to 0.75% by weight. Whereas the compressive strengths at 1% and 1.25 % on addition of basalt and steel fiber are lower as compare to normal cement concrete.

The target mean strength has been increased up to 1% by weight. Whereas the split tensile and flexural strength at 1.25 % addition of basalt and steel fiber are lower as compare to normal cement concrete.

In the above statement we observed that basalt fibre concrete which provides outstanding results compared to the steel fibre in the following aspects like compression, split tensile and flexural strength.

When basalt fiber is compared with steel fiber, deforms is having higher strength values than the later.

Also it was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibers than the basalt fiber reinforced concrete. It shows that the presence of fibers in the concrete acts as the crack arrestors.

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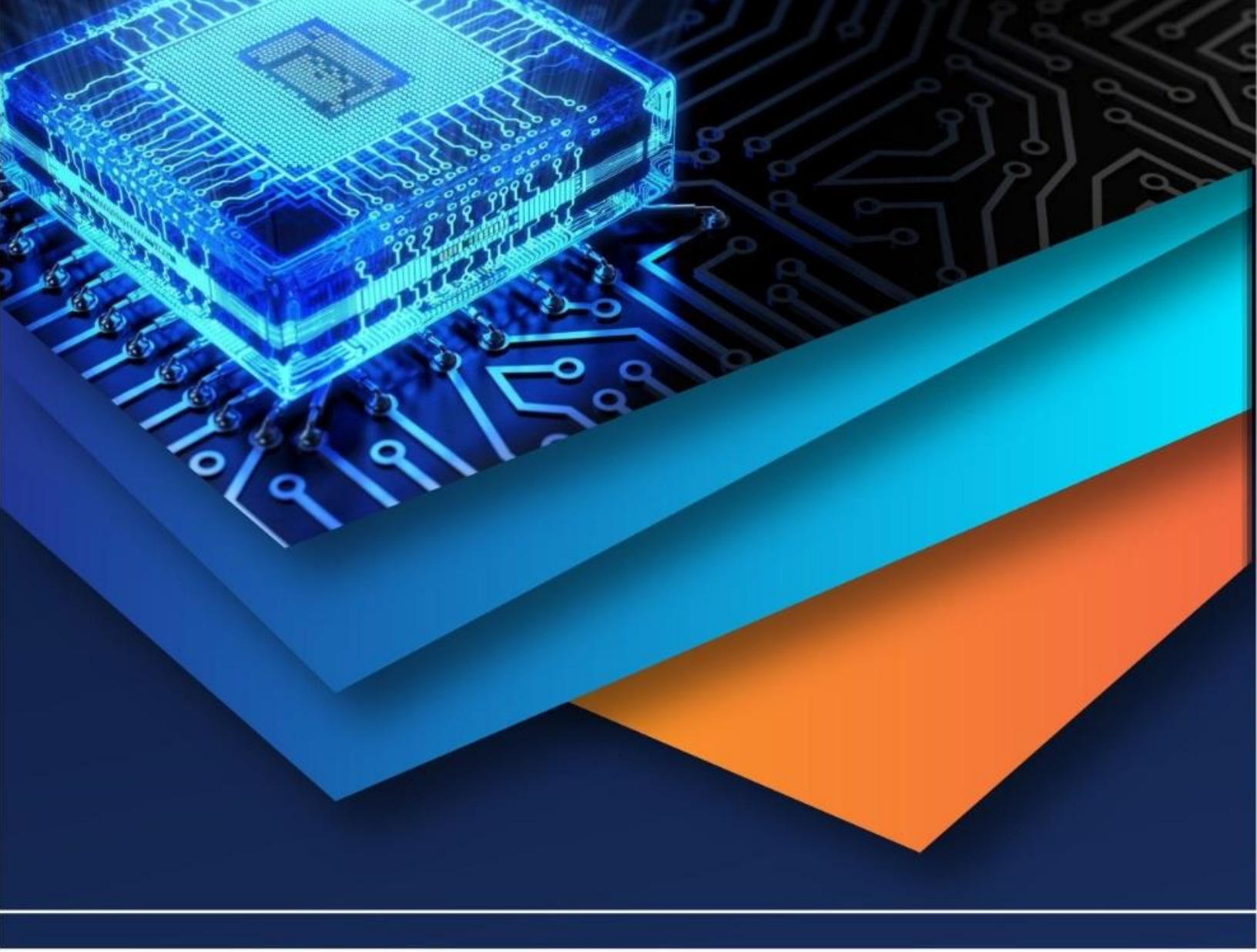

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