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Performance of Light Weight Concrete with Coconut Shell and Fly Ash

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Abstract: ***The major factor that affects the housing delivery is high cost of materials for any conventional concrete. This has lead to find an alternative. An attempt has been made to find an alternative by using partial replacement of coarse aggregate by coconut shell aggregate and cement by fly ash.***
This report provides the information obtained from a literature search. And also provides laboratory experiments on Cement, Sand, Coarse aggregate and Coconut shell. This project is done using partial replacement of coarse aggregate by coconut shell aggregate and cement by fly ash.10 % of fly ash was kept constant as replacement for cement. And Coarse aggregate was replaced by 5%, 10%, 15%, and 20% of coconut shell aggregate.30 concrete cubes of 150x150x150 mm size were casted and 3 cubes were tested after 7 days of curing and 3 cubes were tested after 28 days of curing for each percentage.30 concrete Cylinders of 150x300 mm size were casted and 3 Cylinders were tested after 7 days of curing and 3 Cylinders were tested after 28 days of curing for each percentage.15 concrete Beams of 100X100X500 mm size were casted and 3 beams were tested after 28 days of curing for each percentage.
Two models were done using ANSYS Software using the same failure loads from the experimental part.
Keywords: Light weight concrete, coconut shell, Fly-ash, experimental.

I. INTRODUCTION

Lightweight concrete is distinct as a kind of concrete that covers an increasing agent to increase the capacity of the mixture though also providing additional properties like availability and lowering the dead weight. LWC has a thickness ranging from 300 to 1800 kg/m3. Its lower density aids in reducing dead load, handling costs, haulage, and the advancement of building construction. The weight of lightweight concrete is 25 to 35 percent less than that of traditional concrete.
Lightweight aggregates of industrial by-products are clinker, vermiculite, and the expanded blast furnace slag. They are artificial lightweight aggregates.
Although commercially available lightweight aggregates have been widely used in the production of LWC, using waste materials as lightweight aggregate in concrete can deliver more cost-effective and environmentally friendly results. In recent years, scientists have been researching the use of agricultural waste materials in construction.

A. Coconut Shell

It is the coconut's tough outer layer. Coconut shells have excellent durability, toughness, and abrasion resistance, as well as high strength and modulus. It is meant to be used for a long time. The coconut shell has a density of 1.6 g/cm3. One of the maximum valued plants on the planet is the coconut palm. Coconut plants are grown in 92 nations of the world. Southeast Asia is observed as the source of coconut.
Coconut shells are mainly used as ornaments, fancy items, and household utensils, and the powdered shell is used to make mosquito coils and incense sticks, which are insect repellents.. Many attempts have been made to develop the new structural LWC using coconut shells as coarse aggregate. This project has also attempted to recommend concrete with coconut shell and fly ash as a new structural LWC.

B. Fly ash

Fly ash is a coal combustion product. Large amount of Fly ash waste is generated in Thermal Power stations. Fly ash if not disposed properly will cause serious air pollution problems. It is being used as a pozzolanic material in cement manufacturing process.

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II. LITERATURE REVIEW

A. Utilization Of Fly Ash As Cement Replacement Material To Produce High Performance Concrete

HPCs necessitate a large cement paste volume, which results in increased shrinkage and hydration heat, and increased cost. The authors used fly ash as a mineral admixture to solve these problems.

According to reports, a two-story building measurement 300 m2 was built in the SERC campus employing fly ash, partial replacement for cement in precast strengthened and prestressed concrete structural basics and mortar for plastering masonry work, founded on R&D work at SERC Chennai.

It is reported that the building is giving outstanding service even after two decades.

Authors have tried a design mix of M80 grade using 53-grade cement in their experimental investigation with different percentages of Cement Replacement Material (CRM) of 0% (without fly ash), 15%, 20%, 25% & 30%.

B. Light Weight Concrete Using Coconut Shells as Aggregate

Light Weight Concrete through Coconut Shells as coarse aggregate was investigated experimentally by K. Gunasekaran and P. S. Kumar2. In their experiment, they used Ordinary Portland Cement (43 grade) that complied with IS:8112-1995. As a coarse aggregate, they used crushed coconut shells sieved through a 12.5 mm sieve and river sand as fine aggregate.

According to the study, the compressive strength of nine 100 mm cubes was tested at 3, 7, and 28 days. Saturated-surface-dried (SSD) conditions were used to test the density of the cubes.

C. Light Weight Aggregate Concrete by using Coconut Shell

S. A. Kakade and Dr. A. W. Dhawale[4] have investigated Light Weight Aggregate Concrete using Coconut Shell Aggregates to replace Crushed Stone Aggregates partially. It is reported that 28 days Compressive Strength of coconut Shell Concrete will reduce through increased replacement % of crushed stone aggregate by Coconut Shell Aggregate, with about 10% reduction by using 25% Coconut Shell aggregates and 38% reduction by using 50% Coconut Shell aggregates.

D. Light Weight Aggregate Concrete by using Coconut Shell

B. R. Gautam and L. R. Gangwani[5]have carried out experimental investigations on Coconut Shell Concrete with different combination of natural material and coconut shell.

E. Properties of Concrete by using Coconut Shell as Coarse Aggregate

Vijay Kumar Shukla, Bharti Sharma, Amarnath Gupta[6] have carried out an experimental examination of Coconut Shell Concrete with various percentage replacement of coarse aggregates by Coconut Shell aggregates. Mix design of M20 concrete is made and has arrived at 396 kg of cement, 198 liters of water, 1189 kg of coarse aggregate, and 649 kg of fine aggregate per m^3 of concrete. It is reported here that coconut shell is not suitable construction material.

F. Strength Characteristics of Concrete with Partial Replacement of Cement by Fly Ash and Activated Fly Ash

B.Tipraj, M.Guru Prasad, E.Laxmiprasanna, A.Priyanka, Prashant.K.Hugar7 has carried out experimental investigations through partial replacement of cement via fly ash. An investigational study was supported out using Activated Fly Ash also. An experimental study was carried for the M30 grade of concrete with the following proportions as per mix design.

Cement = 437.77 kg/m^3, Fine aggregates = 650.92 kg/m^3, Coarse aggregates = 1091.85 kg/$m^3$and Water = 197 liters which amounts to ratio of 1:1.4 :2.49 by means of a water cement ratio of 0.45

Fly ash was activated by using Sodium Silicate & calcium Oxide.

G. Characterization of lightweight cement concrete with partial replacement of coconut shell fine aggregate

U. Azunna, Farah N. A. A. Aziz, Pang M. Cun and Mohamed M. O. Elhibir[8] have carried out experimental study of Concrete with partial replacement of fine aggregate by coconut shell aggregates. It is stated that different types of waste materials such as cockle shell, periwinkle shell, date seed, rubber seed, corncob, coconut shell, oil palm shell have partially or fully been used to surrogate fine or coarse aggregate introducing lightweight concrete and their properties evaluated by researchers in the past. It is also stated that coconut shell stands out as the most auspicious agro waste for possible replacement of aggregate in concrete production in every investigation.

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H. Mechanical and bond Properties of Coconut shell Concrete

K. Gunasekaran, P.S. Kumar and M. Lakshmipathy[9] have undertaken experimental study of Compressive, flexural and split tensile strengths, impact resistance and bond strength of concrete using coconut shell as coarse aggregate.

It is opined that Coconut Shell Concrete (CSC) could be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly

III. METHODOLOGY

As per Indian standard codes various test are conducted on concrete material. Like specific gravity of cement,fine aggregate (sand), Coarse aggregate, coconut shell aggregate, and water absorption of fine, aggregate coarse aggregate and coconut shell aggregate. Concrete is designed for M30 by IS method of concrete mix design (IS 10262-2019). 10 % of fly ash was kept constant as replacement for cement. And Coarse aggregate was replaced by 5%, 10%, 15%, and 20% of coconut shell aggregate.

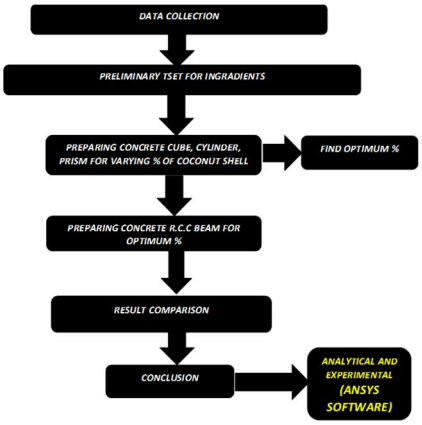

Fig 1 Dry Aggregates

Fig 2 Compacting

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A. Compressive Strength of Cubes

30 concrete cubes of 150x150x150 mm size were casted and 3 cubes were tested after 7 days of curing and 3 cubes were tested after 28 days of curing for each percentage.

B. Split Tensile Strength of Cylinder

30 concrete cylinders of 150x300 mm size were casted and 3 Cylinders were tested after 7 days of curing and 3 Cylinders were tested after 28 days of curing for each percentage.

30 concrete Cylinders of 150x300 mm size were casted and 3 Cylinders were tested after 7 days of curing and 3 Cylinders were tested after 28 days of curing for each percentage.

C. Flexural Strength of Beam

15 concrete Beams of 100X100X500 mm size were casted and 3 beams were tested after 28 days of curing for each percentage.

D. Flexural Strength of RCC Beam

R.C.C beams were casted for conventional concrete (0%) and optimum percentage of coconut shell aggregate at which strength decreases (5%). Beams of Conventional concrete (0%) and Concrete with 5% replacement of coconut shell aggregate are modelled using ANSYS SOFTWARE to find out the behaviors of loading.

IV. RESULT AND DISCUSSION

By use of coconut shell aggregate as partial replacement of coarse aggregate and fly ash as partial replacement of cement has resulted in light weight concrete. Density of concrete reduces by increasing partial replacement of coarse aggregate by coconut shell aggregate. Compressive strength, Split tensile strength, and Flexural strength also decreases by increasing partial replacement of coarse aggregate by coconut shell aggregate.

Sl No	Percentage of replacement of coarse aggregate by Coconut Shell aggregates	Compressive strength (CT) after 28 days curing in N/mm^2	Percentage reduction in compressive strength
1	0%	33.81	
2	5%	24.49	27.56%
3	10%	22.82	32.5%
4	15%	16.48	51.25%
5	20%	12.81	62.11%

Sl No	Percentage of replacement of coarse aggregate by Coconut Shell aggregates	Split tensile (ST) strength after 28 days curing in N/mm^2	Percentage reduction in split tensile strength
1	0%	3.61	
2	5%	1.97	45.43%
3	10%	2.030	43.76%
4	15%	1.756	51.36%
5	20%	1.464	59.45%

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Sl No	Percentage of replacement of coarse aggregate by Coconut Shell aggregates	Flexural strength (FT) after 28 days curing in N/mm^2	Percentage reduction in flexural strength
1	0%	5.897	
2	5%	4.478	24.06%
3	10%	4.345	26.32%
4	15%	4.021	31.81%
5	20%	3.670	37.76%

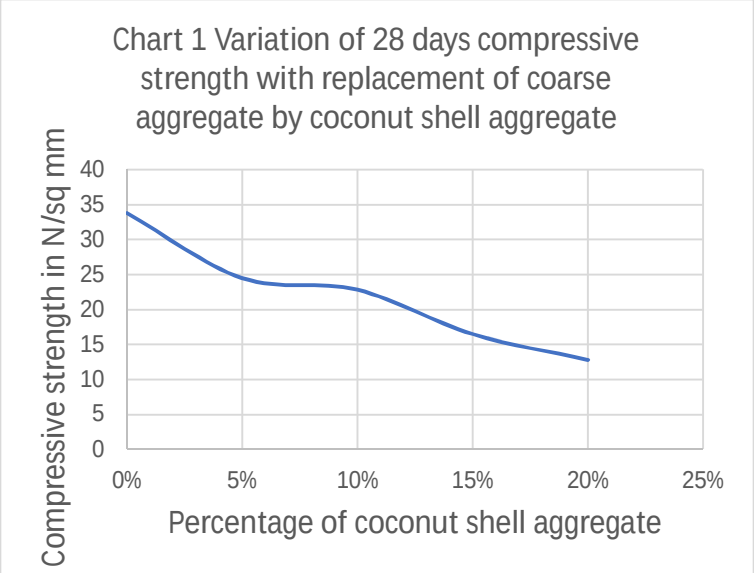

Chart 1 Variation of 28 days compressive strength

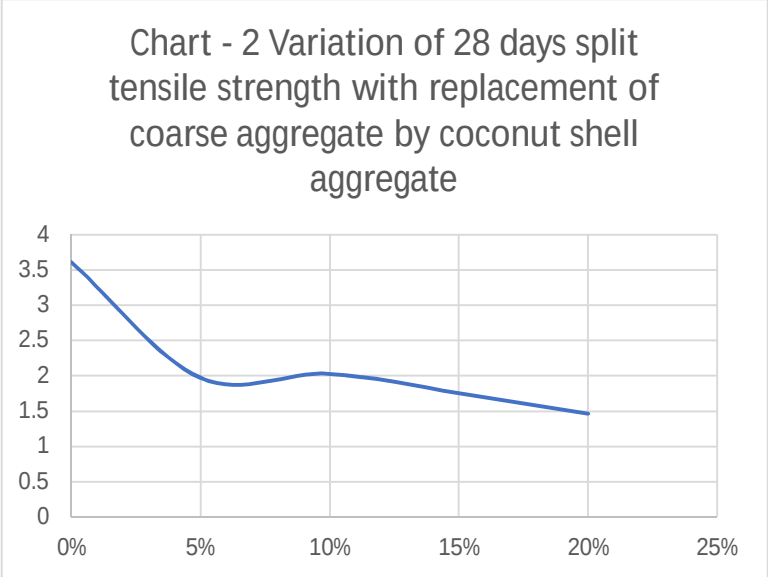

Chart 2 Variation of 28 days Split tensile strength

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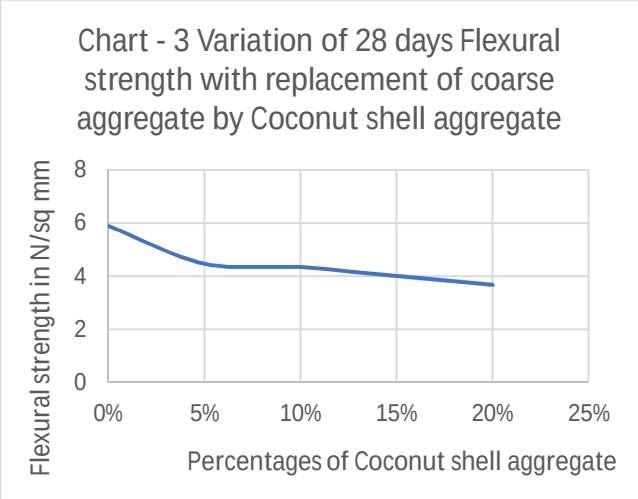

Chart 3 Variation of 28 days Flexural strength

A. Flexural Strength of Reinforced Concrete Beam

Sl No	Percentage of replacement of coarse aggregate by Coconut Shell aggregates	Flexural strength (FS) after 28 days curing in N/mm^2
1	0%	7.266
2	5%	6.833

B. Results of Reinforced Concrete Beam from ANSYS Modelling

Beams of Conventional concrete (0%) and Concrete with 5% replacement of coconut shell aggregate are modeled to find out the loading behaviors, and values are tabulated in the table.

Sl No	Percentage of Coconut Shell aggregates	Failure load in kN	Flexural strength(FS) after 28 days curing in N/mm^2
1	0%	54.50	7.266
2	5%	51.25	6.833

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C. Analyzed Results for ANSYS

Conventional Concrete: RCC Beam was modeled as three-dimensional solid elements. The size of the beam is 150X150 with a 750 mm span. Two equal point loads were applied symmetrically.

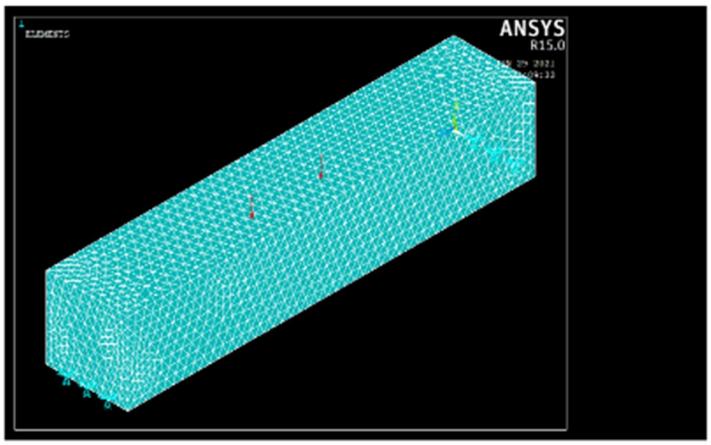

Fig 3 Loading

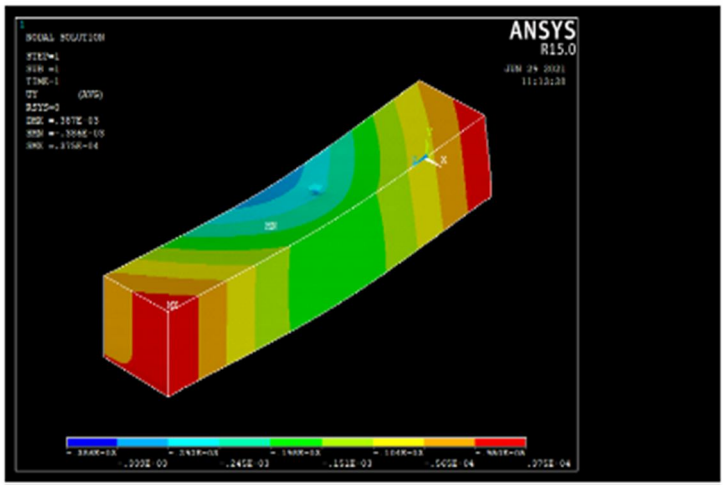

Fig 4 Displacement

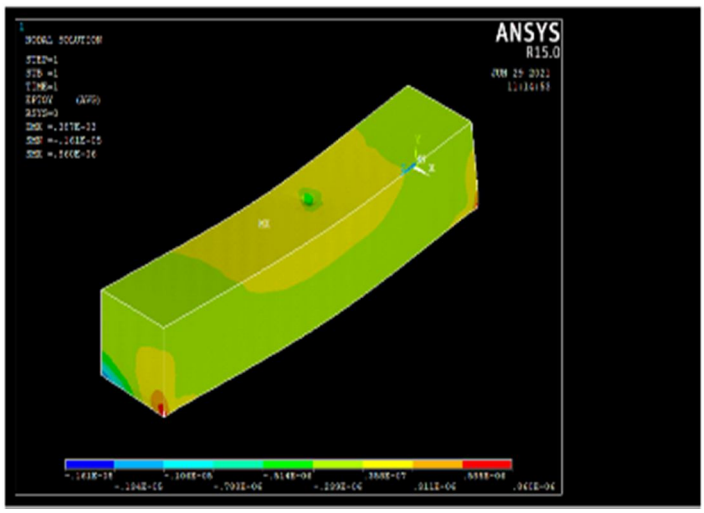

Fig 5 Strain Contour

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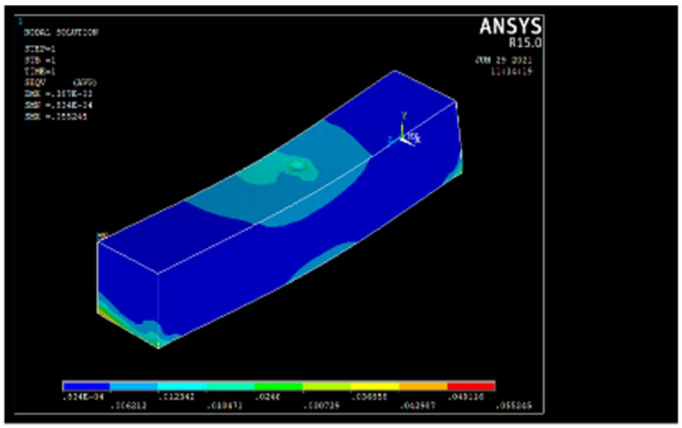

Fig 6 Stress Contour

A reinforced concrete beam's stress and strain contours were studied using ANSYS by simulating the same loading conditions as in the experiments. The loading, Displacement contours, stress contours, and strain contours as indicated by ANSYS are shown in Figures 3,4, 5, and 6, respectively.

V. CONCLUSION

A. Replacement of coarse aggregate by 0%, 5% ,10%, 15% and 20% Coconut shell aggregates resulted in concrete density at 28 days of 2543, 2359, 2392, 2215, and 2157 kg/m^3 respectively.

B. Replacement of coarse aggregate by 5%, 10%, 15% and 20% Coconut shell aggregates resulted in reduction of Compressive strength at 28 days by 27.56%, 32.5%, 51.25% and 62.11% respectively.

C. Replacement of coarse aggregate by 5%, 10%, 15% and 20% Coconut shell aggregates resulted in reduction of Split tensile strength at 28 days by 45.43%, 43.76%, 51.36% and 59.45% respectively.

D. Replacement of coarse aggregate by 5%, 10%, 15% and 20% Coconut shell aggregates resulted in reduction of Flexural strength at 28 days by 24.06%, 26.32%, 31.81% and 37.76% respectively.

E. The concrete with partial replacement of coarse aggregate by coconut shell aggregate and cement by fly ash is more suitable for flooring, roads and pavements etc…than the structural concrete.

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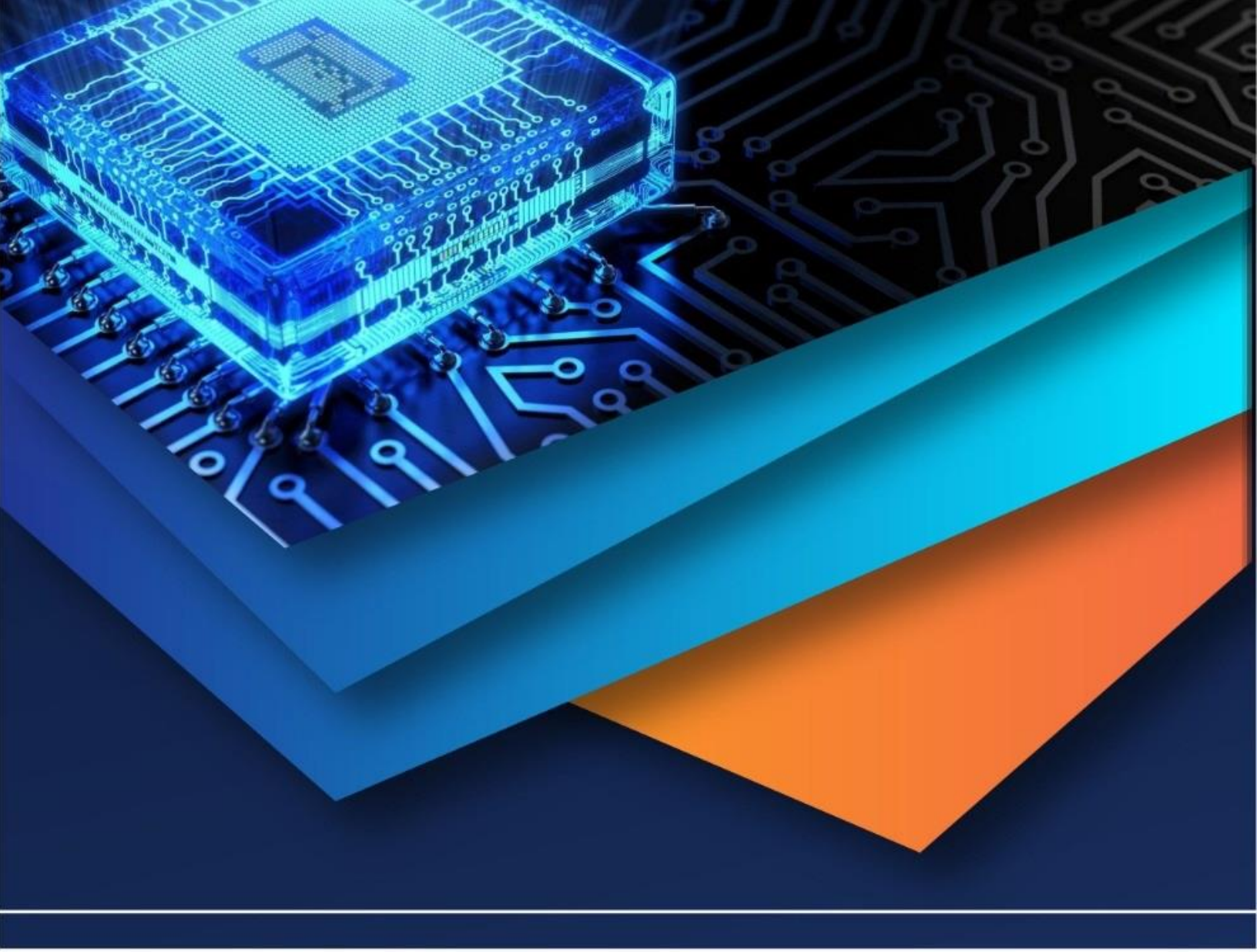

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