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# Effect on The Performance of Concrete Containing Copper Slag and Recycled Aggregate as Fine Aggregate

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***Abstract: Conservation of natural resources and preservation of environment is the essence of any modern development. In last few decades, construction activities increase rapidly. Itsss require more raw materials and it will result in shortage of material in future. Now a days there is trend of recycling and reusing material, which is partial solution of this problem. Also, Industrial wastes are used as raw material. It reduces the consumption of natural resources. Copper slag and recycled aggregate are the industrial waste and recycled material used as a fine aggregate in concrete. Both the material has same physical properties similar to the fine aggregate. By replacing 10% to 50% copper slag as fine aggregate, concrete produced. At the optimum content of copper slag, 10% to 50%of recycled aggregate replaced and the concrete produced.***
***Key words: copper slag, recycled aggregate.***

## I. INTRODUCTION

Aggregates which are used in concrete are obtained either from natural sources or by crushing large size rocks. In order to reduce dependence on natural aggregate in construction, artificially manufactured aggregate and some industrial waste material can be used as an alternative. Also, aggregates are considered as inert material therefore it can be easily replaced in comparison of any other constituent of concrete. Use of copper slag and recycled aggregate as a fine aggregate in concrete reduce amount of natural aggregate in concrete and also useful in waste management.

Avikal Somvanshi, Senior Research Associate, Sustainable Buildings and Habitat Programme, CSE, reported that, in 2013, Indian buildings generated over 530 million tonnes of concrete debris, which is a very huge amount. It required considerable space for dumping. In other hand, copper slag is industrial waste produced during process of smelting. It produced in amount of 24.5 million tonnes per annum, Gorai (2013). As both the materials in huge amount, its use in concrete can cover the problem at such extent.

## II. MATERIALS AND METHOD

### *A. Cement*

Ordinary Portland cement 43 grade was used throughout the experimental investigations. The cement satisfied the requirements of Indian Standard Specification IS: 269-2015.The test results are listed in the Table 1.

Table 1.0 Properties of OPC

| Properties | Value |
|---|---|
| Standard consistency | 30% |
| Initial setting time | 135 min |
| Final setting time | 187 min |
| Le-chetelier soundness | 1.1 mm |

### *B. Fine and Coarse Aggregates*

Coarse aggregates of 20mm down size and fine aggregates of Zone II were used from Saifi materials suppliers, Dahod. The test results on fine and coarse aggregate are presented in the following table 2.0 and 3.0.

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Table 2.0 Physical Properties of Fine Aggregate

| Properties | Unit | Values |
|---|---|---|
| Fineness modulus | - | 2.73 |
| Specific gravity | - | 2.6 |
| Water absorption | % | 1.10 |
| Void ratio | - | 0.33 |
| Bulk density | $Kg/m^3$ | 1.71 |

Table 3.0 Physical Properties of Coarse Aggregate

| Properties | Unit | Values |
|---|---|---|
| Fineness modulus | - | 8.01 |
| Specific gravity | - | 2.78 |
| Water absorption | % | 0.31 |
| Crushing Value | % | 26.37 |
| Impact Value | % | 30.75 |

### *C. Copper slag*

Copper slag is one of the materials that is considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregate. It is a by product obtained during the matte smelting and refining of copper. One of the materials is the copper slag that is produced during mate smelting and converting steps. Therefore, nowadays utilization of secondary materials is being encouraged in construction field. The molten copper slag forms at the bottom of the furnace while molten slag is formed on top. The molten copper slag is then drained off and quenched with water or left in the air to cool. During blasting, copper slag breaks into smaller particles on impact with metal surfaces. After several rounds of reuse, the copper slag gets contaminated with rusts and paints and becomes a waste material but without any change in its chemical composition.

Table 4.0 Physical Properties of Copper Slag

| Properties | Unit | Values |
|---|---|---|
| Fineness modulus | - | 4.75 |
| Specific gravity | - | 3.91 |
| Water absorption | % | 0.15 |
| Crushing Value | % | 26.37 |
| Impact Value | % | 30.75 |

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Table 5.0 Chemical Composition of Copper Slag

| Sr. no | Constituents | Quantity (%) |
|---|---|---|
| 1 | $Sio_2$ | 97.10% |
| 2 | $Aal_2o_3$ | 0.090 |
| 3 | $Fe_2o_3$ | 1.35 |
| 4 | Cao | 1.09 |
| 5 | Mgo | 0.121 |
| 6 | $So_3$ | 0.006 |
| 7 | $K_2o$ | 0.024 |
| 8 | $Na_2o$ | 0.112 |
| 9 | $Ti_2o$ | 0.120 |
| 10 | $Mn_2o_3$ | 0.008 |
| 11 | Sulphide sulpher | 0.082 |
| 12 | Chloride | 0.355 |

### *D. Recycled aggregate*

Large quantities of crushed concrete produced in India and elsewhere in the world. Owing to the increasing cost of landfill, the scarcity of natural resources coupled with the increase in aggregate requirement for construction, the use of recycled aggregate to partially replace the virgin aggregate has, therefore, become more common.

There have been a number of publications on the use of recycled aggregate in concrete. It was concluded that concrete strength decreases when recycled concrete was used and the strength reduction could be as low as 40%. However, no decrease in strength was reported for concrete containing up 20% fine or 30% coarse recycled concrete aggregates, but beyond these levels, there was a systematic decrease in strength as the content of recycled aggregates increased.

Table 6: Physical Properties of Natural Aggregate and Recycled Aggregate

| SR.NO. | PARTICULARS | VALUES | |
|---|---|---|---|
| | | Natural Aggregate | Recycled Aggregate |
| 1 | Specific Gravity | 2.6 | 2.50 |
| 2 | Water Absorption | 1.10% | 0.3% |
| 3 | Bulk Density | 1678.2 $KN/m^3$ | 1469.8$KN/m^3$ |
| 4 | Crushing Values: | 18.4% | 36.3% |

## III. PREPARATION AND CASTING OF TEST SPECIMENS

Concrete cubes of size 150 × 150 × 150mm were casted for all the concrete mixes for compressive strength, 150 × 300mm size cylinders were casted for tensile strength, for the flexural strength, the beam sized 500×100×100 were casted. The test specimens were remoulded after 24 hours of the casting and cured for the 3,7,28 days until they were tested.

*A. S4.0 Mix Design*

The concrete is designed for M30 grade and water cement ratio used for the experimental work is 0.44. The experiments were conducted by replacing sand by copper slag by 10 to 50%. The recycled aggregates were replaced in content of 5%,10%,15%,20% and 25% at the optimum content of copper slag at which it gives optimum strength.

## IV. RESULTS AND DISCUSSION

*A. Compressive Strength Test*

Figure 1.0 Cube Specimen Failure under Compressive Load

The compressive strength of concrete cubes is determined at ages 7 and 28 days and Table 7.0 shows the strength variation of the mix having conventional concrete and partial replacement of sand by copper slag and recycled aggregate. The test is conducted as per IS: 516-1999.

Table 7.0 Compressive Strength Variation

| MIX PROPORTION | COMPRESSIVE STRNGTH(7 DAYS) $N/mm^2$ | COMPRESSIVE STRNGTH(28 DAYS) $N/mm^2$ |
|---|---|---|
| P0 | 22.48 | 38.22 |
| P1 | 25.72 | 39.24 |
| P2 | 27.04 | 41.25 |
| P3 | 27.90 | 42.72 |
| P4 | 28.77 | 45.34 |
| P5 | 26.16 | 38.36 |
| P6 | 24.15 | 39.92 |
| P7 | 27.50 | 41.67 |
| P8 | 29.01 | 43.20 |
| P9 | 30.11 | 45.40 |
| P10 | 26.89 | 38.38 |

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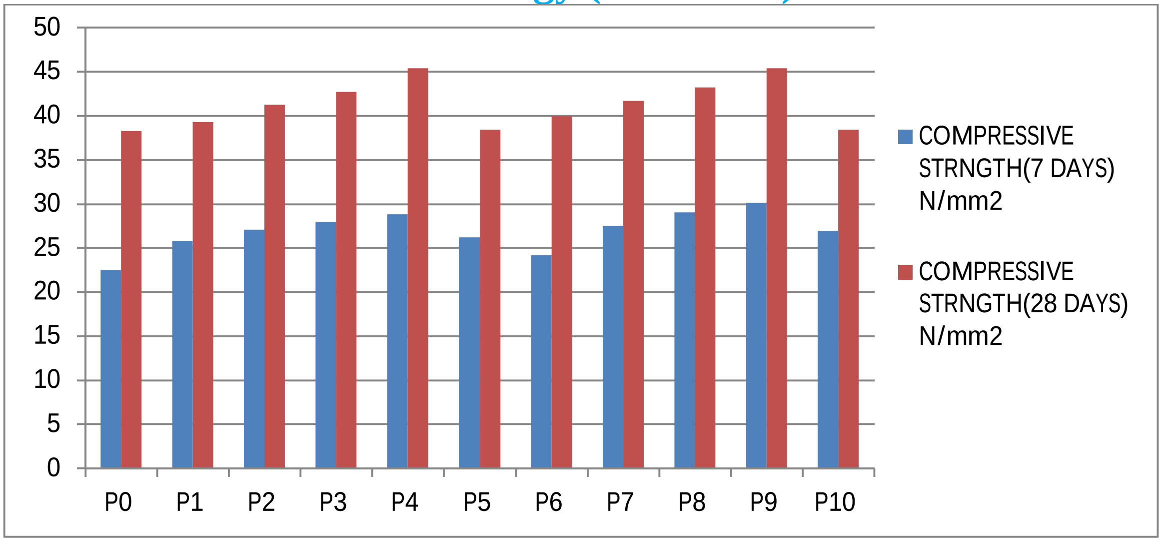


Figure 2.0 Compressive Strengths for 7 and 28 Days

From the above graph, we can conclude there is a certain increase in the strength is noted by increasing amount of copper slag and recycled aggregate. By replacing 10% of sand by copper slag, it will result in increase of 2.66% in compressive strength of concrete. In same manner, by increasing 20%, 30%, 40% and 50% there is a increase in strength is 7.92%, 9.15%, 18.62% and 0.36%.

By replacing recycled aggregates in proportion of 5%, the increase in strength is noted 2.85%. by increasing amount of recycled aggregate in proportion of 10%, 15%, 20%, and 25%, the strength will increase as 8.06%, 10.41%, 18.78% and 0.40% respectively.

From both the graph, we can easily conclude that the proportion of 40% of copper slag gave the optimum strength and beyond it the strength reduced. By keeping copper slag amount constant of 40% and by adding recycled aggregate in proportion of 5%,10%,15%,20% and 25%, the proportion of 25% gave optimum strength. Thus, 40% of copper slag and 20% of recycled aggregates gave optimum strength than the other proportions

### *B. Tensile Strength Test*

The split tensile strength is also measured for 7 days and 28 days for normal concrete and concrete containing copper slag and recycled aggregate. The results are shown as below:

Table 8.0 Tensile Strength Variation

| MIX PROPORTION | SPLIT TENSILE STRNGTH(7 DAYS) $N/mm^2$ | SPLIT TENSILE STRENGTH (28 DAYS) $N/mm^2$ |
|---|---|---|
| P0 | 2.55 | 3.417 |
| P1 | 2.57 | 4.98 |
| P2 | 2.65 | 5.28 |
| P3 | 2.79 | 5.53 |
| P4 | 2.87 | 5.73 |
| P5 | 2.61 | 5.60 |
| P6 | 2.58 | 5.00 |
| P7 | 2.67 | 5.30 |
| P8 | 2.85 | 5.58 |
| P9 | 2.90 | 5.75 |
| P10 | 2.65 | 5.58 |

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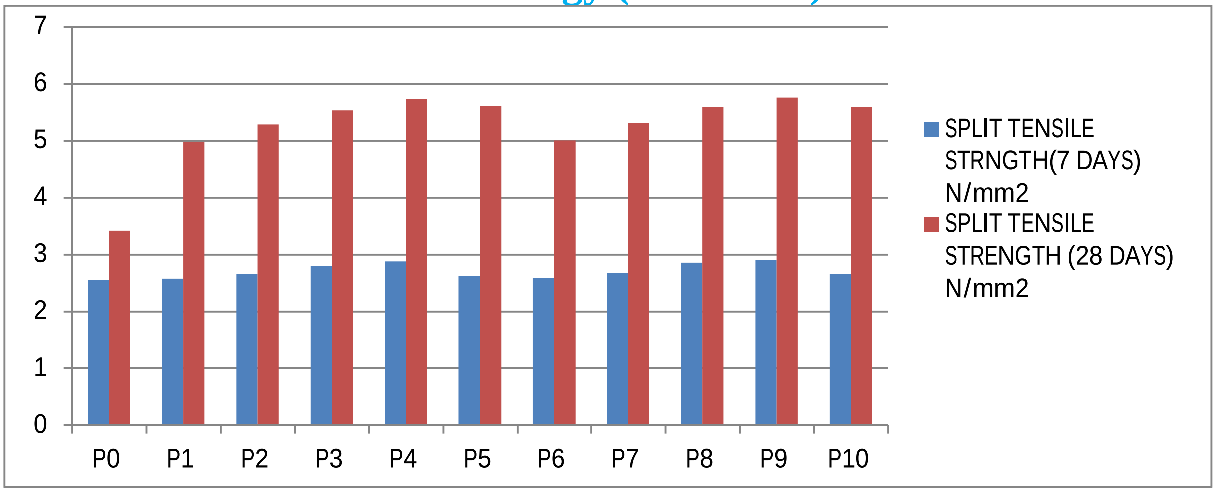


Figure 3.0 Split Tensile Strength for 7 and 28 Days

*C. Flexural Strength Test*

[Table 9: Flexural Strength of Concrete]

| MIX PROPORTION | FLEXURAL STRENGTH (28 DAYS) N/mm$^2$ | MIX PROPORTION | FLEXURAL STRENGTH (28 DAYS) N/mm$^2$ |
|---|---|---|---|
| P0 | 4.12 | P6 | 4.18 |
| P1 | 4.17 | P7 | 4.20 |
| P2 | 4.27 | P8 | 4.44 |
| P3 | 4.35 | P9 | 4.85 |
| P4 | 4.90 | P10 | 4.50 |
| P5 | 4.55 | | |

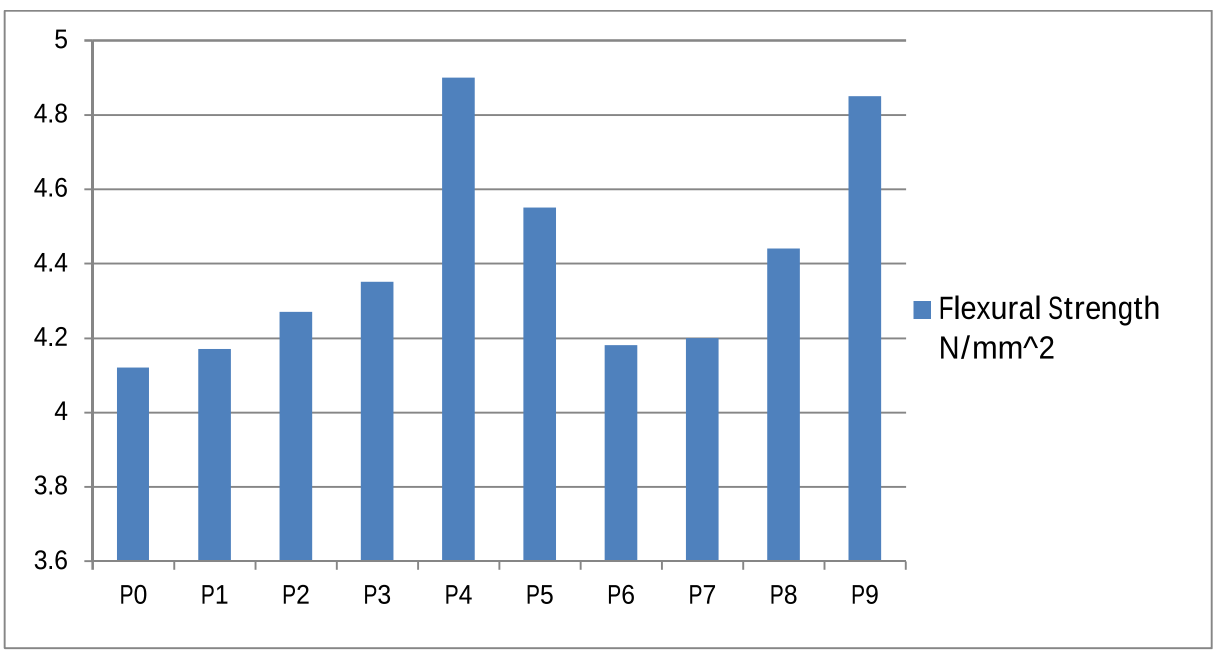


Figure 4.0 Flexural Strength for 28 Days

## V. CONCLUSION

Following remarks are concluded from the experimental work carried out for this research:

*A.* The workability of concrete increases by adding copper slag, as the water absorption rate of copper slag is lesser in comparison of fine aggregate. Thus, workability of concrete can be increased by adding copper slag.
*B.* By adding copper slag in various proportions, there is increase in strength is tto be noted.
*C.* Addition of copper slag of 40% of fine aggregate, gave optimum workability and gave more slump.
*D.* Due to high specific gravity of copper slag, the density of concrete increased as increasing the volume of copper slag by replacing fine aggregates.
*E.* Recycled aggregate also give strength to the concrete when added in certain proportion.
*F.* Addition of recycled aggregate of 20% gave optimum strength, and there is no major adverse effect on concrete due to recycled aggregate.
*G.* Due to high water absorption rate of recycled aggregate, there is a decrease in slump when RCA added in optimum proportion.
*H.* About 25%of recycled aggregate gave optimum strength to the concrete.
*I.* About 40% of copper slag also give more strength to the concrete in comparison of other proportional mixes.
*J.* There is increase in compressive strength, split tensile strength and flexural strength due to sand replacement by copper slag and recycled aggregate.
*K.* Due to using recycled aggregates and copper slag, it prove good at the point of environmental view.
*L.* By use of these material, its becomes easy to conserve the natural resources like sand and also its being solution of problem like dumping of such waste materials.

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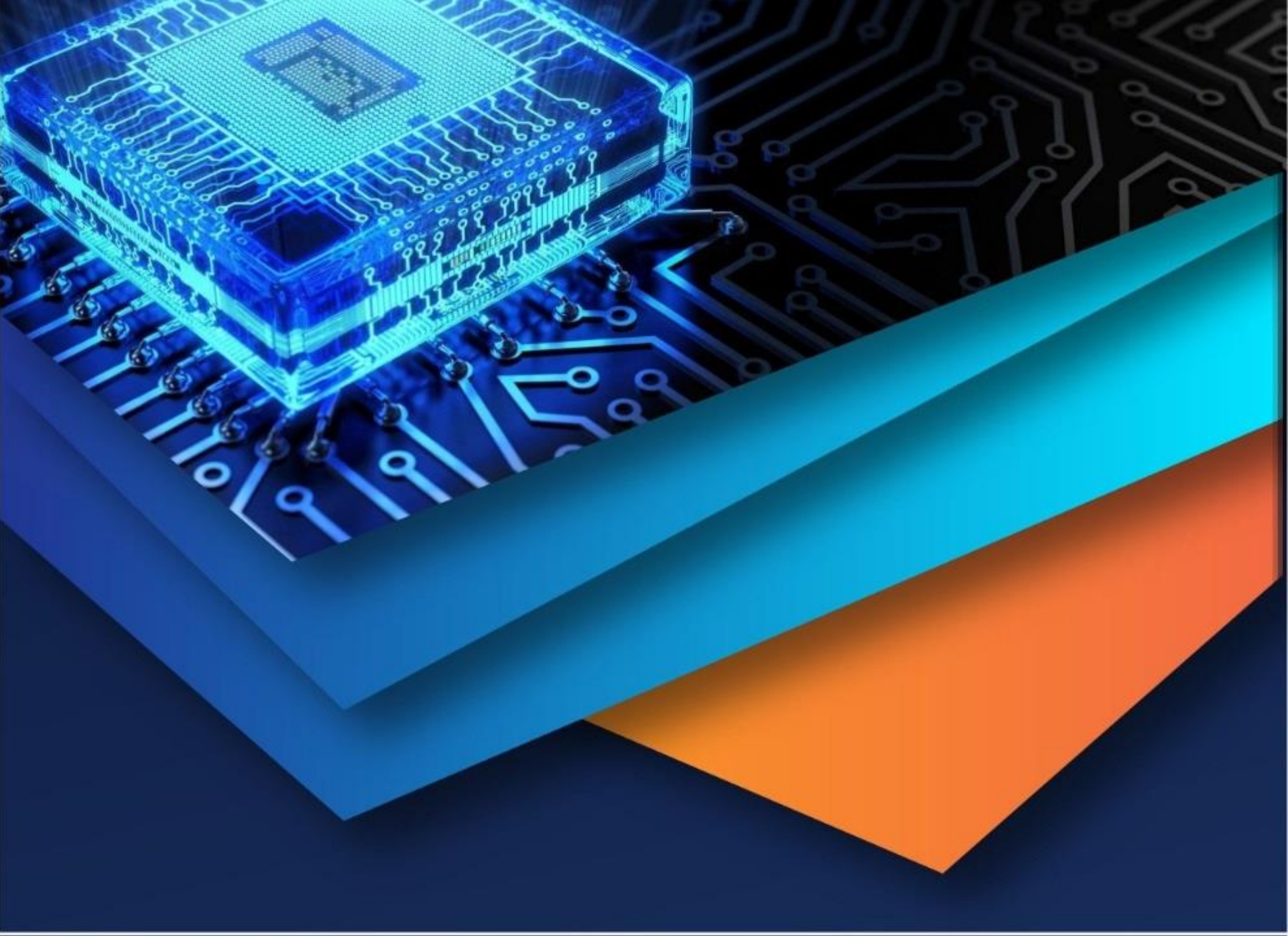


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