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Partial Replacement of Coarse Aggregate with Coconut shell and using Pulp Black Liquor as Admixture

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Abstract: ***This Concrete is a construction material composed of cement, fine aggregate and coarse aggregate mixed with water. Due to rapid development, construction rate is increasing day by day. Coarse aggregate is the major component of concrete. Natural resources are widely exploited for the availability of aggregates. To improve the properties of concrete, now a days admixtures are widely used. In this project we are partially replacing coarse aggregate with coconut shell and Pulp Black Liquor (PBL) is used as an admixture. PBL is a waste product from paper industry. It is a by-product of Kraft process when digesting pulp wood into paper. 15% of coarse aggregate is replaced with coconut shell, which is the optimum value obtained by studies. PBL is added in 1%, 1.2%, 1.4% and 1.6%. Addition of coconut shell reduces the exploitation of natural resources. Addition of PBL increases workability of fresh concrete and strength will be increased with its addition. Hence both coconut shell and PBL are waste products, the mix thus obtained is a sustainable alternative.***
Keywords: Pulp black liquor, Coconut shell, Strength tests, Density and Durability.

I. INTRODUCTION

This Concrete is a construction material which is used worldwide. Its utilization is increasing at a higher rate due to infrastructural development. Increasing production in concrete results in some negative impact on nature such as extensive extraction of aggregates from natural resources. Thus it is important to find out an alternative to replace aggregates. Coconut shell is an agricultural waste which is readily available. The shells are non-biodegradable, so that it can be readily added to concrete. From various studies it is observed that replacing 15% of coconut shell (CS) gives the optimum value.

In modern construction techniques admixtures are added to concrete in order to increase properties of concrete. They are materials other than cement, aggregates and water which are added during or before mixing. In this study we are using Pulp Black Liquor (PBL) as an admixture. Admixtures can be plasticizers, retarders, accelerating, water reducing and air entraining. PBL is used as a plasticizer admixture. PBL is a by-product of paper industry. It is easily available. PBL is added in various dosages such as 1%, 1.2%, 1.4% and 1.6%.

After addition of PBL and coconut shell various properties of concrete such as workability, compressive strength, flexural strength, split tensile strength and density are checked and the results are compared with that of control mix.

II. MATERIALS USED

Concrete is the construction material composed of cement, fine aggregate, coarse aggregate and water. In this project we are replacing 15% of coarse aggregate with coconut shell and pulp black liquor is used as an admixture.

A. Cement

Cement is the binder used for construction that sets, hardens and adheres to other materials to bind them together. Different types of cement is available in the market. In this study we had used 53 grade ordinary Portland cement.

B. Fine Aggregate

Aggregate passing through 4.75 mm IS sieve and retaining on 75 micron IS sieve are called fine aggregates. The purpose of fine aggregate is to fill the voids in the coarse aggregate to act as a workability agent. In this study manufactured sand is used as fine aggregates.

C. Coarse Aggregate

Coarse aggregates are particles that retain on 4.75mm IS sieve. They are crushed gravel or stone which is formed as a result of natural disintegration. The function of coarse aggregate is to act as the main load bearing component of concrete. Aggregates passing through 20 mm IS sieve is used as coarse aggregate in this study.

D. Coconut Shell

Coconut shell is the strongest part of coconut that is located between coconut flesh and coconut husk. Coconut shell is composed of lignin, cellulose, pentosans etc. In this study coconut shell is broken in to small chips of size varying from 10 mm to 20 mm. It is used along with fibers. Coconut shell is soaked in water for 24 hours before mixing.

E. Pulp Black Liquor

Pulp black liquor (PBL) is a by-product of paper industry. It is a by-product of Kraft process when digesting pulp wood into paper pulp by removing lignin hemicellulose another extractives from the wood to free the cellulose fiber. It is easily available. Due to these factors we are trying to use pulp black liquor as an admixture in concrete. Admixture can be retarders, plasticizers, water reducing, accelerating and air entraining. PBL is used as plasticizer admixture. It is collected from Canara paper mill, Changanassery.

F. Water

Water used for mixing and curing shall be clean and free from injurious amount of oils, acids, alkalis, salts, sugar, etc. Potable water is generally used for mixing. pH of water should be 6-8. Sea water should not be used for mixing or curing.

III.TESTS ON MATERIALS

Different tests are done on materials such as cement, fine aggregate, coarse aggregate and coconut shell to determine its properties.

TABLE 1
Properties of Cement

Sl No.	Tests	Obtained value	Standard Value	IS code
1	Specific gravity	3.1	2.8 – 3.2	IS 4031 (Part 3)
2	Fineness of cement	1%	< 10%	IS 4031 (Part 2)
3	Standard consistency	34%	25 – 35 %	IS 4031 (Part 4)
4	Initial setting time	40 mins	≥30 mins	IS 4031 (Part 5)
5	Compressive strength of cement			
	7^{th} day	38N/mm^2	37 N/mm^2	IS 4031 (Part 6)
	28^{th} day	54N/mm^2	53 N/mm^2	IS 4031 (Part 6)

TABLE 2
Properties Of Fine Aggregate

Sl No	Tests	Obtained Value	Standard Value	IS Code
1	Specific gravity	2.6	2.5 – 3	IS 2386 (Part 3)
2	Bulk modulus	1745 kg/m^3	1650-1750 kg/m3	IS 2386 (Part 3)
3	Fineness modulus	3.6	2 – 3.5	IS 383 : 1970

TABLE 3
Properties Of Coarse Aggregate

Sl No.	Tests	Obtained Value	Standard Value	IS Code
1	Specific gravity	2.73	2.5 – 2.9	IS 2386 (Part 3)
2	Water absorption	0.352 %	0.3 – 2.5%	IS 2386 (Part 3)
3	Bulk density	1633 kg/m^3	1520–1680 kg/m^3	IS 2386 (Part 3)
4	Fineness modulus	5.52	5.5 – 8.0	IS 383: 1970

TABLE 4
Properties of Coconut Shell

Sl No.	Tests	Obtained value
1	Specific gravity	1.27
2	Water absorption	19.8 %
3	Bulk density	523 kg/m^3
4	Shell thickness	2 - 7

IV. TEST ON CONCRETE

To determine various properties of concrete, specimens are casted and various tests are done. The specimens casted are cubes (15cm x 15cm x 15cm), cylinders (15cm diameter and 30cm height) and beams (50cm x 10cm x 10cm). Tests were conducted to determine properties such as compressive strength, split tensile strength, flexural strength, workability, density and durability. Six set of specimens were casted including control mix. The mix proportion used is 1:1.5:3.

Control Mix (CM) : 0% CS + 0%PBL
Mix 1 (M1) :15% CS + 0% PBL
Mix 2 (M2) :15% CS +1% PBL
Mix 3 (M3) :15% CS + 1.2% PBL
Mix 4 (M4) :15% CS +1.4% PBL
Mix 5 (M5) :15% CS + 1.6% PBL

A. Slump Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check workability of freshly made concrete, and ease with which concrete flows. A frustum cone called a slump cone is used to do slump test. The cone is properly cleaned and oiled. The fresh concrete is then filled in 4 layers by tamping with 25 strokes. The cone can be removed from the concrete immediately by raising it slowly in vertical direction. This allows the concrete to subside and the slump shall be measures immediately by determining the difference between the height of the mould and that of the highest point of the specimen.

B. Compressive Strength

Compressive strength of concrete is the characteristic strength attained by the specimen after 28 days of curing. It is measured by crushing specimen in a compression testing machine. Compressive strength of concrete can be calculated by dividing failure load after 28 days of curing by the loaded area. In most cases concrete attains 95% of its strength after 28 days of concrete.

C. Split tensile strength

Splitting tensile strength of concrete is an indirect method to determine the tensile strength of concrete. The test specimen is a cylinder of 30cm length and 15cm diameter. In direct tensile strength test it is impossible to apply true axial load. There will be always some eccentricity thus splitting tensile strength test is used. The test is done after 28 days curing. The specimen is kept longitudinally on compression testing machine and compressive load is applied till failure. Then splitting tensile strength of concrete is calculated.

D. Flexural strength

Flexural strength is a measure of tensile strength of concrete. It is a measure of unreinforced concrete beam to resist failure in bending. The specimen used is a beam of size 50cm × 10cm × 10cm. The specimen is tested after 28 days of curing period. The specimen is placed on a flexural strength testing machine and load is applied till the specimen breaks. Then strength is then calculated.

E. Density

Density is the relationship between the mass of the substance and how much space it takes up. The specimen is weighed after 28 days of curing and its volume is calculated. The density is then calculated.A structural light weight concrete has a density on order of 1440 to 1840 Kg/m^3 and normal weight concrete has density on order of 2240 to 2400 Kg/m^3.

F. Durability

Durability test is performance testing techniques using to determine characteristic under the various loading conditions over time. The test is done after 28 days of curing. The specimen is weighed and dried in hot air oven for 24 hours. The specimen is again weighed after drying and percentage water absorption in calculated.

V. RESULTS AND DISCUSSIONS

A. Slump Test

The test is conducted on fresh concrete soon after mixing. The workability of fresh concrete is increased by the addition of PBL. Finally workability decreased by the addition of 1.6% of PBL. For CM and M1, workability was 3cm and it gradually increased to 5cm, 7cm, and 8cm by the addition of 1%, 1.2% and 1.4% PBL. The result is shown in table 5.

TABLE 5
Slump Test

Mix	CM	M1	M2	M3	M4	M5
Slump Value (cm)	3	3	5	7	8	3

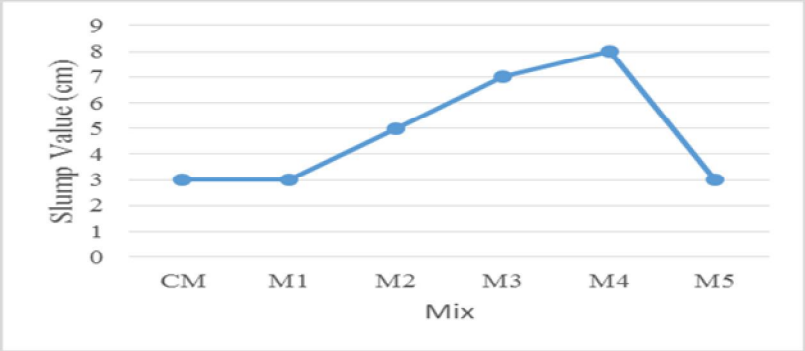

Fig 1: Graph of slump test

B. Compressive Strength Test

Compressive strength test was conducted on a cube of size 15cm x 15cm x 15cm. The results obtained is shown in Table 6. On addition of 15% of coconut shell, compressive strength decreased. Compressive strength started to increase by the addition of PBL.

TABLE 6
Compressive Strength

Mix	CM	M1	M2	M3	M4	M5
Compressive strength (N\mm^2)	35.2	25	26.2	27.55	28	28

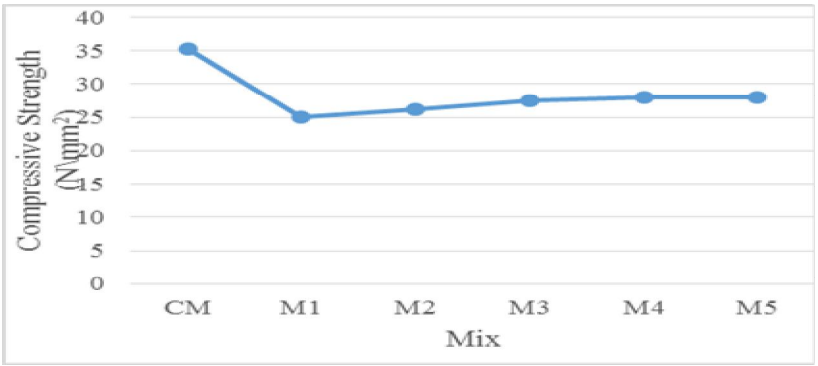

Fig 2: Graph of compressive strength test

C. Split Tensile Strength Test

Cylinders of diameter of 15cm & length 30cm were casted to test the split tensile strength of concrete. The result obtained is shown in Table 7. By the addition of coconut shell, split tensile strength decreased. Split tensile strength started to increase by the addition of PBL.

TABLE 7
Split Tensile Strength Test

Mix	CM	M1	M2	M3	M4	M5
Split tensile strength (N /mm^2)	2	1.25	1.273	1.839	1.98	1.98

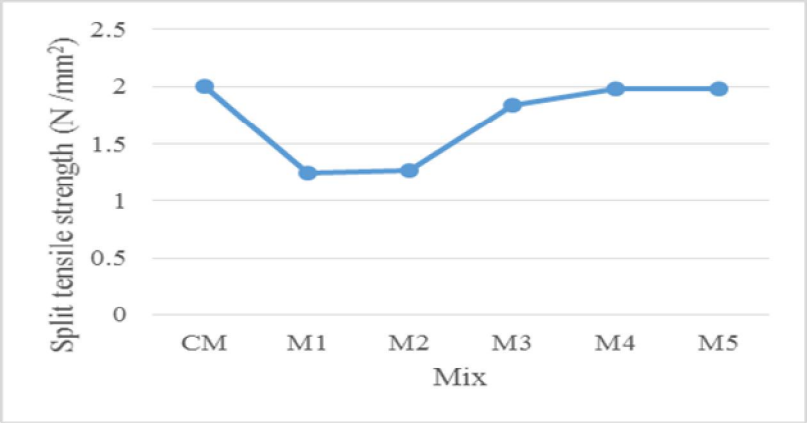

Fig 3: Graph of split tensile strength

D. Flexural Strength Test

Beams of size 50cmx10cmx10cm was used to conduct this test. The result obtained is shown in Table 8. The flexural strength of concrete decreased with the addition of 15% of coconut shell. The strength increased by the addition of PBL.

TABLE 8
Flexural Strength

Mix	CM	M1	M2	M3	M4	M5
Flexural strength (N/mm^2)	6.5	4.375	4.65	5.08	5.25	5.25

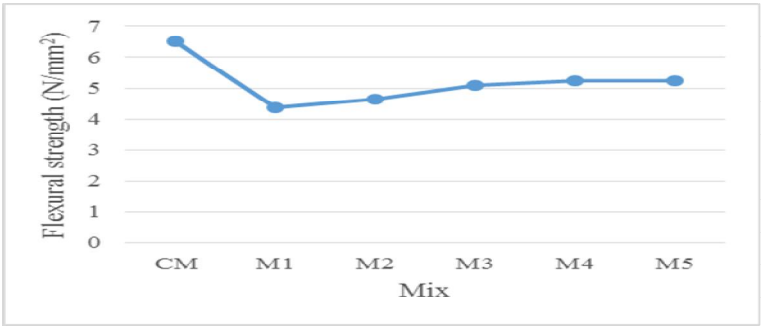

Fig 4: Graph of flexural strength test

E. Density Test

Density of the specimen at the age of 28 days is determined using concrete cube of size 15cmx15cmx15cm. The result obtained is shown in Table 9. The density of concrete decreased by 6% with the addition of 15% coconut shell. The density further decreased by the addition of PBL. The reduction in density continued till the addition of 1.2% PBL and then it starts increasing.

TABLE 9. Density

Mix	Mass(kg)	Volume(m^3)	Density(kg\m^3)
CM	8.41	$3.375x10^{-3}$	2492
M1	7.9	$3.375x10^{-3}$	2340
M2	8.1	$3.375x10^{-3}$	2393
M3	7.95	$3.375x10^{-3}$	2357.93
M4	8.2	$3.375x10^{-3}$	2429.9
M5	8.4	$3.375x10^{-3}$	2486.51

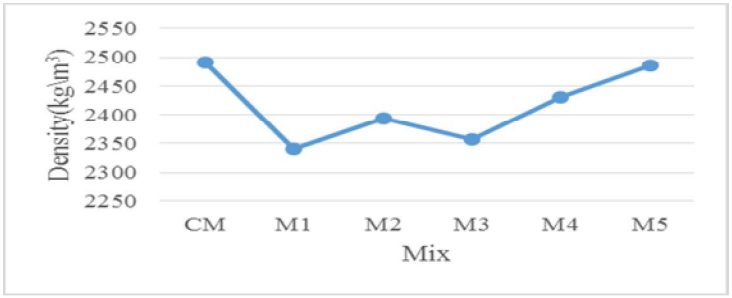

Fig 5: Graph of density test

F. Durability

Durability test is done by saturated water absorption test. The test is done using a cube of size 15cm x 15cm x 15cm. Weight of specimen is noted at 28 days of curing, and is then over dried for 1 day. Then the water absorption is determined. Water absorption and durability are inversely proportional, i.e., the specimen with least water absorption is more durable.

TABLE 10
WATER ABSORPTION OF CONCRETE

Mix	Wet weight (kg)	Dry weight (kg)	Water absorption (%)
CM	8.54	8.47	1.54
M1	8.047	7.9	1.86
M2	8.182	8.079	1.27
M3	8.34	7.958	4.78
M4	8.4	8.201	2.426
M5	8.648	8.392	3.050

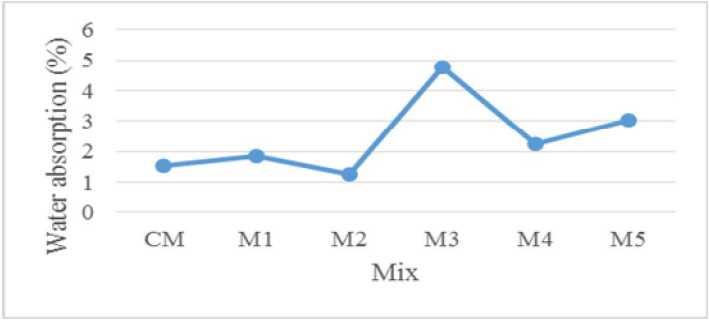

Fig 6: Graph of saturated water absorption test

VI. CONCLUSIONS

A. Maximum workability was obtained for M4 mix.
B. Workability of fresh concrete increased by 62% with the addition of 15% coconut shell and 1.4% of PBL.
C. PBL acts as a plasticizer admixture.
D. Maximum compressive strength, split tensile strength and flexural strength was obtained for M4 mix.
E. Compressive strength of concrete decreased by 20% with the addition of 15% coconut shell and 1.4% PBL.
F. Split tensile strength of decreased by 1% with the addition of 15% coconut shell and 1.4% PBL.
G. Flexural strength of concrete decreased by 19% with the addition of 15% coconut shell and 1.4% PBL.
H. Density of concrete remained within the limit of normal structural concrete.
I. Minimum water absorption was observed in M2 mix. Thus, among all the mixes, the mix with 15% CS and 1% PBL seems to be more durable.

VII. ACKNOWLEDGMENT

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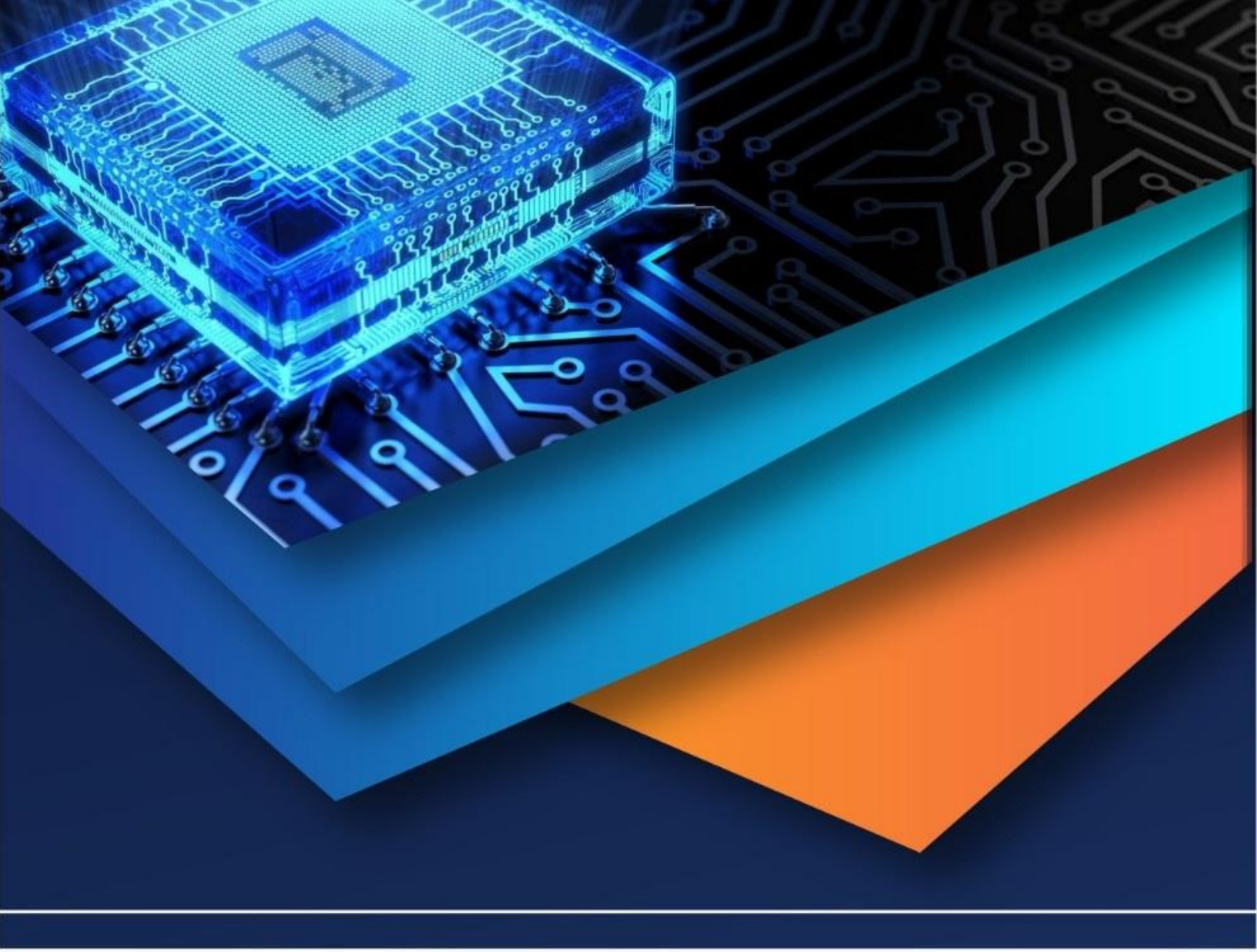

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