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Mechanical Studies of Self Compacting Concrete Using Plastic Aggregate

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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 optimum dosage. The fresh properties of SCC reveal that the workability of concrete are enhanced by using plastic aggregate. Strength properties such as compressive strength shows that up to 30% replacement of coarse aggregate there is no significant 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.
Key words: Self compacting concrete, plastic aggregate, M40 grade concrete, fresh properties, Mechanical properties,

I. INTRODUCTION

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 .The addition of some types of plastic aggregate such as rigid polyurethane foam waste or heat-treated expanded polystyrene foam (MEPS) decrease the slump value of the resulting concrete mix due to the presence of large amounts of surface pores in these aggregates . Ismail and Al-Hashmi reported that at 20% replacement of fine aggregate by plastic aggregates density decreases by 8.7% below the reference concrete. Marzouk et al. The compressive strength of concrete and cement mortar is a fundamental property that is thoroughly studied in almost all research works related to plastic aggregate. In all of these studies it was found that the incorporation of plastic as aggregate decreased the compressive strength of the resulting concrete/mortar. 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. 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. Frigione reported that the compressive strength of concrete prepared by replacing 5% in weight of natural fine aggregate by PET waste aggregate (PETW) is slightly lower (not lower than 2%) than that of concrete containing natural aggregate . Kou et al. reported that the reduction is up to 47.3% at 45 % replacement of natural fine aggregate by PVC granules with respect to the control mix.

II. 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 3.1.

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

Sl.no	Property	Value
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 3.2

Table 2. Physical properties of Fine aggregate

Description	Fine Aggregate
Specific gravity	2.7
Water absorption (%)	1.05
Bulk density(g/cm^3)	1.560
Fineness modulus	2.99
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 3.3.

Table 3. Physical properties of Coarse aggregate

Description	Coarse aggregate
Specific gravity	2.78
Water absorption (%)	0.6
Loose Bulk density(g/cm^3)	1.386
Rodded Bulk density (g/cm^3)	1.430
Impact value (%)	22.54
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.3.4. Plastic aggregates are shown in figure1

Table 4. Physical Properties of Plastic Aggregate

Description	Plastic Aggregate
Specific gravity	1.08
Water absorption (%)	0.4
Loose Bulk density(g/cm^3)	0.583

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Rodded Bulk density(g/cm^3)	0.616
Impact value (%)	4.4
Crushing value (%)	4.94
Fineness modulus	6.86

Fig 1. Plastic Aggregate

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. Water

Potable drinking water with pH value ranging between 6 to 7 available within the Pondicherry Engineering College Campus has been used for making Self Compacting concrete.

III. 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	Materials	Quantity(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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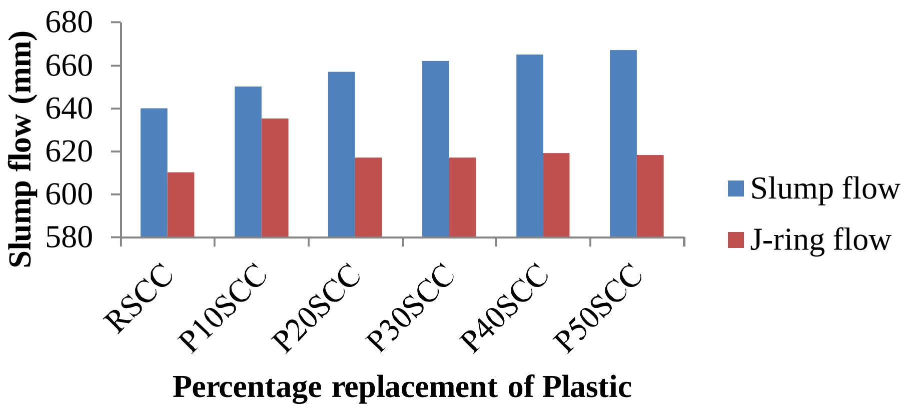
IV. EXPERIMENTAL PROGRAM

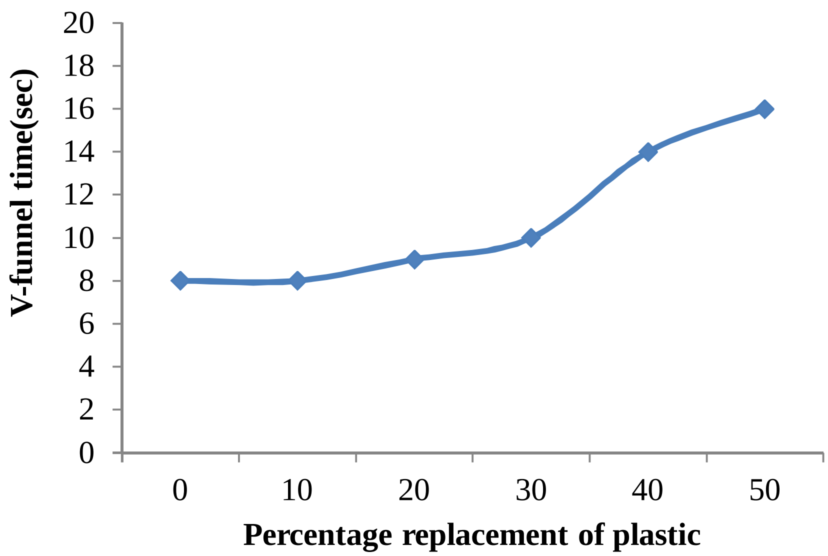
A. Fresh properties

The results of the fresh properties are given in Table 5.1 and its variation is shown in fig 5.1 to fig 5.6 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





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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.

Table 7. Compressive strength (MPa)

Mix no	Mix designation	Compressive strength (MPa) (28days)
1	RSCC	49.8
2	P10SCC	50.2
3	P20SCC	48
4	P30SCC	46.3
5	P40SCC	42.4
6	P50SCC	37

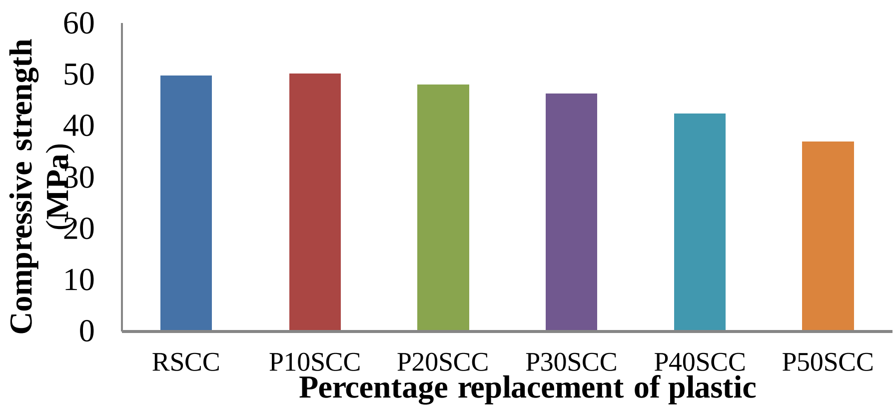

Fig 2 Compressive Strength at 28 days

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 and in Fig 3.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 (MPa)

Sl.no	Mix id	Split tensile strength (MPa) 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

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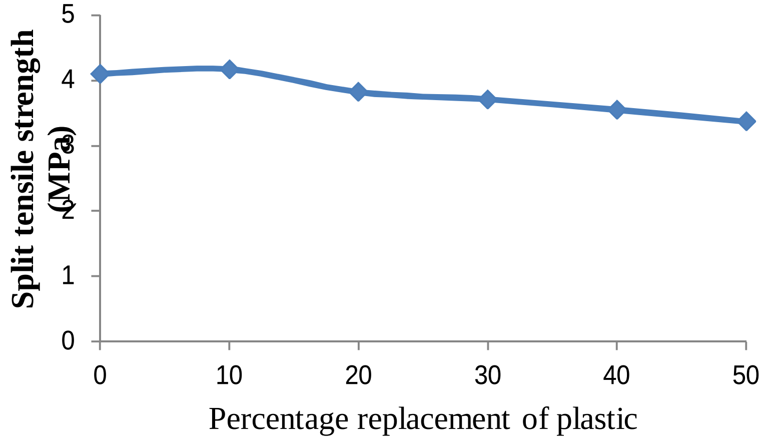

Fig 3 Split tensile Strength at 28 days

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 4

Table 9 Flexural Strength (MPa)

Sl .No	Mix Id	Flexural strength (MPa) 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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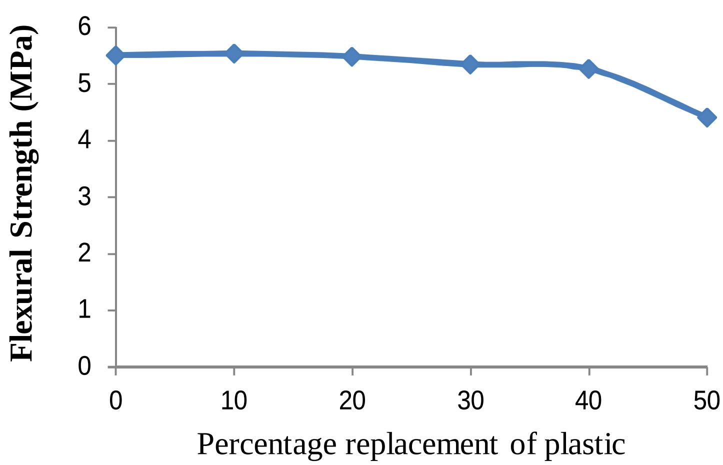

Fig 4 Flexural strength at 28 days

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.5

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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

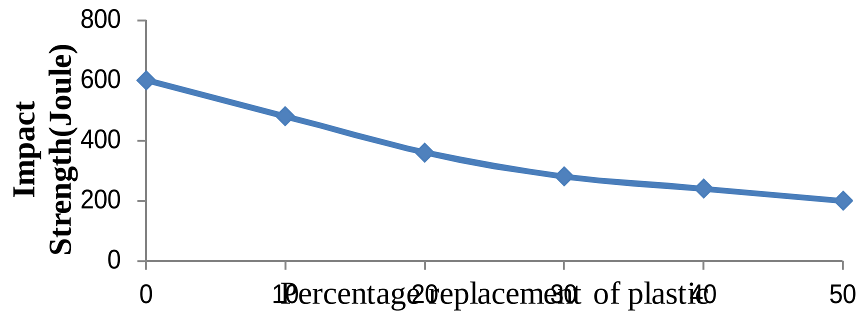

Fig5 Impact Strength

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.6

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

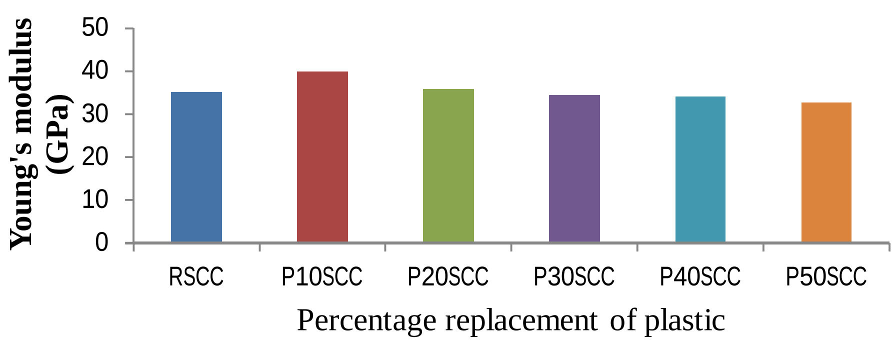

Fig6. Young's modulus

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V. CONCLUSIONS

Reduction in the compressive strength was between 15%and 33% for concrete containing 20–50% plastic waste.

The reduction in Split tensile strength of about 17.8% at 50% plastic aggregate when compared to reference concrete.

The reduction of Flexural strength about 19.9% at 50% replacement of plastic aggregate when compared to reference concrete.

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.

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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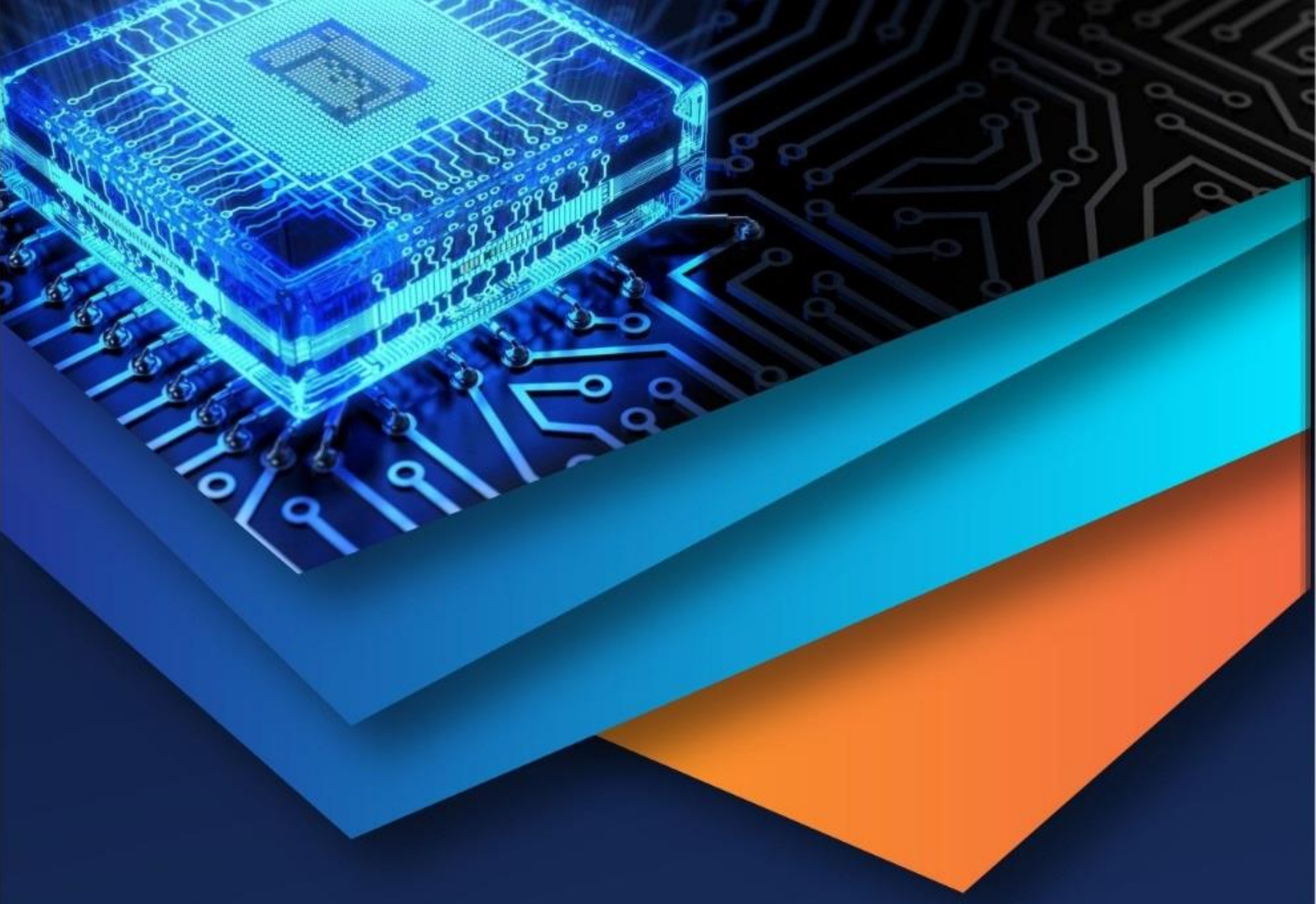

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