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An Overview on Utilization of Industrial Waste in Civil Ezgineering

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***Abstract** -In general, fine aggregate is very important factor in concrete volume, so their selection is important, also they control concrete properties. Fine aggregate provide strength and wear resistance in different applications. Hence, the selection and proportioning of fine aggregate should be given careful attention. The fine aggregate such as sand or stone dust etc is used in concrete production with coarse aggregate. This paper presents a review on the use industrial waste like red sand from bauxite industry in concrete production by replacing the fine aggregate. This will help in achieving economy in construction industry as well as saving environmental degradation in term of reduced mining and less pollution. In present study we use red sand in different proportion in concrete mix to find various strength properties.*

***Key words** – Ordinary Portland cement, Fly ash, Red sand, Concrete mix*

I. INTRODUCTION

Concrete is the most commonly used construction material, and the demand for it will increase as the demand for infrastructure development increases. Unfortunately, Ordinary Portland Cement (OPC) production depletes significant amounts of natural resources as it is a high energy-intensive construction material to produce, third only after the production of steel and aluminum. Furthermore, natural aggregate constitutes a substantial portion of traditional concrete. The natural source of coarse aggregate is crushed rock; and fine aggregate is naturally extracted from sand quarries.

The production of one tone of OPC also releases one tone of carbon dioxide into the atmosphere. The worldwide cement industry is responsible for about 7% (and rising) of the world‘s total carbon dioxide generation. Apart from environmental issues associated with the concrete industry, traditional concrete is not very durable in harsh environments, such as exposure to freezing weather, sea water or sulphuric soils. Thus, it is essential to find methods to increase the durability of traditional concrete by using appropriate replacements for concrete constituents; e.g. aggregate. It is now believed that using more durable and less energy intensive construction materials is inevitable for the construction industry. Various types of by product are used in construction in toady world like fly ash, rice husk ash, copper slag etc. in present study we use red sand as replacement material of sand in concrete mix. In present study we use 25 %, 50 %, 75 % and 100 % red sand in place of fine sand to find various properties of concrete.

A. Material Used for Present Study

Concrete is a variable material. It is not practical to expect that the characteristics of a concrete mix can be identically replicated on a consistent basis. One of the main reasons for the variability in the concrete is because of the variability in the materials used to make the concrete. The five basic constituents of concrete used in present study are:

1) *Cement :*Grade of cement 53 grade can influence the mix design. Grade of cement indicates minimum strength of cement in N/mm² tested as per standard conditions laid down by IS codes (OPC 53 grade – IS 12269 – 1987 e.g. a 53 grade cement should give minimum strength of 53 N/mm² at (28 days).Higher the strength of cement, higher is the strength of concrete for the same water/cement ratio. In other words a higher strength of cement permits use of higher water/cement ratio to achieve the same strength of concrete. The IS 10262 - 2009 for mix design gives the different curves of cement based on the actual strength of cement on 28th day. These cement curves give water/cement ratio required to achieve a given target strength. Information on grade of cement may not be as useful as the actual 28days strength of cement.
2) *Water:* The water employed in the mixtures was taken from the Indus institute of engineering technology, concrete laboratory which is tap water. This water was also used in the curing tanks.
3) *Fine Aggregate:* Fine aggregate /sand is a very important mineral for the expansion of society. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. River sand is one of the world‘s most plentiful resources (perhaps as much as 20% of the Earth‘s crust is sand) and has the ability to replenish itself. River sand is vital for human well-being & for sustenance of rivers.

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4) Red sand:The red sand is one of the major solid wastes coming from Bayer process of alumina production. For the present work it was collected from HINDALCO, At Renukoot, Uttar Pradesh. The conventional method of disposal of red sand in ponds has often adverse environmental impacts as during monsoons, the waste may be carried by run-off to the surface water courses and as a result of leaching may cause contamination of ground water

Fig. 1 Red Sand

5) *Coarse Aggregate :* Maximum size of aggregate is the standard sieve size (40mm, 25mm, 20mm, 12.5mm, 10mm) through which at least 90% of coarse aggregate will pass. Maximum size of aggregate affects the workability and strength of concrete.It also influences the water demand for getting a certain workability and fine aggregate content required for achieving a cohesive mix. For a given weight, higher the maximum size of aggregate, lower is the surface area of coarse aggregates and vice versa. As maximum size of coarse aggregate reduces, surface area of coarse aggregate increases. Higher the surface area, greater is the water demand to coat the particles and generate workability. Smaller maximum size of coarse aggregate will require greater fine aggregate content to coat particles and maintain cohesiveness of concrete mix.

B. *Objective of the Study*

1) To evaluate the properties of concrete mixtures made with red sand as a fine aggregate.
2) To identify the workability strength and durability of concrete containing red sand.
3) Red sand concrete can lead to the usage of bauxite residue in the future and paves the way to gradually replacing conventional concrete with less energy-intensive construction materials.

II. LITERATURE REVIEW

GlenisterDJ, Thornber MR (1985), find in his study that the neutralization of red mud will help toreduce the environmental impact caused due to its storage and also lessen significantly the ongoing management of the deposits after closure. It will also open opportunities for re-use of the residue which to date have been prevented because of the high pH.
McConchie D, Clark M, Hanahan C (2000), said that the seawater neutralization does noteliminate hydroxide from the system but converts the readily soluble, strongly caustic wastes into less soluble, weakly alkaline solids. The carbonate and bicarbonate alkalinity of the waste is removed primarily by reaction with calcium to form aragonite and calcite.
Wahyuni (2005),find in her study the effects of substituting natural yellow sand with Red Sandon the low strength concrete. She also looked at using different percentages of fly ash as cement replacement. It was found that concrete using Red Sand as fine aggregate had a low workability in comparison to an equivalent mix using natural sand. This low workability resulted in poor compaction of the concrete, adversely affecting the durability. Specifically the concrete had high water permeability and chloride diffusion.
Kavehsol(2008), said that there is a proper use of red sand in geopolymerconcrete. The moisture content of red sand prior to use has a great influence on the workability of geopolymer concrete mixture: in order to achieve the desired workability, red sand must be in SSD condition. The inclusion of red sand has been found to reduce the compressive strength of geopolymer concrete.
MajidDavood (2008),the main objective of their research was to investigate the possibility ofusing the coarse fraction of bauxite residue (red sand) as a fine aggregate substitution in concrete mix design suitable for marine environment. The opportunity to achieve low strength concrete using this potential resource for construction applications was also investigated. The tests for alkali aggregate reactivity showed that the Red Sands were non-reactive‖, being significantly less reactive than the Natural Yellow Sand. This suggests that alkali silica reaction will not be a problem if the aggregates are used in concrete.

PeerapongJitsangiam (2008),find in his study that thestabilized red sand is a viable option for use as abase course material in road construction in Western Australia. The stabilized red sand exhibits resilient modulus and permanent deformation characteristics that exceed that of the commonly used material for road bases (crushed rock added with 2% GP cement).

III. METHODOLOGY

A. Overview

This study was focused primarily to determine whether red sand and its derivatives can be used as an alternative to natural sand as fine aggregate M35 grade concrete. As stated earlier, the scope of this project was to have five different mixes, each with a characteristic strength of 35 MPa which is suitable for footing, Residential and Highway application. The constituents of the concrete consisted of cement, coarse aggregate (20mm) and fine aggregate (NS and RS) and water. It was trialed as the only fine aggregate in one concrete batch and in order to provide a comparison, a concrete mix using NS was used as a control mix. NS was chosen as it is already widely accepted and used within the construction industry as a fine aggregate in concrete.

B. Tests Conducted on Materials

Each mix underwent a series of tests. These tests were chosen to assess the individual characteristic of the aggregates as well as the workability, strength and durability indicators of the concrete. A complete list of the tests is given below

1) Particle Size DistributionSpecific Gravity
2) Water Absorption
3) workability
4) Compressive Strength
5) lexural Strength

IV. RESULT AND ANALYSIS

A. Physical Properties

Some physical characteristics of fine aggregates used in this research are summarized in Table (4.1). The similarity of natural sand properties with red sand are noteworthy. Red sand contain pH value of 8.98 where neutralized red sand pH value given in the table. Due to a higher percent of fines in red sand, its surface area is greater than natural sand and it can be concluded that the workability of concrete mixes incorporating red sand as a fine aggregate.

Table 4.1 Physical Characteristics of Fine Aggregates

Parameters	Specific gravity
Natural sand	2.66
Red sand	2.52

B. Water Absorption of Aggregates

An important characteristic of the fine aggregate is the amount of water that is absorbed by the aggregate itself. It is desirable to use the SSD condition for aggregates when making concrete mixes. The amount of water absorption can be found allowing adjustment to the amount of free water and the amount of fine aggregate in the concrete mix. This allows the fine aggregate to be oven dried and a small amount of water added; which is more accurate than simply observing the fine aggregate and making an assumption when it is at the surface saturated dry (SSD) condition.

Table 4.2 shows the water absorption of each fine aggregate. The water absorption for RS is very similar to the natural sand. This is to be expected given the similar chemical composition and mineralogical makeup of the sands. The water absorption for NS and RS are less than the average acceptable value shown in IS Code as 2%. The result is unusual for NS as a common aggregate, however is unlikely to pose any significant problems as higher values for water absorption tend to be more detrimental than low values. The value for RS as with the NS, is unlikely to be detrimental to a concrete mix.

Table 4.2 Water Absorption of Fine Aggregates (%)

Property	NS	RS	Method
Water absorption	.78	1.05	IS

C. Sieve Analysis and Fineness Modulus

Sieve analyses were performed for NS, RS and CA in accordance with BIS. To ensure the samples taken were representative, a weighing machine was used to separate the samples into the minimum required weight. The results are summarized in Table 4.3.

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Table 4.7 Fineness Modulus for Various Fine Aggregates

Property	NS	RS	Method
Fineness Modulus	2.68	1.70	Calculation

D. Workability Of Fresh Concrete

Slump measurements, a common method of workability measurement in practice, were used as indicators of consistency of the concrete in accordance with IS. Workability was also judged through a visual inspection of the concrete mixes during mixing and pouring and a general feel of the practicality of the mixes workability.

1) *Slump Test:* Overall, all the mixes did have a moderate workability level but at least this was consistent throughout. Average slump values are shown in Table 4-5. The slump was measured twice, once for each batch. Although IS (Standards India 1997) states that for high slumps exceeding 110 mm a tolerance of ± 30 mm is permitted., these high slumps value were a little too high for practical use in comparison with commercial concrete and would not be accepted in industry.With such a high workability, special care was taken not to over tamping the concrete by the rod to avoid segregation of the concrete. Figure 4-3 shows the average, upper and lower slump values of the mixes.

Table 4.8 Workability Experienced of Concrete Mixes

Mix	M1	M2	M3	M4	M5
Average slump	80	75	70	60	55

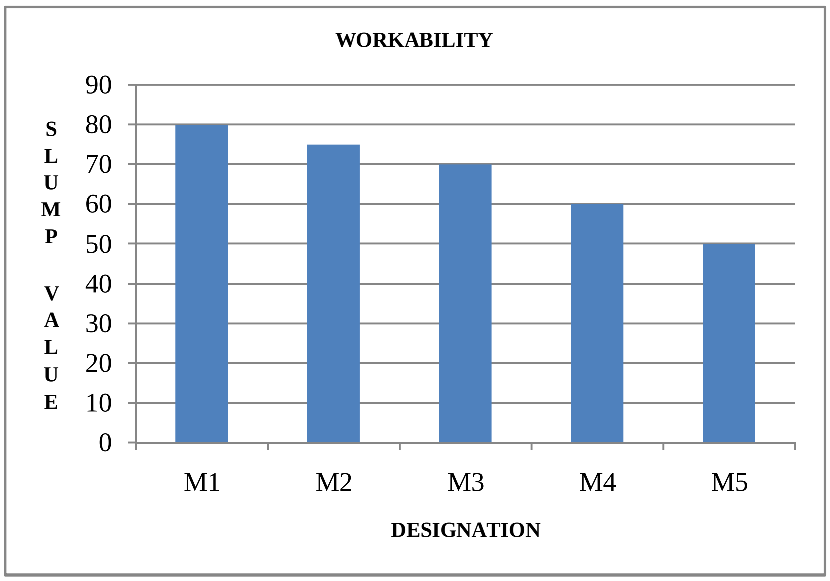

Figure 4.1 Workability of various mix

E. Compressive Strength

The characteristic compressive strength is generally the foremost specification for concrete. It is also usually the most important property of the concrete. Whether it is the primary consideration of a concrete mix or not the compressive strength is always specified and tested, to a high standard of quality control. Not only is the compressive strength an important test it is also generally considered the most easily obtained test for hardened concrete on site, thus most preferable.

Mixtures 1 to 5 were made with different percentages of red sand. mixture 5 used red sand as 100 percent (specific gravity of red sand were used) of the total fine aggregate and, whereas mixture 4 was made with a ratio 75:25 of red sand to natural sand and also mixture 3 was made with a ratio 50:50 of red sand to natural sand. Mixture 2 used red sand as the sole fine aggregate and mixture 1 comprised 100% natural sand. All other constituents were kept constant. For each mix, specimens were tested for compressive strength after 7, 14 and 28 days after casting.

Table 4.9 Detail of compressive strength of mixes

RS content	Mix designation	7 day N/mm²	14 day N/mm²	28 day N/mm²
0	M1	24	29	35.8
25	M2	26	32.8	39.7
50	M3	28	35.9	42.3
75	M4	25.3	32.3	40
100	M5	23.4	29.2	37.6

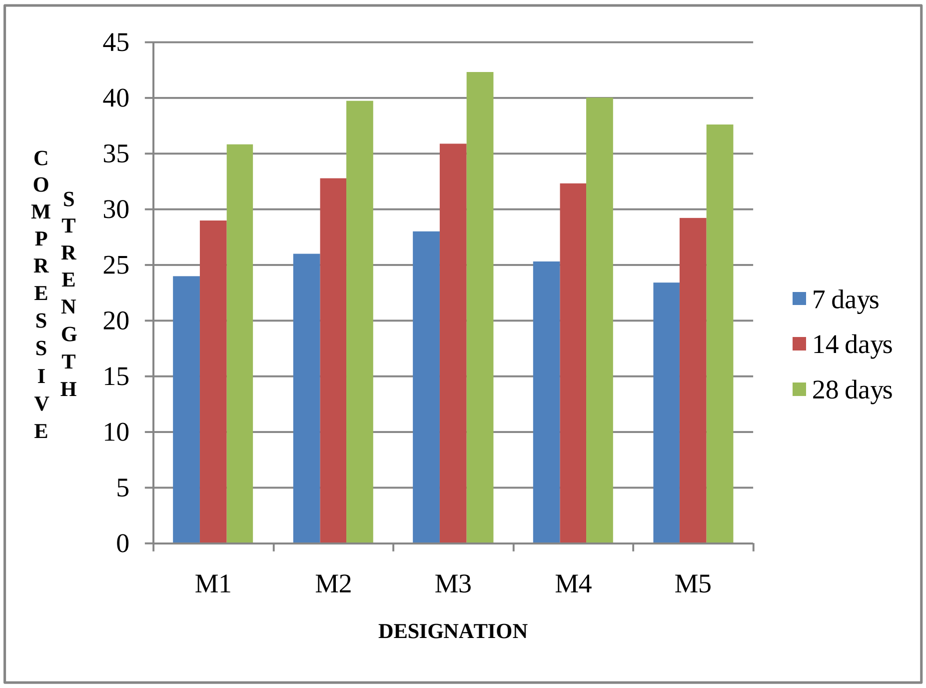

Figure 4.2 Comparison of Compressive Strength for various mix

F. Flexural Strength

Flexural strength, also known as modulus of rupture, or bend strength, or traverse rupture strength is a material property, defines as the stress in a material just before it yield in a flexural test. The traverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stressMixtures 1 to 5 were made with different percentages of red sand. mixture 5 used red sand as 100 percent (specific gravity of red sand were used) of the total fine aggregate and, whereas mixture 4 was made with a ratio 75:25 of red sand to natural sand and also mixture 3 was made with a ratio 50:50 of red sand to natural sand. Mixture 2 used red sand as the sole fine aggregate and mixture 1 comprised 100% natural sand. All other constituents were kept constant.For each mix, specimens were tested for compressive strength after 7, 14 and 28 days after casting.

Table 4.10 Detail of flexural strength of mixes

RS content	Mix designation	7 day N/mm²	14 day N/mm²	28 day N/mm²
0	M1	3.749	3.931	4.382
25	M2	3.892	4.112	4.485
50	M3	3.986	4.215	4.50
75	M4	3.820	4.175	4.286
100	M5	3.694	3.914	4.055

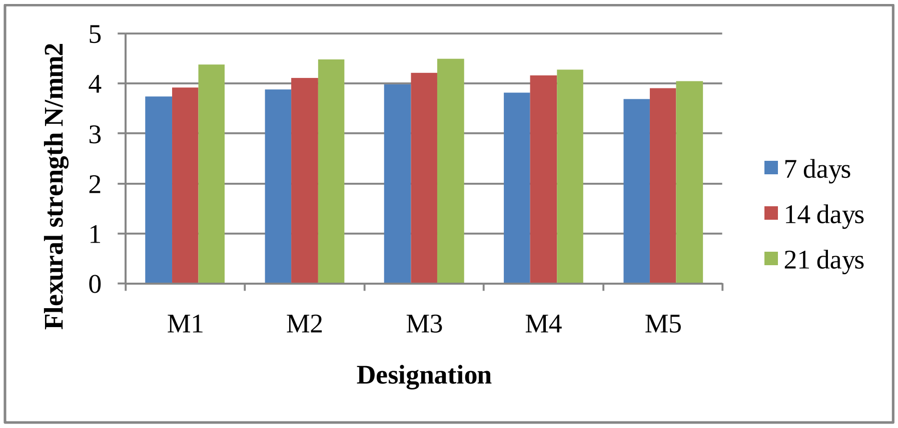

Figure 4.3 Comparison of Flexural Strength for various mix

V. SUMMARY AND CONCLUSION

The main objective of this research was to investigate the possibility of using the coarse fraction of bauxite residue (red sand) as a fine aggregate substitution in concrete mix design suitable for commercial environment. The opportunity to achieve low strength concrete using this potential resource for construction applications was also investigated.

The impact on concrete mix design and properties of manufactured concrete were evaluated with a series of laboratory standard tests. The tests conducted in this research were just a few of those possible for assessing the strength and durability behavior of concrete mixes. From the results obtained, the following conclusions are made:

A. In order for satisfactory performance in a concrete incorporating Sea water Neutralized Red Sand gave target compressive strength results in excess of the Indian standard requirement, that is 35 MPa, and they were capable of producing adequate compressive strengths for a M35 grade concrete.
B. In comparison to concrete using Natural Sand, concrete using Red Sand achieved similar strength characteristics greater than that of the control mix. Partially replaced red sand by the weight of natural sand also showed improved strength in the tests.
C. In the case of Red sand replaced concrete mixes (M1, M2, M3, M4, M5), the slump recorded slightly lower values than desirable, especially with the Natural Sand mixes(M1).
D. Concrete using Sea water Neutralized Red Sand also showed similar strength characteristics, there were some durability concerns for Sea water Neutralized Red Sand mixes with 20mm coarse aggregate. The compressive strengths of Red Sand mixes were higher than that of Natural Sand. It seems the trends for all coarse aggregate were almost the same regardless of the fine aggregate used.
E. Compressive strength of concrete increased with the increase in sand replacement up to 50% (M3) with different replacement levels of red sand after that it goes decreasing. However, at 25 and 50% replacement level of fine aggregate with red sand, an increase in strength was observed with the increase in age, in case of 75% and 100% replacement level of fine aggregate with red sand, an decrease in strength was observed with increase in age.
F. Flexural strength also showed an increase with increase in replacement levels up to 50% (M3) of Red Sand with fine aggregate after that it goes decrease.
G. In the case of M35 concrete mixes, M2 and M3 Red Sand mixes performed similarly better than the control mixes, but in case of M4 and M5 control mix is better, however there were some concerns in regards to durability indicators.
H. From the results obtained, it can be deduced that Red Sand used in M35 grade concrete can achieve increased strengths to an equivalent mix using Natural sand
I. More importantly, for application in severe environments, it offers improvements in performance for the durability characteristics (water absorption) assessed. Sea water neutralized Red Sand can also achieve similar strengths to traditional concrete and has good durability and a lack of workability when combined with a Red Sand.
J. Based on the results of all of the marine grade concrete mixes, the indication is that Red Sand performs better as a replacement of fine aggregate.

As such, Red Sand showed ability to replace natural materials, when combined with a 20 mm coarse aggregate. Using Red Sand in low strength concrete showed that they do have potential to be used in industry and these material can be a viable sustainable solution to reduce Red Sand stockpiles.

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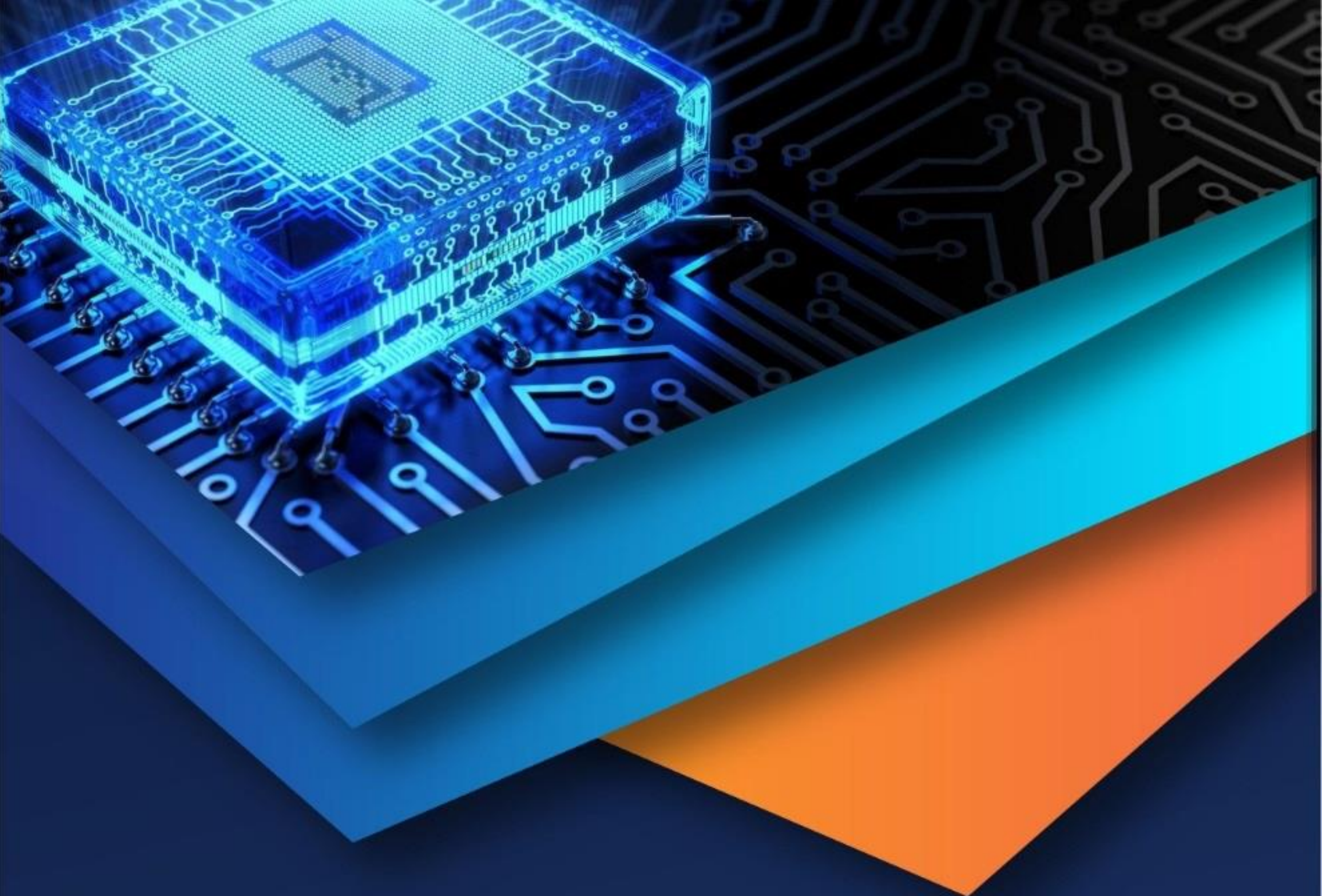

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