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Partial Replacement of Waste Foundry Sand and Recycled Aggregate in Concrete

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Abstract- ***Low cost concrete production by replacement of fine sand with Foundry sand is a new trend and makes effectively use of Waste foundry sand as engineering material by reducing disposal and pollution problem. Waste foundry sand are by-products which appears to possess the potential to partially replace regular sand as a fine aggregate in concretes, providing a recycling opportunity for them. With the rapid development of construction industry leading to excessive natural resource consumption and the deterioration of the environment, the contradiction between the sustainable development of construction industry and the shortage of resources will become more and more severe. At the same time, a large amount of solid waste is produced in the process of construction of new buildings every year. Today, the reuse of construction waste has become a common concern issue and deserves deep researches. It can be foreseen that the recycled aggregate concrete as a method of reuse and recycling of the construction waste will bring considerable economic and environmental benefits. This paper identifies a potential use of wastes from foundry industry and construction industry for utilization in construction industry and represents the experimental investigation on utilization of foundry waste as a partial replacement of natural sand by 0%, 20%, 40%, 60% and recycled aggregate as a partial replacement of natural coarse aggregate by 0%,20%,40% and 60%. Concrete mixtures were produced, tested and compared in terms of strength with the conventional concrete. These tests were carried out to evaluate the strengths for 7 and 28 days.***

Keywords- ***Waste foundry sand(WFS), Recycled aggregate(RA),Compressive strength, Split tensile strength, Flexural strength.***

I. INTRODUCTION

The worldwide consumption of sand as fine aggregate in concrete production is very high and several developing countries have encountered some strain in the supply of natural sand in order to meet the increasing needs of infrastructural development in recent years. To overcome the stress and demand of river sand, researchers and practitioners in the construction industries have identified some alternatives.

Ferrous and non ferrous metal casting industries produce several million tons of by-product in the world. WFS is major by-product of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand for land filling is becoming a problem due to rapid increase in disposal cost. In an effort to use the WFS in large volume, research has being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate.

Waste foundry sand (WFS) is a by-product from the production of both ferrous and nonferrous metal castings. It is high quality silica sand. Foundries use high quality size-specific silica sands for use in their moulding and casting operations. Normally raw sand is of a higher quality than the typical bank run or natural sands used in fill construction sites. In the casting process, moulding sands are recycled and reused many times. Eventually, when, recycled sand degrades to a level that it can be no longer is reused in the casting process. When it is not possible to further reuse sand in the foundry, it is removed from the foundry and is termed as waste foundry sand. These WFS is black in colour and contain large amount of fines. The typical physical and .chemical property of WFS is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces (induction, electric arc and cupola) and type of finishing process (grinding, blast cleaning and coating).

The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. The use of recycled aggregates from construction and demolition wastes is showing prospective application in construction as alternative to primary (natural) aggregates. Research on the usage of waste construction materials is very important since the materials waste is gradually increasing with the increase of population and increasing of urban development. The reasons that many investigations and analysis had been made on recycled aggregate are because recycled aggregate is easy to obtain and the cost is cheaper than virgin aggregate. The recycling of Construction and Demolition Wastes has long been recognized to have the potential to conserve natural resources and to reduce energy used in production. RCAs fit into present day motto of 'Reducing, Reusing, Recycling and Regenerating'. The use of recycled aggregate weakens the quality of recycled aggregate concrete which limits its application.

Concrete is a material which is composed of coarse aggregate, fine aggregate, cement and water these each material in concrete

contributes its strength. So, by partial or percentage replacing of material affects different properties of concrete. By using such waste material which harms the environment can be used for the development of low cost and eco-friendly building materials. In this study an experimental investigation is carried out by varying percentage of fine aggregate with waste foundry sand and coarse aggregate with used recycled coarse aggregate to produce low cost and eco-friendly concrete.

The main objectives of the present experimental work are discussed below :

[1] To find the efficiency of the Foundry Sand and recycled aggregate for civil constructions.

[2] To know the fresh concrete properties of foundry sand and recycled aggregate concrete.

[3] To check the possibility of using foundry sand and recycled aggregate in concrete mixes.

Research significance:

The presented research is aimed at studying the properties like optimum percentage of waste foundry sand and recycled aggregate with partial replacement of fine aggregate and coarse aggregate, to determine the optimum concrete mix. The optimum concrete mix is used to determine the compressive, split tensile strength & flexural strength. The research findings will help engineers to understand the overall performance of concrete for flexural strength, split tensile strength & compressive strength.

II. LITERATURE REVIEW

Gurpreet Singh and Rafat Siddique; carried out an experimental investigation to evaluate the strength and durability properties of concrete mixtures, in which natural sand was partial replaced with (WFS). Natural sand was replaced with five percentage (0%, 5%, 10%, 15%, and 20%) of WFS by weight. Compression test and splitting tensile strength test were carried out to evaluate the strength properties of concrete at the age of 7, 28 and 91 days. Test results indicate a marginal increase in strength properties of plain concrete by inclusion of WFS as a partial replacement of fine aggregate.

Nelson, Shing Chai NGO; When the percentage of recycled aggregate increases, the slump test indicates a decreasing trend of workability. The compaction factor test indicated that, the compacting factor ratio is decreases as the percentage of recycled aggregate increases. The compression test indicated that, the concrete specimen with more replacement of recycled aggregate will get the lowest strength when compared to the concrete specimens with less recycled aggregate. tensile test concluded that, the tensile strength is gradually decreases if more percentage replacement of recycled aggregate used in the concrete specimen.

Haliza Bite Mohd Jeffery Ong; The control mixture showed better results compared with the mixture of using recycled aggregate. Research shows that more recycled aggregate is used, the compressive strength of concrete decreases. However, recycled aggregate can be used for structures that do not require a high specification.

Patel Ankit; was reported generation of waste foundry sand as by product of metal casting industries causes environmental problems because of its improper disposal. The experimental investigation was carryout on a concrete carrying waste foundry sand in the range of 0%, 20%, 40% and 60% by weight for M-25 grade concrete (PPC). Material was produced, tested and compared with conventional concrete in terms of workability and strength. The compressive strength increases on increase in % of waste foundry sand as compare to traditional concrete.

Khatib; investigated some mechanical and fresh properties of concrete containing waste foundry sand (WFS). With reference to the properties investigated, they reported that (a) There is systematic loss in workability as the foundry sand content increases which was found by observing the percentage decrease in slump with increase in WFS. (b) All the mixes (with and without WFS) show an increase in strength with curing time. (c) The compressive strength of concrete also decreases with increasing amounts of WFS.(d) The shrinkage increases as the WFS in the concrete increases.

YongjaeKim;(i) As the recycled aggregate replacement ratio increased the recycled aggregate concrete showed an increased workability This may be due to the increased amount of fine particles from the recycling process; (ii) When the coarse aggregate was replaced with the recycled aggregate, compressive strength decreased. As the recycled fines amount increased the additional replacement of the fine aggregate reduced the strength; (iii) When we replace the fine aggregate more than 60%, the strength reduction became more significantly.

V.R Ramkumar, et.al; The result shows that, the flexural strength of concrete with natural aggregate is more than the concrete containing recycled aggregate. However by providing water & acid treatment the strength of recycled aggregate concrete can be improved.

Khatib and Herki; investigated the concrete produced by replacing the fine aggregates with 0%, 30%, 60% and 100% WFS.The properties investigated at 7, 28 and 90 days curing times. The results indicate that there is systematic increase in water absorption by capillary action, a decrease in compressive strength and Ultrasonic pulse velocity with increasing amounts of WFS in concrete. They also reported that adequate strength can be achieved using an appropriate replacement level of foundry sand.

Ayed Ahmad Zuhud; (i) Due to light weight of recycled aggregate and bad compaction because of the nature of recycled aggregate and its texture, the density of recycled aggregate concrete is lower than that of natural aggregate by5.5%; (ii) The absorption capacity of recycled aggregate is more than two times of natural aggregates; due to this the workability of recycled

concrete is reduced; (iii)Using the same quantity of cement, the recycled aggregate concrete can provide strength almost equivalent to a corresponding concrete with natural aggregates.

Baig investigated fresh and hardened properties of concrete containing waste foundry sand (WFS) replaced with 0 to 100% with fine aggregate. The water to cement for all mixes was kept constant. Testing on hardened properties was mainly conducted at 14, 28 and 56 days. The results show that the incorporation of waste foundry sand in concrete causes a systematic decreases in workability, ultrasonic pulse velocity and strength and an increase in water absorption and shrinkage of concrete. They also reported that an acceptable concrete strength can be achieved using foundry sand.

III. MATERIALS USED

A. Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. It plays an important role in construction sector. In this study the Portland Pozzolana Cement (PPC) of 43 grades (Ultratech Cement) is used. The cement used was fresh and without any lumps.

Table No. 1: Physical Properties of Portland Pozzolana Cement

Sr. No.	Properties	Values
1	Grade of cement	43 (OPC)
2	Fineness of cement	7.5%
3	Specific gravity	2.90
4	Initial setting time	30min
5	Final setting time	600min
6	Consistency	35%

B. Fine Aggregate

The locally available river sand was used as fine aggregate in the present investigation. The sand was free from clayey matter, salt and organic impurities. Aggregate that pass through a 4.75mm IS sieve and having not more than 5 percent coarser material are known as fine aggregate. Main function of fine aggregate is to fill the voids in between coarser particles and also helps in producing workability and uniformity in mixture.

Table No. 2: Physical Properties of Fine Aggregate

Sr. No.	Properties	Values
1	Specific gravity	2.44
2	Fineness modulus	2.25
3	Water absorption	1.5%

C. Waste Foundry Sand

Most of the metal industries prefer sand casting system. In this system mould made of uniform sized, clean, high silica sand is used. After casting process foundries recycle and reuse the sand several times but after sometime it is discarded from the foundries known as waste foundry sand. The application of waste foundry sand to various engineering sector can solve the problems of its disposal and harmful effect to environment.

Foundry sand is clean, uniformly sized, high-quality silica sand that is bounded to form moulds for ferrous (iron and steel) and non-ferrous (copper, aluminium, brass) metals. Type of foundry sand depends on the casting process in foundries. Foundry sand is generally of two types: Green sand, Chemically bounded sand. Additive in sand depends on type of metal casting. Use of waste foundry sand as full or partial replacement by fine aggregate helps to achieve different properties or behaviour of concrete.

Advantages of Foundry Sand

In Embankments

In Barrier layers construction

In Flow able fills in Road way construction
As Soil reinforcement
In Portland cement concrete

Other Engineering Application
Portland cement manufacturing
Mortars
Agriculture /soil amendments
Verification of hazardous materials
Smelting
Rockwool manufacturing
Fiberglas manufacturing
Landfill cover or hydraulic barriers

Table No. 3: Chemical Properties of Foundry Sand

Sr. No.	Constituent	Value (%)
1	$Si0_2$	83.93
2	Al_20_3	0.021
3	Fe_20_3	0.950
4	Ca0	1.03
5	Mgo	1.77
6	$S0_3$	0.057
7	LOI	2.19

D. Recycled Aggregate

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris.

Recycled aggregates are a way of reusing materials by keeping them from being disposed into landfills. They are more cost efficient than most regular aggregates. Recycled aggregates lower the amount of energy and raw materials used for the production of it.

Advantages of recycled aggregate

i) Emission of carbon dioxide is almost negligible
ii) Provides improved strength and durability
iii) Reduces permeability
iv) Improves workability

E. Coarse Aggregate

The aggregate having size more than 4.75 mm is termed as coarse aggregate. The graded coarse aggregate is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm etc. 80mm size is the maximum size that could be conveniently used for making concrete. They may be in the form of irregular broken stone or naturally occurring gravel.

Table No. 4: Physical Properties of Coarse Aggregate

Sr. No.	Properties	Values
1	Specific gravity	3.125
2	Size of aggregate	20mm
3	Fineness modulus	5.96
4	Water absorption	2%
5	Impact test	15.25%
6	Crushing test	22.5%

F. Water

Water plays an important as it contributes in chemical reaction with cement. Water is used for mixing as well as for curing

purpose also it should be clean and free from salts, acids, alkalis and other harmful materials. Generally, ordinary water is used for mixing concrete.

IV. METHODLOGY ADOPTED FOR CONCRETE MIX

Grade of concrete – M20
Design – IS 456:2000 & 10262:2009
In this experimental work, a total of 64 numbers of concrete specimens were casted. The mix design of concrete was done according to Indian standard guidelines for M20 grade. The experimental work has been carried out on the test specimen to study strength properties as a result of replacing fine aggregate by WFS for 0%, 20%, 40% and 60% and replacing coarse aggregate By RA for 0%, 20%, 40% and 60%. Concrete mixtures were prepared with different proportions of waste foundry sand and recycled aggregate. For each test, either 3 samples from each mix were tested at each curing age, and the average values were used in the Analysis.

Table No. 5: Mix Proportion for M20 grade

Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate(kg)	Water(lit)
401	559	1233	186
1	1.38	3.05	0.46

V. RESULTS AND DISCUSSIONS

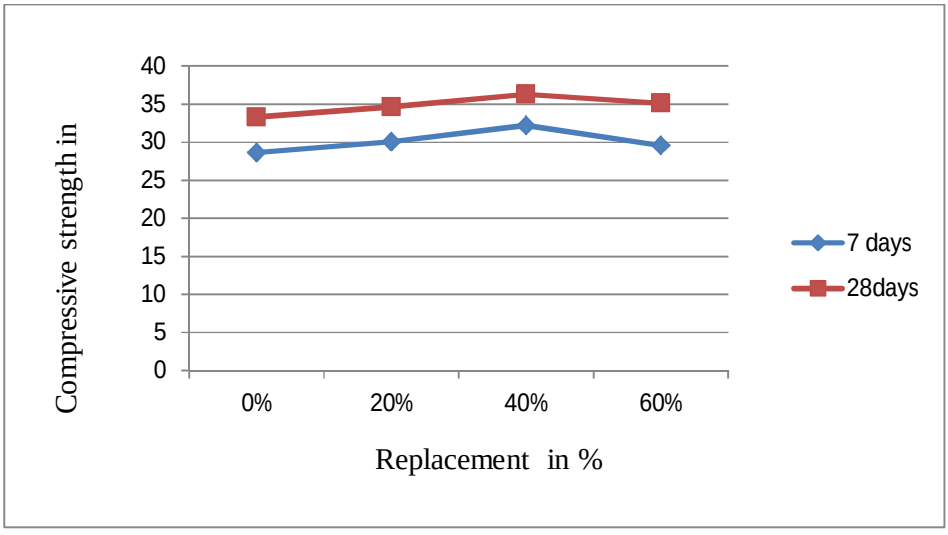
The study was conducted to find out the influence of waste foundry sand and recycled aggregate on strength properties of normal concrete. The effects of following parameters were studied. Compressive strength, Split tensile strength and flexural strength at various percentage replacement of fine aggregate with waste foundry sand and coarse aggregate with recycled aggregate on some of normal concrete.

A. Compressive Strength

Compressive strength tests were performed on cube samples of size 150mm X 150mm X 150mm using compression testing machine. Three samples per batch were tested with the average strength values reported in table 5

Table No. 5: Compressive Strength Test Results

Sr. No.	Replacement	Average Compressive Strength	
		At 7days (N/mm²)	At 28days (N/mm²)
1	0%	28.67	33.33
2	20%	30.10	34.65
3	40%	32.22	36.28
4	60%	29.56	35.12



Graph No. 1: Representation of Compressive Strength Values

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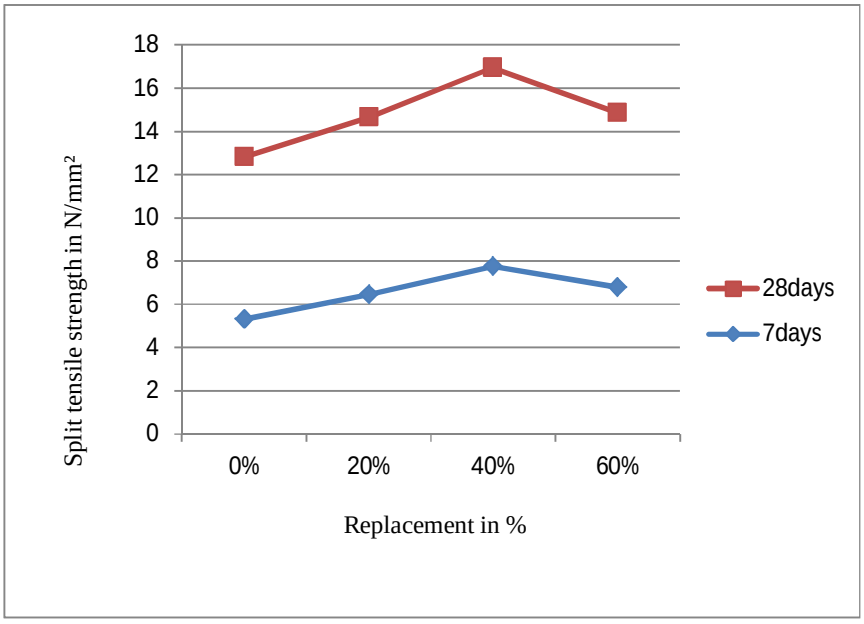
B. Splitting Tensile Strength

Splitting tensile strength tests were performed on universal testing machine(UTM) using cylindrical samples of size 150 mm X 300 mm. Three samples per batch were tested with the average strength values reported in table 6.

Table No. 12: Split Tensile Strength Test Results

Sr. No.	Replacement	Average Split Tensile Strength	
		At 7days (N/mm²)	At 28days (N/mm²)
1	0%	5.31	7.52
2	20%	6.45	8.22
3	40%	7.76	9.18
4	60%	6.80	8.05



Graph No.2: Representation of Split Tensile Strength

C. Flexural Strength

Flexural strength tests were performed on universal testing machine(UTM) using beam samples of size 150mmx150mmx750mm. Two samples per batch were tested with the average strength values reported in table 7.

Table No. 13: Flexural Strength Test Results

Sr. No.	Replacement	Average Split Tensile Strength	
		At 7days (N/mm²)	At 28days (N/mm²)
1	0%	5.20	6.34
2	20%	6.38	7.69
3	40%	7.45	8.12
4	60%	6.40	7.35

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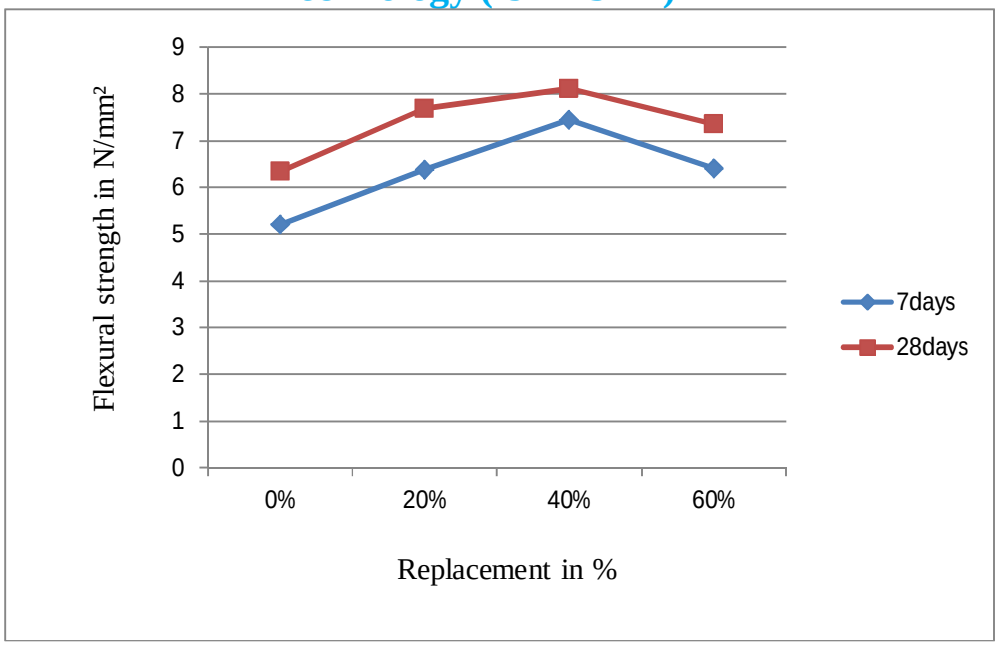

Graph No.3: Representation of flexural Strength

VI. CONCLUSIONS

Depending upon above results and methodology adopted following conclusion were made regarding properties of concrete incorporating waste foundry sand and recycled aggregate.

It is found that compressive strength of concrete mix is increases with increase in percentage of waste foundry sand and recycled aggregate as compare to normal concrete. It was maximum for 40% replacement after that it reduces.

It is also found that split tensile strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40%replacement after that it reduces.

It is also found that flexural strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40%replacement after that it reduces.

Increase of average compressive strength 4.47%, 10.615% & 4.237% as compared to conventional concrete.

Increase in average split tensile strength 15.38%, 34.10% & 17.554% as compared to conventional concrete.

Increase in average split tensile strength 21.99%, 35.67% & 19.50% as compared to conventional concrete.

The possibility of substituting natural fine aggregate with industrial by-product aggregate such as waste foundry sand and recycled aggregate offers technical, economic and environmental advantages which are of great importance in the present context of sustainability in the construction sector.

As waste foundry sand is waste from metal industries and recycled aggregate is waste from construction industries therefore both waste can be effectively use in concrete mix hence an eco-friendly construction material.

By using this waste in concrete, problems regarding to safely disposal is reduced.

VII. ACKONWLEDGEMENT

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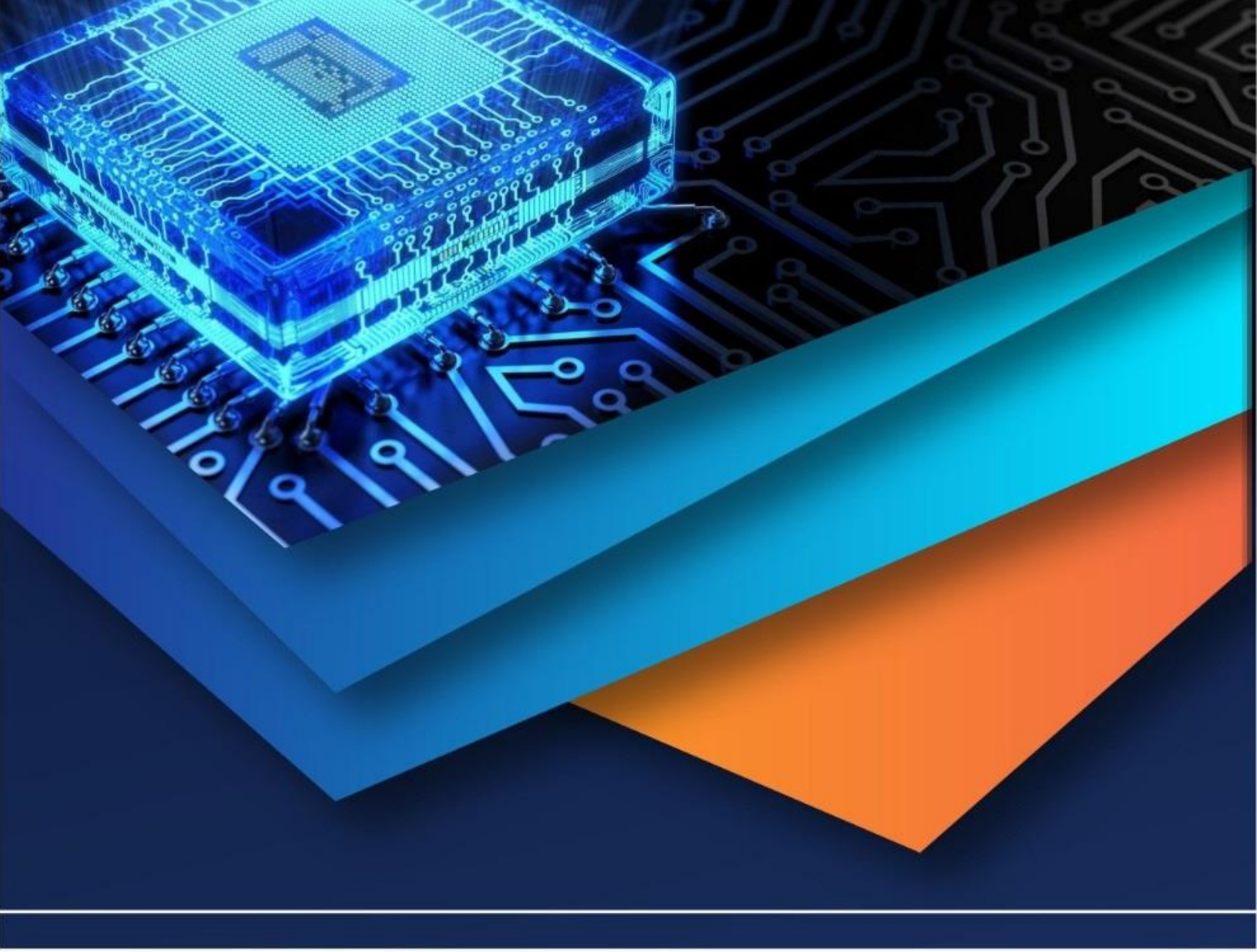

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