iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** V **Month of publication:** May 2018

DOI: http://doi.org/10.22214/ijraset.2018.5140

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Experimental Investigation on Partial Replacement of Cement by Prosopis Juliflora Ash & Coarse Aggregate by Seashells

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Abstract: ***In current situation increasing cement manufacturing industries emits excessive carbon dioxide to nature. Also accumulated industrial wastes to environment are commercially concerned for safe disposal. In developing countries the cost of construction with concrete shows a tremendous increase which necessitates partial replacement in concrete. Mesquite wood ash (prosopis juliflora) is a by-product generated by the process of combustion of wood obtained from wood-fired power plants, hotels, paper mills and other wood burning industries. This paper evaluates the compressive strength, split tensile strength, flexural strength of partially replaced concrete with conventional M30 grade concrete. The experimental study on the physical properties of the replaced materials was conducted. In this paper, optimum partial replacement of 10% seashell for coarse aggregate, 5%, 10,% and 15% partial replacement of prosopis juliflora ash for cement is considered. The design mix M30 is used for casting cubes, cylinders and beams and tested for 7 days, 14 days and 28 days compressive, split tensile and flexural strength respectively. The compressive strength of replaced concrete attained the compressive strength of conventional concrete at an optimum composition of 15% Prosopis juloflora ash and 10% seashell. The split tensile strength of conventional concrete is attained at 15% Prosopis juloflora ash and 10% seashell composition while flexural strength is slightly increasing at this optimum composition of 15% Prosopis juloflora ash and 10% seashell. T he fine structure of prosopis juliflora ash fills more voids and provides superior pore structure and thereby improvising its strength at later stages due to reduced permeability.***
Keywords: Prosopis juliflora, flexural strength, compressive strength, split tensile, seashell.

I. INTRODUCTION

Concrete, as a construction material, has the largest production of all structural components in construction. Conventional concrete is a versatile material and it consists of cement, fine aggregate and coarse aggregate. The characteristic of concrete varies with composition, ageing, water/cement ratio. The performance of concrete is assessed by the compressive strength for designing various structures. Concrete is the best material of choice where strength, durability, impermeability, fire resistance and absorption resistance are required. [1][8]. Compressive strength is considered as an index to assess the overall quality of concrete and it is generally assumed that an improvement in the compressive strength results in improvement of all other properties. Even though the mix proportioned concrete achieves the desired compressive strength at specified age, the role of flexural strength is vital role in concrete. Utilization of wastes materials like wood ash, Mesquite wood ash, rice husk ash, saw dust ash, coconut shell ash are used partial in concrete to minimize environmental and ecological problems.[9]

As modern engineering practices become more demanding, there is a corresponding need for special types of materials with novel properties. Scientists, engineers and technologists are continuously on the searching for materials, which can act as substitute for conventional materials or which possess such properties as would enable new designs and innovations resulting in to economy, so that a structure can be built economically [4]. Many attempts have been made to develop new materials, which is the combination of two or more materials. Such materials are called composite materials. Concrete can be concluded as a composite material as it is a mixture of different materials. For the cost reduction in concrete, use of pozzolanic materials such as blast furnace slag, fly ash can be suggested for cement, sea shells, glass and ceramic material for fine aggregates and finally palm kernel shells, coconut shells and sea shells for coarse aggregates. The utilization of these substitute materials in concrete would reduce the problem of disposal faced by thermal power plants and industrial plants, agricultural areas and there by achieving the required strength of concrete .[5][6] The Mesquite tree [7] (Prosopis Juliflora) value lies in its exceptional tolerance of heat, drought and marginal soils. It also has tolerances over strongly saline or alkaline soils. It also withstands seasonal waterlogging .It is sensitive to cold weather and frost.

The ability to grow on saline and alkaline soils considers mesquite as a valuable reclaimer of soil in very poor and degraded lands, rocky soils or abandoned copper mines. Mesquite does have only positive impact on soil.

Nowadays the main emphasis is on green and sustainable development. Cement industry is one of the major contributors to pollution by releasing carbon dioxide. By partial replacement of cement with pozzolanic materials like prosopis juliflora ash, the excessive demand for the cement in construction field can be met out with the consideration of green and eco-friendly environment. [2] Prosopis juliflora ash is difficult to decompose. So using prosopis juliflora ash is a major step towards sustainable development. As the concrete is weak in tension, so with steel fibres addition shall improve flexural and tensile strength. Prosopis juliflora ash is obtained from biomass waste power plants as a waste material. Prosopis juliflora ash does not have cementitious property by itself which is responsible for strength generation. But in presence of water it reacts with free lime obtained from cement and form hydrated products (c_2s and c_3s) which helps in attaining the strength and also improving the durability. As the prosopis juliflora ash is very fine in structure, it fills more voids and provides superior pore structure and thereby improves its strength at later stages due to reduced permeability.[2][3]

By the process of disintegration of dead animals, the wastes accumulated near the sea shore forms Seashells. The three layers of seashell are outer, intermediate and inner layer in which outer layer is made up of calcite material whereas inner layer is otherwise known as nacre which is made up of calcium carbonate. Calcium carbonate is abundant in seashell which enhances the strength like coarse aggregates.[6]

II. MATERIALS USED

A. Cement

Ordinary Portland cement of grade 53 is used in the study. Several basic tests were conducted for cement namely consistency test, setting time and specific gravity tests. [3]

B. Prosopis Juliflora Ash

The ash is obtained by burning Prosopis Juliflora (Karuvelam in tamil) which is collected and burnt in open atmosphere in the local area near Avadi, Chennai. Several basic tests were conducted like specific gravity, fineness, and consistency and setting time. The burnt ash passing through 90 microns were used for testing. The proportion of 5,10%,15% P.J Ash were used for partial replacement of cement.[10] The properties of OPC 53 grade and Prosopis juliflora ash with requirements as per IS 8031-1988 are represented in table 1.

Fig 1 Prosopis Juliflora Ash

Table 1 Properties of cement and prosopis juliflora ash

Tests	OPC- 53 grade	Prosopis Juliflora Ash (PJA)	Requirements as per IS:8031-1988
Specific gravity	3.18	2.8	3.12-3.19
Consistency	25%	23%	-
Setting time	527 minutes	432 minutes	Not more than 600min
Fineness	7%	6%	Not more than 10%

C. Fine Aggregate

The locally available material is used as fine aggregate. The basic tests of dry sieve analysis using mechanical sieve shaker, specific gravity, water absorption tests were also conducted. The specific gravity observed to be 2.7. The particle size ranges from 4.75 mm to 150 micron confirming to Zone II as per the IS code provisions represented below in table 2. [4] The properties of the fine aggregate are represented in table 2a.

Table 2: Requirement of fine aggregate as per IS: 383 -1970(Ref. 2002)

IS sieve Designation	Percentage passing			
	Zone I	Zone II	Zone III	Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	36-70	55-90	75-100	90-100
600 micron	15-34	35-90	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15
Remarks	Very coarse	Coarse	Medium	Fine

Table 2a Properties of fine aggregate

Tests	Fine aggregate	As per IS: 383-1978
Specific gravity	2.7	2.55 minimum
Fineness modulus	2.46	Fine sand
Water absorption	1%	-

D. Coarse Aggregate

Coarse aggregate ranging from 20mm is used. The basic test involves specific gravity, water absorption and aggregate impact test. The specific gravity was observed to be 2.67. The aggregate impact value was found to be 7.29%. The water absorption percentage of 0.6% is obtained. The properties of the aggregates are represented in table 2b.

E. Seashell

Seashell of almost same size and shape were collected and tested for water absorption and aggregate impact Test. The referred literatures on seashell replacement varies the percentage of partial replacement from 10% to 30%, but in this study a constant percentage replacement of 10% is considered as it is the optimum value on comparison.[6][13] The aggregate impact value was found to be 6.8%. The water absorption percentage of 0.8% is Obtained [5] The properties of the seashells are represented in table 2b.

Table 2b Properties of coarse aggregate and seashell

Tests	As per IS: 383-1978	Coarse aggregate	Seashell
Specific gravity	2.6 minimum	2.67	-
Water absorption	-	0.6%	0.8%
Aggregate impact value	<45%	7.29%	6.8%

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Fig 2 Seashell

III. METHODOLOGY

A. Literature review
B. Material selection
C. Basic test on Material (Cement, fine aggregate, coarse aggregate, mesquite wood ash, seashell)
D. Mix design for M30 grade
E. Casting of cube, cylinder and beam
F. Compressive, split tensile and flexural strength test
G. Comparative analysis of strength conventional concrete and replaced concrete
H. Result and discussion
I. Conclusion

IV. RESULTS AND DISCUSSION

A. Mix Proportion Of The Replaced Concrete

The design mix M30 is adopted. The mix design is done using codal reference with water cement ratio as 0.48 to meet the water demand for easy workability. The mix proportion is considered for optimum composition of seashell as 10% and variation of 5%,10%,15% of Prosopis Juliflora ash as a partial replacement for coarse aggregate and cement respectively. [9][13] The mix proportion of the replacement material is represented in table 3.

Table 3 Mix Proportion

Mix ratio	1Cement(OPC and Ash)	1.9(F.A)	2.9(C.A and Seashell)
Conventional concrete	cement	Fine aggregate	Coarse aggregate
Replaced Concrete (P.J Ash and seashell)	95% Cement + 5% P.J Ash	Fine aggregate	90% C.A + 10% seashell
	90% Cement + 10% P.J Ash	Fine aggregate	90% C.A + 10% seashell
	85% Cement + 15% P.J Ash	Fine aggregate	90% C.A + 10% seashell

B. Compressive Strength

The cubes of size 150x150x150 mm were casted for testing compressive strength for 7 days, 14 days and 28 days for, 5% P.J Ash and 10% seashell, 10% P.J Ash and 10% seashell, 15% P.J Ash and 10% seashell as partial replacement for cement and coarse aggregate respectively.[6][14] The compressive strength of conventional concrete was achieved with 5% P.J Ash & 10% seashell, 10% P.J Ash & 10% seashell, 15% P.J Ash & 10%. Seashell on 7 th, 14th day and 28 th day of testing.[11] The results were tabulated in Table 4.

Table 4 Compressive Strength

Specimen	7 th day(MPa)	14 th day(MPa)	28 th day(MPa)
Conventional concrete	27.01	34.20	38.90
Replaced Concrete (5% P.J Ash and 10% seashell)	27.06	34.35	38.90
Replaced Concrete (10% P.J Ash and 10% seashell)	27.46	35.40	39.15
Replaced Concrete (15% P.J Ash and 10% seashell)	27.70	36.70	40.08

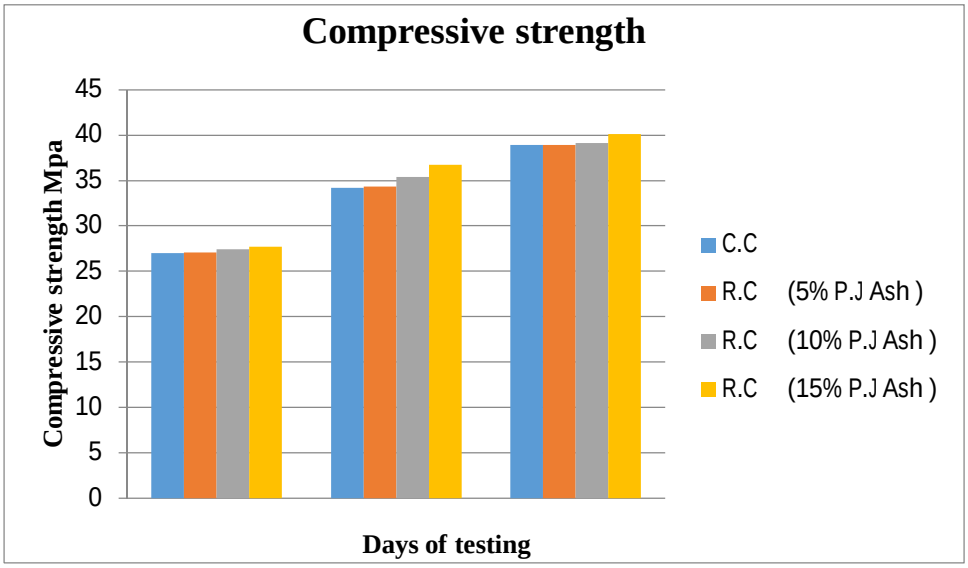

Fig 3 Comparison of Compressive Strength of Conventional and Replaced concrete on various days of testing

Fig 3a Tested specimen for compression

C. Split Tensile Strength

Cylinder specimen of size 300mm height and 150mm diameter were casted for the mix proportion M30 for various replacement proportions of 5% P.J Ash & 10% seashell, 10% P.J Ash & 10% seashell, 15% P.J Ash & 10% seashell and cured for 7 days, 14days and 28 days.[14] After curing period the split tensile strength of the specimen were tested using compressive testing machine.[12] The curing periods are 7 days , 14 days and 28 days and tested to find the split tensile strength of concrete and the results were obtained.[11] The Split tensile strength calculated shows a slight decrease when compared to conventional concrete and tabulated below in table 5.

Table 5 Split Tensile Strength

Specimen	7 th day(MPa)	14 th day(MPa)	28 th day(MPa)
Conventional concrete	3.45	4.53	5.21
Replaced Concrete (5% P.J Ash and 10% seashell)	2.74	3.80	4.08
Replaced Concrete (10% P.J Ash and 10% seashell)	2.86	3.93	4.88
Replaced Concrete (15% P.J Ash and 10% seashell)	3.13	4.32	5.09

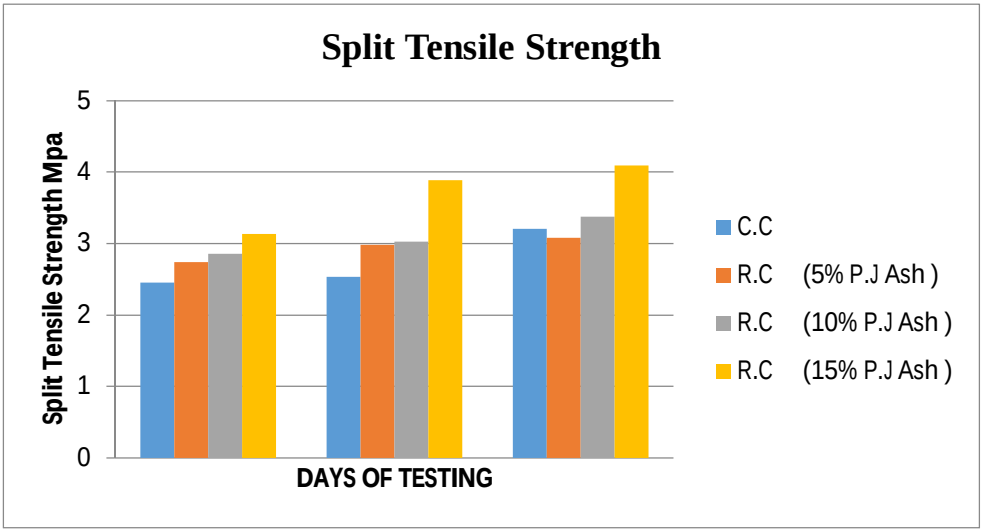

Fig 4 Comparison of Split Tensile Strength of Conventional and Replaced concrete on various days of testing

Fig 4a Tested specimen for split tensile

D. Flexural Strength

The beams were casted of size 750x150x150mm for various replacement proportions of 5% P.J Ash & 10% seashell, 10% P.J Ash & 10% seashell, 15% P.J Ash & 10% seashell and cured for 7 days, 14days and 28 days. [14] The specimens were tested for 7 days, 14days and 28 days as shown in figure 5. The flexural strength calculated shows a slight increment than conventional concrete and tabulated in table 6.

Table 6 Flexural Strength

Specimen	7 th day(MPa)	14 th day(MPa)	28 th day(MPa)
Conventional concrete	3.86	4.07	4.95
Replaced Concrete (5% P.J Ash and 10% seashell)	3.97	4.46	4.98
Replaced Concrete (10% P.J Ash and 10% seashell)	4.37	4.58	5.27
Replaced Concrete (15% P.J Ash and 10% seashell)	4.81	4.96	5.7

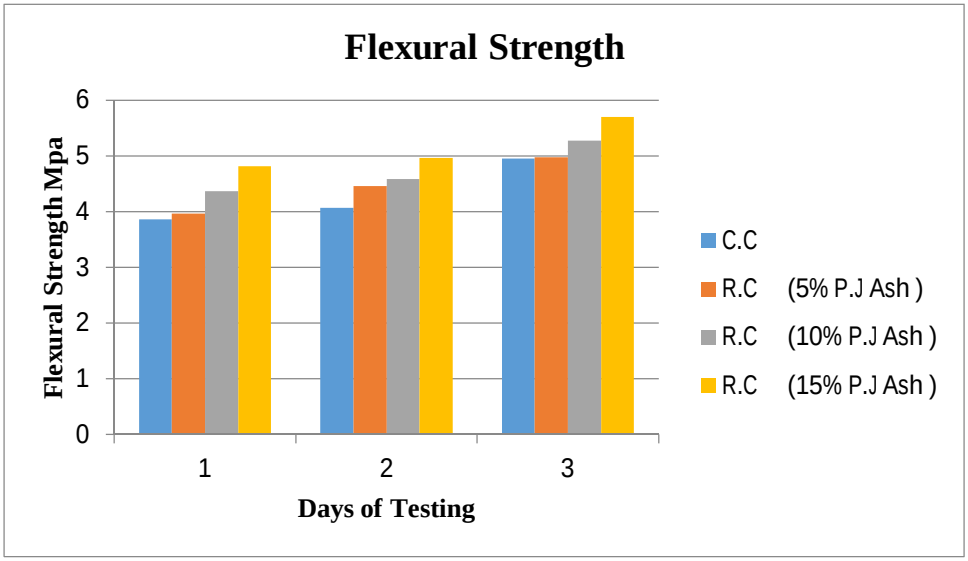

Fig 5 Comparison of Flexural Strength of Conventional and Replaced concrete on various days of testing

Fig 5a Tested specimen for Flexural strength

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Table 7 Comparative Strength Analysis on various tests

Specimen	Compressive strength (MPa) 1	Split tensile strength (MPa) 2	Flexural strength (MPa) 3
C.C	38.9	3.21	4.95
R.C (5% P.J Ash)	38.9	3.08	4.98
R.C (10% P.J Ash)	39.15	3.38	5.27
R.C (15% P.J Ash)	40.08	4.09	5.7

Fig 6 Comparison of Strength of Conventional and Replaced concrete on various tests

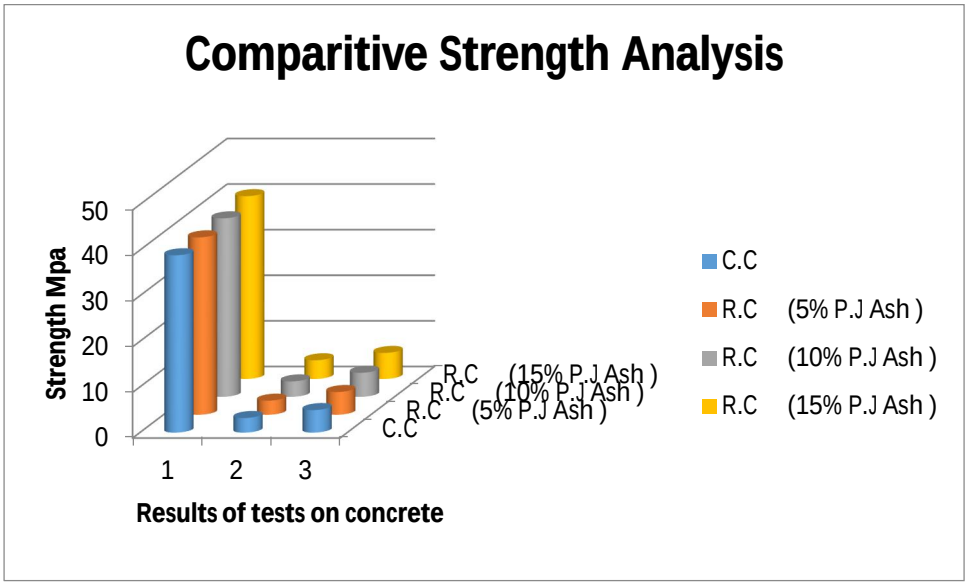

Fig 6a Comparison of Strength of Conventional and Replaced concrete on various tests

V. CONCLUSION

From the above experimental study the usage of waste plantation materials available in the local region can be recommended for the partial replacement of cement and coarse aggregate. The test results determine the of compressive strength, flexural strength with a slight decrease in split tensile strength for the considered proportion of 5% Prosopis Juliflora Ash & 10% Seashell, 10% Prosopis Juliflora Ash & 10% Seashell and 15% Prosopis Juliflora Ash & 10% Seashell as a partial replacement in cement and coarse aggregate respectively. The following observation are listed below.

A. The workability of concrete decreased with the increase in proportion of prosopis juliflora ash content due to the increase in water demand.
B. The compressive strength of replaced concrete of 15% prosopis juliflora ash content increases to 5% of target mean strength of M30 mix.
C. The split tensile strength of replaced concrete of 15% prosopis juliflora ash content decreases to 2% of strength of conventional concrete of M30 mix.
D. The flexural strength of replaced concrete of 15% prosopis juliflora ash content increases to 15% of strength of conventional concrete of M30 mix.
E. The optimum proportion of 15% prosopis juliflora ash content and 10% seashell shows the improvement in performance of compressive and flexural strength of replaced concrete.
F. The chemical properties of the prosopis juliflora ash and the resistance to chemical attack need to be further studied for further performance of this partially replaced concrete.

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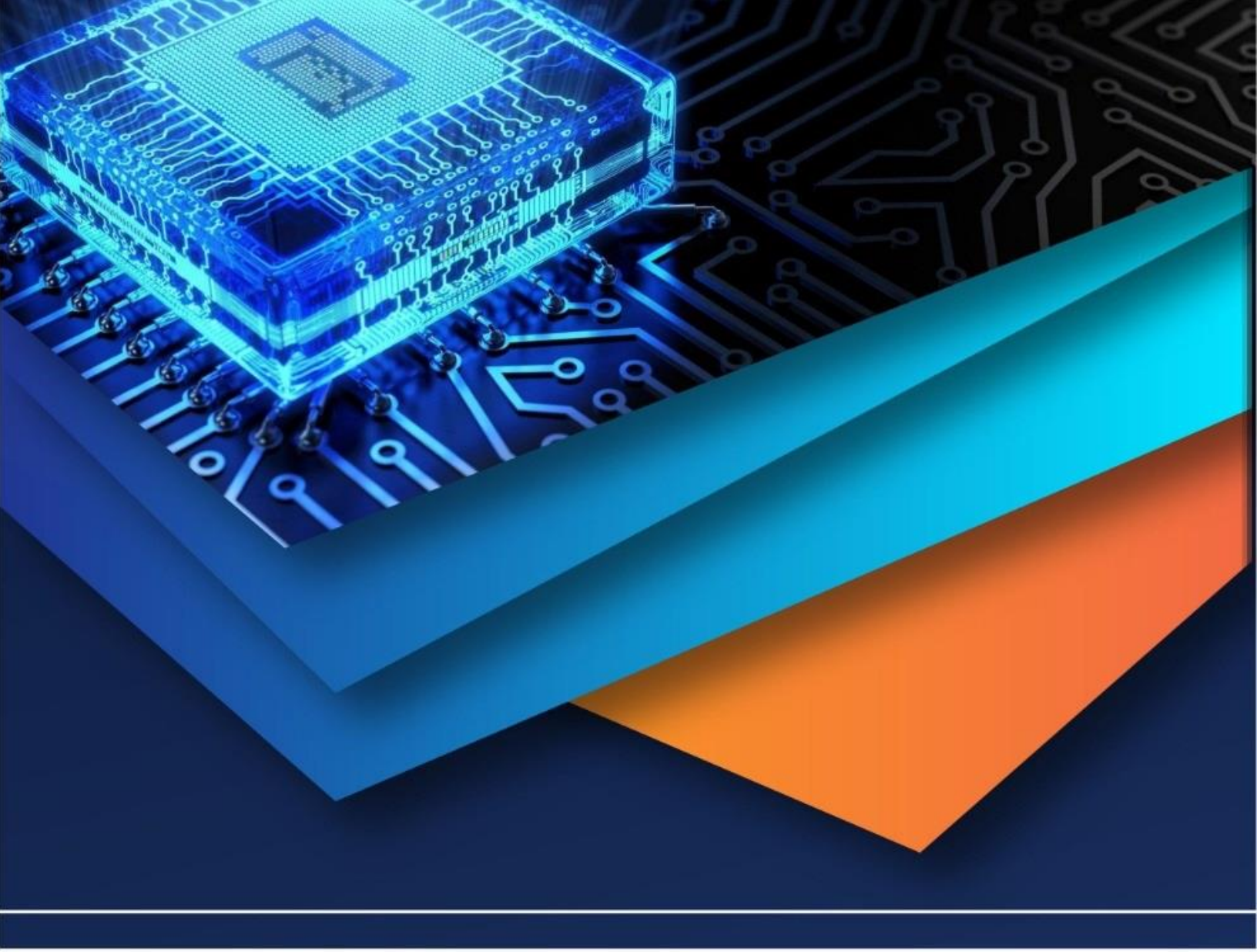

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