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# Waste Plastic Induced in Self Compacting Concrete to Avoid Plastic Pollution

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***Abstract: In this present study the plastic aggregate obtained from E-waste is used as a partial replacement of coarse aggregate in self-compacting concrete. An experimental investigation on the fresh, hardened characteristics of concrete using M40 grade of Self compacting concrete are carried out by casting standard concrete with various volume fractions of plastic aggregate such as 0%, 10%, 20%, 30%, 40%, 50% to determine optimal dosage. The fresh properties of SCC reveal that the workability of concrete are improved by using plastic aggregate. Strength properties such as compressive strength shows that up to 30% substitution of coarse aggregate there is no major change in compressive strength as compared to normal concrete. Beyond that there is drop in compressive strength for 50% replacement of coarse aggregate by plastic aggregate. Split tensile strength, Flexural strength and Young modulus of concrete increases for 10% plastic aggregate. Beyond that strength decreases upto 50% replacement. Impact strength decreases for all replacement levels.***
***Keywords: SCC, Fresh Properties, Compressive Strength, Split Tensile Strength, Flexural Strength, Young Modulus, Plastic Aggregate,***

## I. INTRODUCTION

SCC contains powder material as constituent in addition to the traditional concrete materials. Therefore, in general, the density of SCC seems to be higher than the density of normal concrete. Use of lightweight aggregates in the production of concrete can decrease the self-weight of structures. This can result in reduced members' sections and, therefore, it will save on overall construction costs. Lightweight aggregates are generally classified either as natural or artificial. Polystyrene plastic aggregate are a type of artificial ultra-lightweight non-absorbent aggregate. It is obtained from the Polystyrene type of plastic waste. Mostly polystyrene type plastics are used for making electronic goods. Also plastic is composed of several toxic chemicals, and therefore plastic pollutes soil, air and water. Since plastic is a non-biodegradable material, land-filling using plastic would mean preserving the harmful material forever. The hazards that plastics pose are numerous. They may block the drainage system of a city.

## II. LITERATURE REVIEW

In the majority of the studies, a lower slump value of fresh concrete due to the incorporation of several types of plastic aggregates than that of the conventional concrete mix was observed and an increasing addition of plastic aggregate further lowers the slump value .The reasons for the lower slump value of the concrete mix containing plastic aggregate are the sharp edges and angular particle size of plastic aggregate. In a few studies, an increase in the slump value due to the incorporation of plastic aggregate is also reported .The increase of the slump of concrete mixes due to the incorporation of plastic aggregates is due to the presence of more free water in the mixes containing plastic than in the concrete mix containing natural aggregate since, unlike natural aggregate, plastic aggregates cannot absorb water during mixing.

Albano et al reported that concrete with 10% of recycled PET exhibits a compressive strength that meets the standard strength values for concrete with moderate strength .The reduction in compressive strength was more pronounced in concrete containing larger flaky PET aggregate than smaller one. Saikia and de Brito observed similar trends in compressive strength for concrete containing fine and coarse flaky PET aggregate, which was mainly due to the loss of workability of the concrete mix due to the shape of the PET aggregate, especially for larger particles. Batayneh et al. also observed a reduction in the compressive strength of concrete due to the addition of plastic waste as a partial substitution of fine aggregate . For 20% replacement compressive strength shows a sharp reduction up to 72% of the original strength. Ismail and Al-Hashmi reported that the compressive strength of concrete prepared by replacing 10%, 15% and 20% of fine natural aggregate by PET aggregate are higher than the minimum compressive strength required for structural concrete, which is 17.24 MPa, even though the values are lower than the compressive strength of concrete containing only natural aggregate. Albano et al. the decrease in splitting tensile strength was due to the increased porosity of concrete caused by the incorporation of PET aggregate as well as the increase in w/c ratio . Kan and Demirbog˘a also reported that the splitting tensile strength of concrete containing heat-treated expanded polystyrene (MEPS) aggregate decreases with its increasing content in concrete, due to the generation of more porosity because of the incorporation of MEPS . Batayneh et al. reported that the decreasing trend of splitting tensile strength was not as prominent as that for compressive strength. Ismail and Al-Hashmi their results showed that the flexural strength of plastic waste concrete mixes at each curing age was prone to decrease with the increase of the plastic waste ratio in these mixes. Saikia and de Brito also found lower flexural strength values for concrete containing PET aggregate than for concrete containing natural aggregate only Hannawi et al. reported that the elastic nature and the non-brittle characteristics under loading of the plastic aggregate might have an effect on the observed flexural strength. Marzouk et al. reported that the modulus of elasticity values (as determined by the ultrasonic method) decreased as PET quantity increased. Compared with the modulus of elasticity of reference mortar (27.94 MPa), a 50% reduction was observed for the mortar prepared by replacing 50% of fine natural aggregate by PET aggregate. The reduction in modulus of elasticity was due both to the reduction of mortars bulk densities and to the presence of plastic aggregates, which decreased the velocity of wave by disturbing the ultrasonic wave propagation.

## III. MATERIAL INVESTIGATION

### *A. Cement*

Ordinary Portland cement of 53 grade is used in this project work. The physical properties of cement are given in Table 1

Table 1.Physical properties of Cement (OPC 53 grade)

| Sl.No | Description | Result |
|---|---|---|
| 1 | Standard Consistency | 31% |
| 2 | Initial setting time | 137min |
| 3 | Final setting time | 303 min |
| 4 | Specific gravity | 3.11 |

### *B. Fine Aggregate*

Good quality river sand free from silt and other impurities passing through 4.75 mm sieve is used in this study. The physical properties of fine aggregate are shown in Table 2

Table 2. Physical properties of Fine aggregate

| Sl.No | Description | Result |
|---|---|---|
| 1 | Specific gravity | 2.7 |
| 2 | Water absorption (%) | 1.05 |
| 3 | Bulk density(g/cm$^3$) | 1.560 |
| 4 | Fineness modulus | 2.99 |
| 5 | Zone | I |

### *C. Coarse Aggregate*

Coarse aggregate is passing through 20 mm and retaining on 10mm sieves are used for experimental work. The physical properties of coarse aggregate are given in Table 3.

Table 3. Physical properties of Coarse aggregate

| Sl.No | Description | Result |
|---|---|---|
| 1 | Specific gravity | 2.78 |
| 2 | Water absorption (%) | 0.6 |
| 3 | Loose Bulk density(g/cm$^3$) | 1.386 |
| 4 | Rodded Bulk density (g/cm$^3$) | 1.430 |
| 5 | Impact value (%) | 22.54 |
| 6 | Fineness modulus | 7.17 |

### *D. Plastic Aggregate*

The polystyrene waste material collected from Lotus plastic Pvt.Ltd. Mettupalayam Puducherry. The physical properties of plastic aggregates are given in Table.4.

Table 4. Physical Properties of Plastic Aggregate

| Sl.No | Description | Result |
|---|---|---|
| 1 | Specific gravity | 1.08 |
| 2 | Water absorption (%) | 0.4 |
| 3 | Loose Bulk density(g/cm$^3$) | 0.583 |
| 4 | Rodded Bulk density(g/cm$^3$) | 0.616 |
| 5 | Impact value (%) | 4.4 |
| 6 | Crushing value (%) | 4.94 |
| 7 | Fineness modulus | 6.86 |

### *E. Fly Ash*

Class F is fly ash normally produced from burning anthracite or bituminous coal and is procured from Ennore, Chennai and is used for this project work. Specific gravity of Fly-ash is 2.05

### *F. Silica Fume*

However, silica fume is also very effective in reducing or eliminating bleed and this can give rise to problems of rapid surface crusting.

### *G. Super Plasticizer*

In this project SP with higher specific gravity, named Supaflo SPL for attaining the required flow characteristics is used. Specific gravity of Super Plasticizer is 1.21

### *H. Mix Proportioning*

The mix design arrived for the M40 grade of concrete using the above mentioned procedure is given in the following Table 5

Table 5. Mix Proportioning

| Sl.No | Description | Quantity(kg/m$^3$) (kg/m$^3$) |
|---|---|---|
| 1 | Cement | 450 |
| 2 | Flyash | 126 |
| 3 | Silica Fume | 45 |
| 4 | Sand | 894 |
| 5 | Coarse aggregate (20mm) | 307 |
| 6 | Coarse aggregate(12.5mm) | 307 |
| 7 | Water | 220 |
| 8 | Super plasticizer | 9 |

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## IV. EXPERIMENTAL PROGRAM

### A. *Fresh Properties*

The effect of plastic aggregate on the slump flow, V-funnel and J-ring are studied. It shows an increasing trend in slump flow as replacement of plastic aggregate increases. This could be explained by hydrophobic nature of plastic aggregate and the lower internal friction resulting from the replacement of coarse aggregates by plastic aggregate. V-funnel increases as plastic aggregate percentage increases. However the results obtained satisfies the EFNARC criteria .The results of the fresh properties are given in Table 6 for M40 grade of concrete at various percentage replacements of plastic aggregate.

Table 6. Workability Properties

| Sl.No | Mix Id | Slump flow (mm) | V-funnel (sec) | J-ring Flow(mm) | J-ring Blockage(mm) |
|---|---|---|---|---|---|
| 1 | RSCC | 640 | 8 | 610 | 6 |
| 2 | P10SCC | 650 | 8 | 635 | 7 |
| 3 | P20SCC | 657 | 9 | 617 | 7 |
| 4 | P30SCC | 662 | 10 | 617 | 8.3 |
| 5 | P40SCC | 665 | 14 | 619 | 8.5 |
| 6 | P50SCC | 667 | 16 | 618 | 9 |

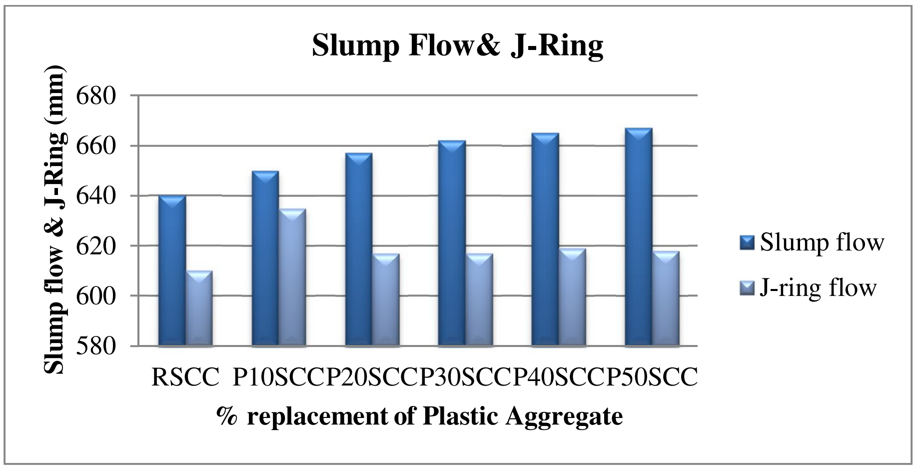


Fig1 Slump Flow& J-Ring

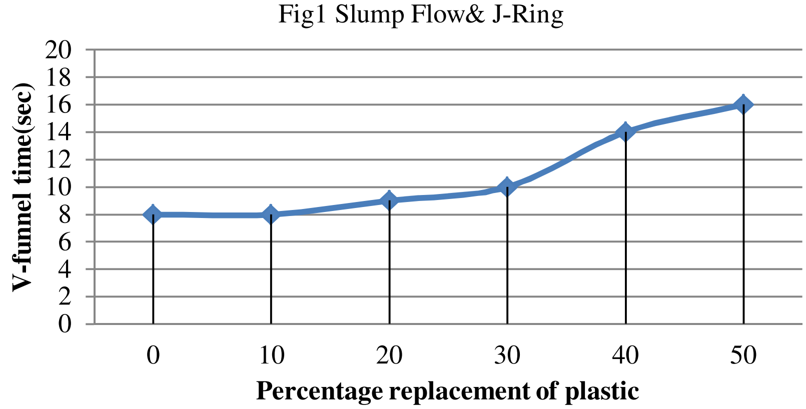


Fig 2 V-funnel time

### B. *Strength Characteristics*

#### 1) *Compressive Strength*

Compressive strength has been found out at the age of 28 days after moist curing the specimens continuously. Results shows that up to 30% replacement of coarse aggregate there is no significant change in compressive strength as compared to the normal concrete. Beyond that there is drop in compressive strength for 50% replacement of coarse aggregate by plastic aggregate.

The test results are presented in Table 7 and its variation is shown in Fig 3**.** Plastic is considered to be a hydrophobic material, so this may restrict the water necessary for cement hydration from entering through the structure of the concrete specimens during the curing period.

Table 7. Compressive strength at 28 days

| Sl.No | Mix designation | Compressive strength in N/mm$^2$ (28days) |
|---|---|---|
| 1 | RSCC | 49.8 |
| 2 | P10SCC | 50.2 |
| 3 | P20SCC | 48 |
| 4 | P30SCC | 46.3 |
| 5 | P40SCC | 42.4 |
| 6 | P50SCC | 37 |

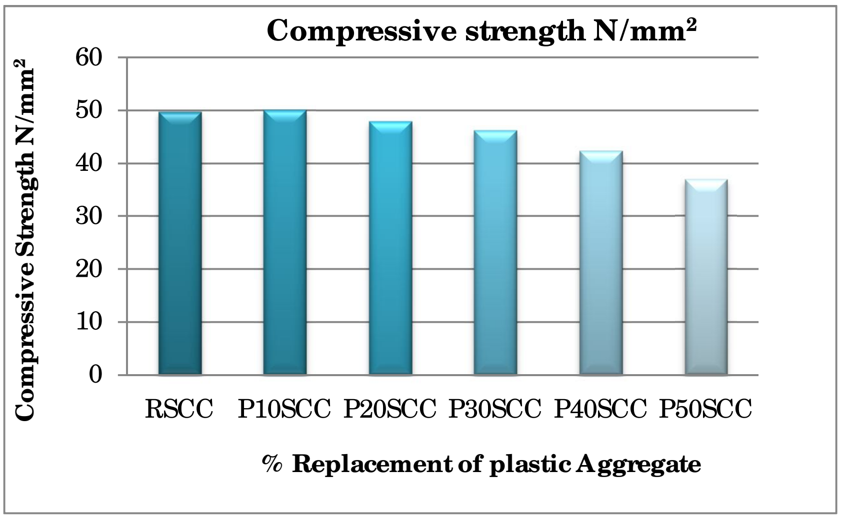


Fig 3 Compressive Strength at 28 days

### 2) *Split Tensile Strength*

The split tensile strength of the SCC was found out at the ages of 28 days. The values are represented in Table 8. In general concrete is poor in tension and good in compression. Since the thermoplastics are ductile in nature and are good in tensile strength, from the graph it is concluded that as the replacement percentage increases the tensile strength decreases.

Table 8. Split tensile strength at 28 days

| Sl.no | Mix designation | Split tensile strength N/mm$^2$ 28 days |
|---|---|---|
| 1 | RSCC | 4.10 |
| 2 | P10SCC | 4.17 |
| 3 | P20SCC | 3.82 |
| 4 | P30SCC | 3.71 |
| 5 | P40SCC | 3.55 |
| 6 | P50SCC | 3.37 |

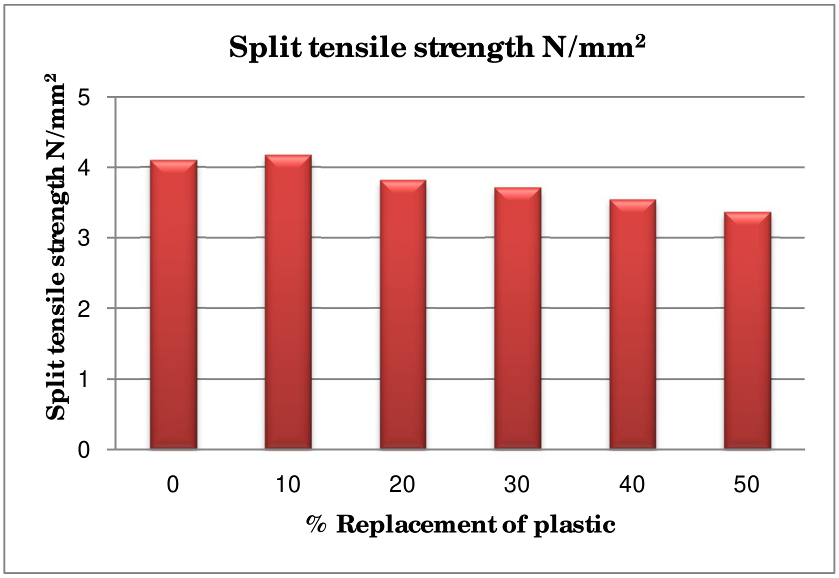


Fig 4. Split tensile strength at 28 days

*3) Flexural Strength*

The result of flexural strength with percentage replacement of coarse aggregate with plastic aggregate has given in Table 9and its variation is shown in Fig 5

Table 9 Flexural Strength at 28 days

| Sl .No | Mix Id | Flexural strength N/mm$^2$ 28 days |
|---|---|---|
| 1 | RSCC | 5.51 |
| 2 | P10SCC | 5.54 |
| 3 | P20SCC | 5.49 |
| 4 | P30SCC | 5.35 |
| 5 | P40SCC | 5.27 |
| 6 | P50SCC | 4.41 |

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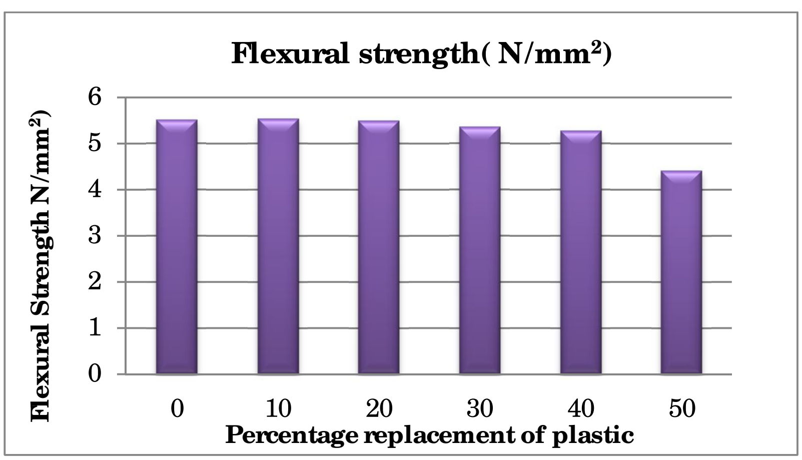


Fig 5 Flexural strength at 28 days

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*4) Impact Strength*

The impact strength of the SCC was found out at the ages of 28 days. The results are given in the Table10 and its variation is shown in Fig.6

Table 10 Impact Strength (Joule)

| Sl.No | Mix Id | Initial crack (blows) | Final crack (blows) | Impact strength ( Joule) |
|---|---|---|---|---|
| 1 | RSCC | 12 | 15 | 601.92 |
| 2 | P10SCC | 10 | 12 | 481.53 |
| 3 | P20SCC | 6 | 9 | 361.15 |
| 4 | P30SCC | 5 | 7 | 280.89 |
| 5 | P40SCC | 3 | 6 | 240.77 |
| 6 | P50SCC | 3 | 5 | 200.64 |

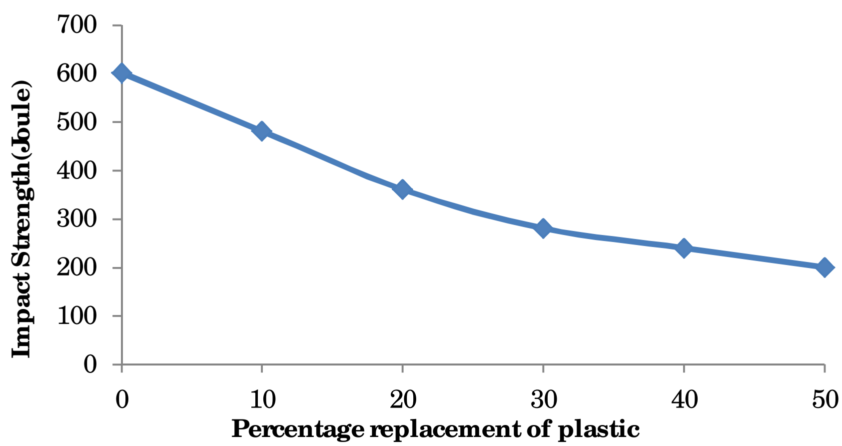


Fig 6 Impact Strength

*5) Young's Modulus*

The effect of plastic aggregate on elastic modulus of SCC shows that for 10% plastic aggregate the elastic modulus is higher when compared to the normal concrete. The results of modulus of elasticity are given in the Table11 and its variation is shown in Fig.7

Table 11 Young's modulus

| Sl.No | Mix Id | Young's modulus (GPa) |
|---|---|---|
| 1 | RSCC | 35.20 |
| 2 | P10SCC | 39.91 |
| 3 | P20SCC | 35.97 |
| 4 | P30SCC | 34.37 |
| 5 | P40SCC | 34.08 |
| 6 | P50SCC | 32.85 |

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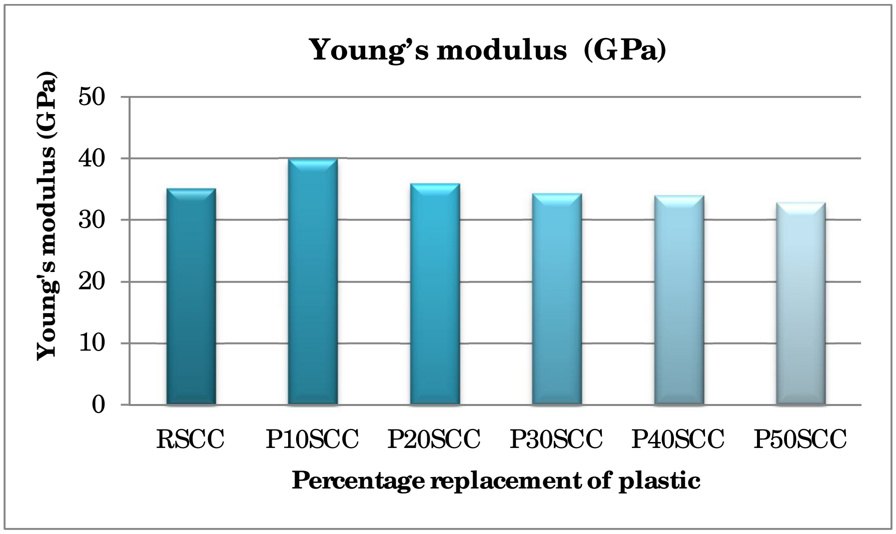


Fig 7. Young's modulus

## V. CONCLUSIONS

1) Reduction in the compressive strength was between 15%and 33% for concrete containing 20–50% plastic waste.
2) The reduction in Split tensile strength of about 17.8% at 50% plastic aggregate when compared to reference concrete.
3) The reduction of Flexural strength about 19.9% at 50% replacement of plastic aggregate when compared to reference concrete.
4) Impact strength of concrete tends to decrease at all replacement of coarse aggregate by plastic aggregate .The decrease of about 66 % at 50% replacement when compared to reference concrete.
5) For 10% replacement the elastic modulus is higher than reference concrete. The reduction of about 7% at 50% replacement of plastic aggregate when compared to reference concrete.

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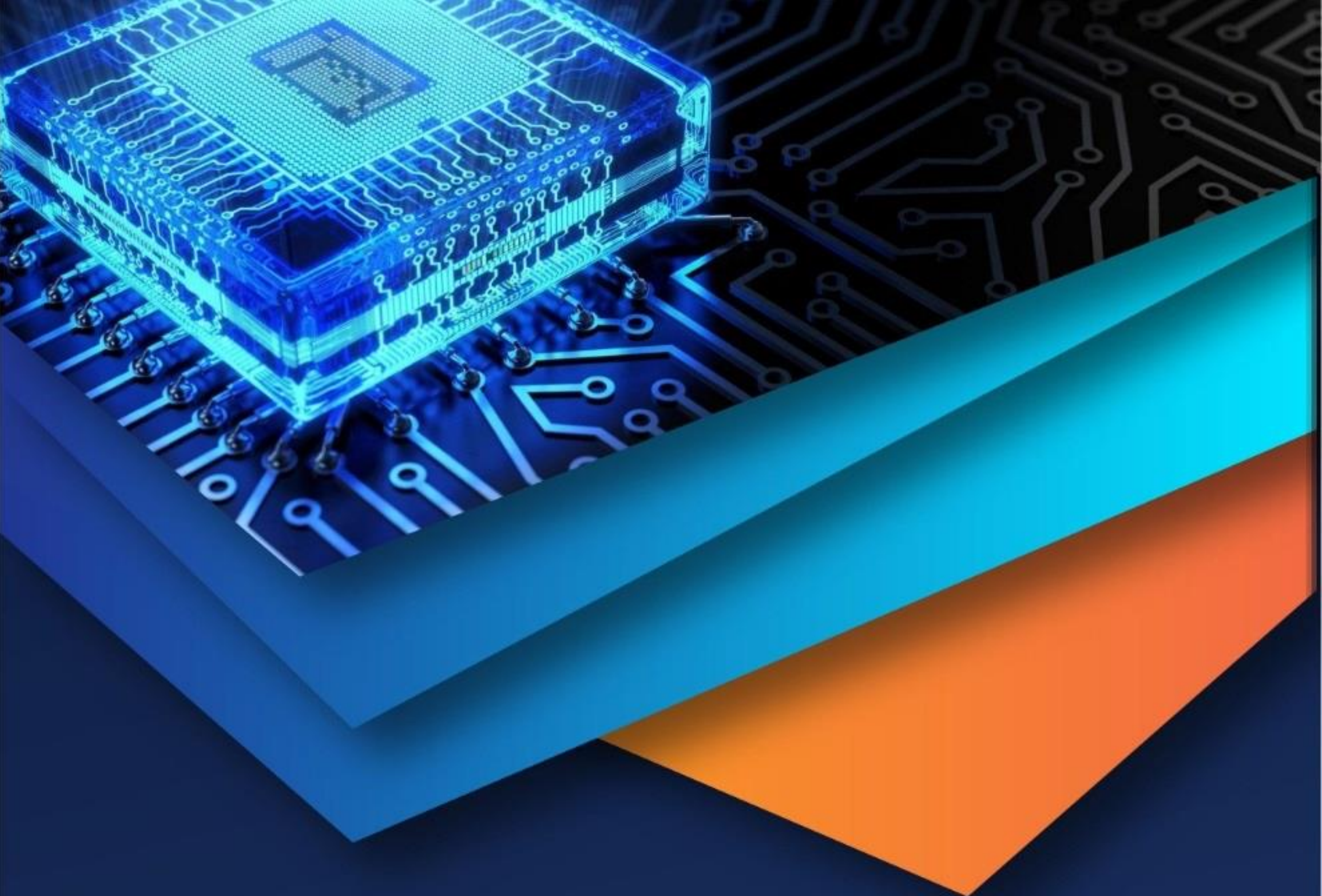


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