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Effect of Latex Modified Self-Compacting Concrete (M-25) by Partial Replacement of Cement with Glass Powder

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Abstract: Self-compacting concrete (SCC) is defined as a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. To improve the performance of SCC, polymers are mixed with SCC. It has been observed that polymer-modified self-compacting concrete (PMSCC) is more durable than conventional self-compacting concrete due to superior strength and high durability. There is a current trend in all over the world to utilize the treated and untreated industrial by- products, domestic wastes etc. as raw materials in concrete. These not only help in the reuse of the waste materials but also create a cleaner and greener environment. This study aims to focus on the possibility of using waste material in a preparation of innovative concrete. One kind of waste was identified: Glass Powder (GP). The use of this waste (GP) was proposed in different percentage as an instead of cement for production of latex modified self-compacting concrete.
Keywords: Self-Compacting Concrete, Glass Powder, SBR latex, Compressive Strength

I. INTRODUCTION

Conventional concrete generally constitutes cement, fine aggregates, coarse aggregates and water. As times change, there is a need to provide better concrete, in terms of its strength, durability, etc. Special concretes need to be designed which are task specific.

Self-compacting concrete (SCC) as the name suggest is the concrete which get compacted without vibration. The self-compacting concrete was developed in Japan in late 1980's. By the early 1990's Japan has developed and used SCC that does not required vibration to achieve full compaction. Because of its wide advantages by the year 2000, the SCC has become popular in Japan for prefabricated products and ready mixed concrete. Several European countries recognized the significance and potentials of SCC developed in Japan. During 1989, they founded European federation of natural trade associations representing producers and applicators of specialist building products (EFNARC). To call a SCC successful it must possess following properties:

Have a fluidity that allows self-compaction without external energy.

Remain homogeneous in a form during and after the placing process and

Flow easily through reinforcement

A. SBR Latex

SBR latex is a carboxylated styrene butadiene copolymer latex admixture that is designed as an integral adhesive for cement bond coats, mortars and concrete to improve bond strength and chemical resistance. SBR latex is sometimes used as part of cement based sub structural (basement) Waterproofing systems where as a liquid it is mixed with water to form the Gauging solution for mixing the powdered tanking material to a slurry. SBR aids the bond strength, reduces the potential for shrinkage and adds an element of flexibility, its offers better durability, reduced shrinkage and increased flexibility, as well as being resistant to emulsification in damp conditions.

B. Latex Modified Self Compacting Concrete

Addition of latex to conventional unmodified concrete reduces the amount of water required to achieve the appropriate viscosity for placement of the mix. This lower water requirement results in a cured concrete with higher compressive strength. The latex forms elastic membranes throughout the matrix of concrete, reducing the formation of voids and hairline cracks during the curing stage. The Latex Modified Concrete (LMC) resists penetration of oil, water, salts and aids in the adhesion of new concrete to old. The flexural strength is improved, and there is increased abrasion resistance.

Volume 5 Issue IV, April 2017
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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

In this dissertation work, latex modified self-compacting concrete compositions containing 5% SBR latex by weight of cement were prepared. Concrete cubes, cylinders and beams were cast using these latex modified self-compacting concrete to perform compressive strength, split tensile strength and flexural strength tests

C. Glass Powder

Glass is an amorphous solid that has been found in various forms for thousands of year and has been manufactured for human use since 1200 BC. Glass is one the most versatile substance on earth, used in many applications and in a wide variety of forms, from plain clear glass to tempered and tinted varieties, and so forth. After its usage it is usually dumped in landfills. Since glass is a non-biodegradable material, landfills do not provide a friendly environment.

II. EXPERIMENTAL WORK

A. Material used and their Properties

1) *Cement:* Ordinary Portland Cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirmed as per IS 4031-1988 and all the quality tests were conducted conforming to the specifications of 12269-1987.Results of the various test are Tabulated in Table 1

Table 1: Physical Properties of Ordinary Portland cement:

Characteristics	**Observed Value**
Normal Consistency	32%
Initial Setting Time	48 minutes
Final Setting Time	625 minutes
Specific Gravity	3.15
Compressive Strength at 28 days	43.3 Mpa

2) *Fine Aggregate:* The Fine Aggregate used was locally available coarse Sand. The test procedure as per IS 383: 1970 was carried out to determine the properties of Fine aggregate. The Results of the various test are tabulated in Table 2

Table 2: Physical Properties of Fine Aggregate:

Characteristics	Observed Value
Grade Zone	III
Fineness Modulus	2.3
Specific Gravity	2.60
Silt Content	1.7%

3) *Coarse Aggregate:* The Coarse Aggregate used was locally available. The test procedure as per IS 383: 1970 was carried out to determine the properties of Coarse aggregate. The Results of the various test are tabulated in Table 3

Table 3: Physical Properties of Coarse Aggregate

Characteristics	Observed Value
Fineness modulus	6.92
Specific Gravity	2.64
Water Absorption	0.40%

4) *Glass Powder:* Waste glass available locally in Lucknow shops is been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size. In this studies glass powder ground in ball/ pulveriser for a period of 30 to 60 minutes resulted in particle sizes less than size 150 µm and sieved in 75 µm. As glass powder with particle size less than 75µm possess pozzolanic properties, past investigation reveals that glass powder can be effectively use as partial replacement of cement.

Volume 5 Issue IV, April 2017
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Image of glass powder Used in Experiment

Table 4: Physical properties of glass powder

S.No	Physical properties of glass powder	Value
1	Specific gravity	2.6
2	Fineness Passing 150µm	99.5
3	Fineness Passing 90µm	98
4	Colour	White

Table 5: Chemical properties of glass powder

S.No	Chemical properties of glass powder	% by mass
1	SiO_2	67.330
2	Al_2O_3	2.620
3	Fe_2O_3	1.420
4	TiO_2	0.157
5	CaO	12.450
6	MgO	2.738
7	Na_2O	12.050
8	K_2O	0.638
9	ZrO_2	0.019
10	ZnO	0.008

5) *Super Plasticizer (SP):* Super plasticizer is essential for the creation of SCC. The job of SP is to impart a high degree of flow ability and deformability, however the high dosages generally associate with SCC can lead to a high degree of segregation. CICO PLAST SUPER-HS is utilized in this project, which is a product of CICO Company having a specific gravity of 1.14. Super plasticizer is a chemical compound used to increase the workability without adding more water. It was used to provide necessary workability. Properties of CICO PLAST SUPER-HS are tabulated in Table 6

Table 6: Properties of admixture

Characteristics	CICO PLAST SUPER-HS
Specific Gravity	1.14
Role in Concrete	Improves workability & flow properties, Produces concrete of very high strength

B. *Mix Proportioning*

The mix proportion was done based on the method proposed by EFNARC guidelines. As per the Code Book IS: 10262 -2009, the

Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

mix design was done for M25 grade mix and the amount of materials was calculated. Table 8 gives the quantities required for M25 grade of concrete Mix. The mix was checked for self-compact ability by flow test, J ring test, V funnel test and L-Box test. Flow test and V-funnel tests for checking the filling ability and L-box test, J ring test for the passing ability. The mixes were checked for the SCC acceptance criteria given in Table 7

Table 7: SCC - Acceptance Criteria

Method	Properties	Range of values
Flow value	Filling ability	650-800mm
V-funnel	Viscosity	8-12 sec
L-box	Passing ability	0.8-1.0
J ring	Passing ability	0-10

Mix Design Trial of Self-Compacting Concrete for 1 m^3 of Concrete:

Trial	Cement (kg)	W/C ratio	F.A (kg)	C.A (kg)	C.A/F.A ratio	Admixture %	Admixture (kg)	Slump value (mm)	V funnel (sec)	L box (H2/H1)	J ring (mm)
SCC 1	440	0.45	1003.71	726.82	0.7241	1.1	4.84	600	20	0.5	18
SCC 2	440	0.45	1003.11	726.39	0.7241	1.2	5.28	610	16	0.6	17
SCC 3	440	0.45	1002.53	726.00	0.7241	1.3	5.72	630	15	0.5	15
SCC 4	440	0.45	1002.00	725.55	0.7241	1.4	6.16	650	13	0.7	11
SCC 5	440	0.45	1001.37	725.13	0.7241	1.5	6.60	700	10	0.9	8

Mix design trial of latex modified self-compacting concrete for 1 m^3 of concrete

Trial	SBR Latex %	Cement (kg)	W/C ratio	F.A (kg)	C.A (kg)	Admixture %	Admixture (kg)	Slump value (mm)	V funnel (sec)	L box (H2/H1)	J ring (mm)	Remark
LMSCC 1	5	440	0.45	1001.37	725.13	1.5	6.60	Not measurable	7	0.8	16	Bleeding
LMSCC 2	5	440	0.45	1002.00	725.55	1.4	6.16	Not measurable	7	0.6	18	Segregation
LMSCC 3	5	440	0.45	1002.53	726.00	1.3	5.72	850	8	0.5	11	Flow is more
LMSCC 4	5	440	0.45	1003.11	726.39	1.2	5.28	700	10	0.9	9	Flow is good


Slump Test for SCC

Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

J- Ring Test of SCC

V-funnel test for SCC

L-box test for SCC

C. Mixes

The basic mix proportion for M25 grade of SCC is cement, fine aggregate, coarse aggregate, water and admixture. 1: 2.279: 1.650. Mix 1 contains 0% glass powder and 0% SBR latex. Mix 2 contain 0% glass powder and 5% SBR latex replacing cement by weight, then 3, 4, 5 and 6 contains 2.5%, 5%, 7.5% and 10% of glass powder by weight with 5% SBR latex replaced by cement by weight. Total 6 mixes were studied. Water/cement ratio of 0.45 for M25 were maintained for all the concrete mixes. Details of replacements are tabulated in the table below.

Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Types of mix	% replacement of glass powder	SBR latex %	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Glass powder (kg)	Water (w/c = 0.45) (kg)	Admixture (kg)
M1	0	0	440	1003.11	726.39	0	198	5.28
M2	0	5	440	1003.11	726.39	0	198	5.28
M3	2.5	5	429	1003.11	726.39	11	198	5.28
M4	5	5	418	1003.11	726.39	22	198	5.28
M5	7.5	5	407	1003.11	726.39	33	198	5.28
M6	10	5	396	1003.11	726.39	44	198	5.28

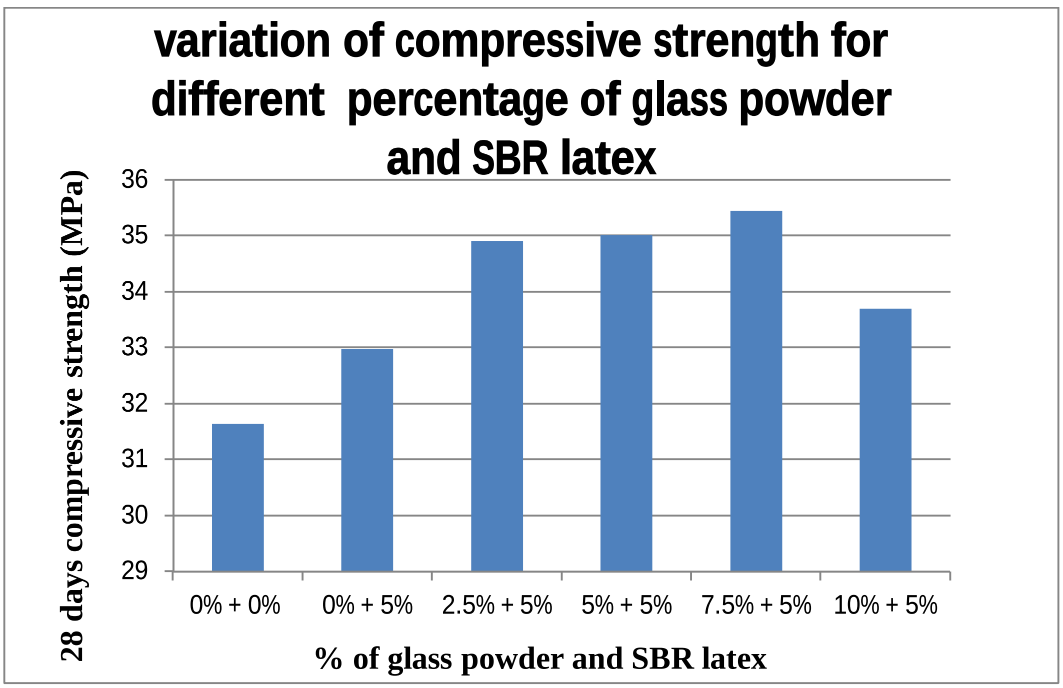
III. DISCUSSION OF RESULT

A. *Compressive Strength*

Compressive strength test was performed according to IS 516: 1959.Cubes of specimen of size 150 mm x 150 mm x 150 mm were prepared for each mix. Result table for compressive strength of cube at 28 days is given below and plotted graphically.

Compressive Strength of concrete at 28 days

	Types of mix	% of SBR latex	% of glass powder	Compressive strength in MPa
Mix Grade M25	M1	0	0	31.64
	M2	5	0	32.98
	M3	5	2.5	34.91
	M4	5	5.0	35.01
	M5	5	7.5	35.45
	M6	5	10	33.70



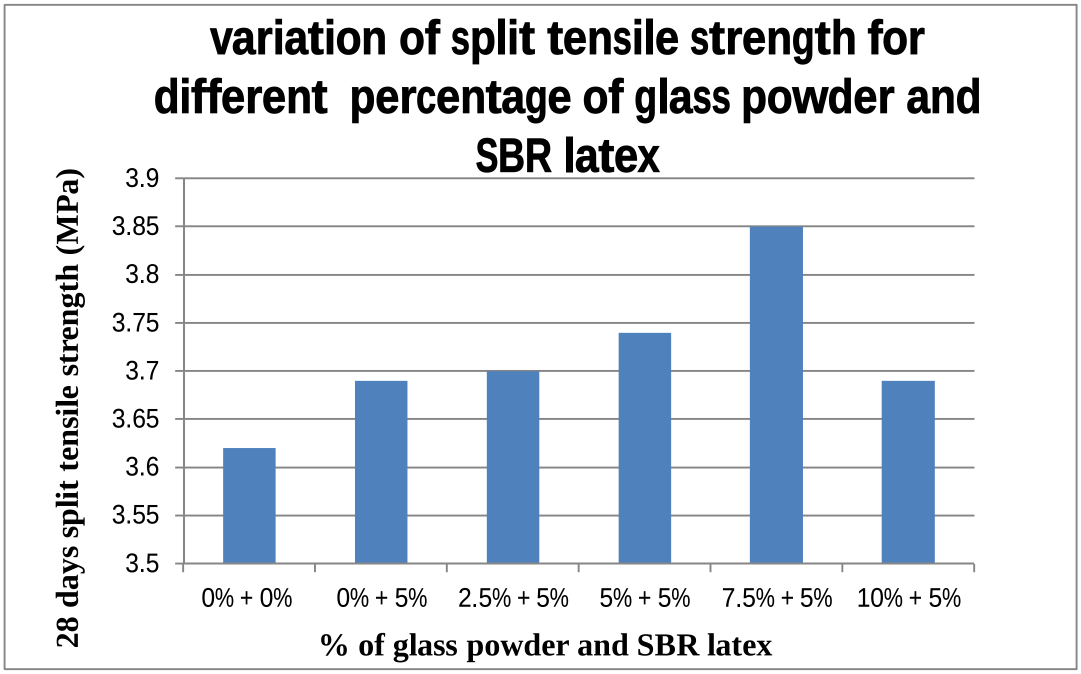
Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

B. Split Tensile Strength

The test were performed according to the procedure adopted in IS 5816: 1999. Cylinder of size 150 mm x 300 mm were prepared for each mixes. Result table for Split Tensile strength of cylinder at 28 days is given below and plotted graphically

Split Tensile Strength of concrete at 28 days

	Types of mix	% of SBR latex	% of glass powder	Split tensile strength in MPa
Mix Grade M25	M1	0	0	3.62
	M2	5	0	3.69
	M3	5	2.5	3.70
	M4	5	5.0	3.74
	M5	5	7.5	3.85
	M6	5	10	3.69

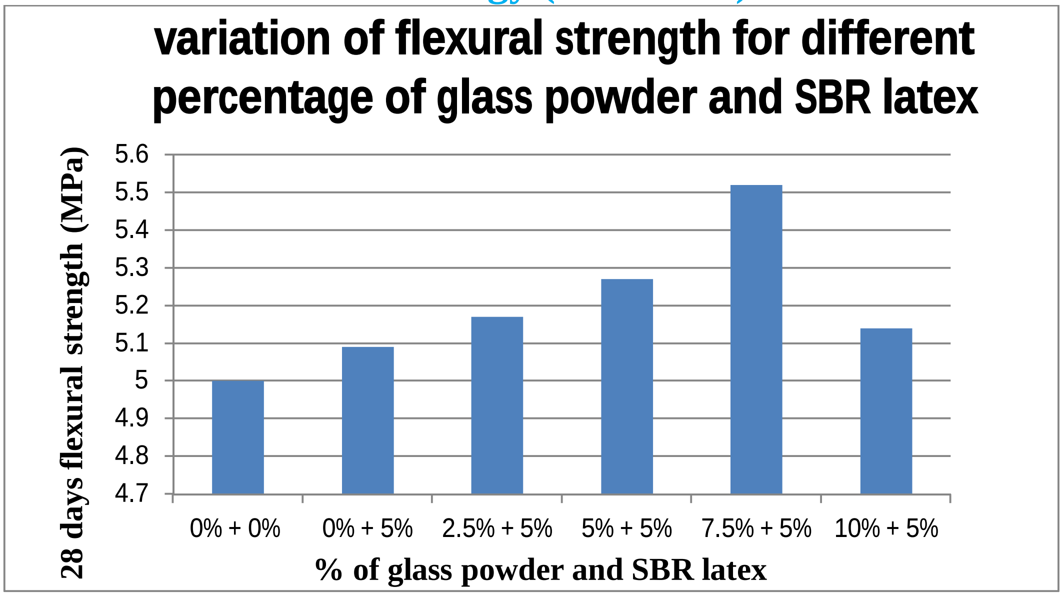


C. Flexural Strength

Flexural strength test was performed according to IS 9399:1979. Beams of specimen of size 500 mm x 100 mm x 100 mm were prepared for each mix. Result table for flexural strength of beam at 28 days is given below and plotted graphically.

Table Flexural Strength of concrete at 28 days

	Types of mix	% of SBR latex	% of glass powder	Flexural strength in MPa
Mix Grade M25	M1	0	0	5.00
	M2	5	0	5.09
	M3	5	2.5	5.17
	M4	5	5.0	5.27
	M5	5	7.5	5.52
	M6	5	10	5.14



IV. CONCLUSION

Based on the experimental study on concrete mixes, the following conclusions could be made:

A. It has been found that compressive strength, split tensile strength & flexural strength have their maximum values for 5% SBR latex dosage. The compressive strength is increased by 4.2%, split tensile strength by 2.0% & flexural strength by 1.8% when compared to their nominal strength.

B. When 5% SBR latex is added along with 7.5% Glass powder dosage, maximum strengths are obtained. The compressive strength is increased by 12%, split tensile strength by 6.35%, & flexural strength by 10.4% when compared to their nominal strength.

C. The maximum strength was achieved for 7.5% replacement of cement with glass powder in latex modified self-compacting concrete. Further addition of glass powder reduces the strength.

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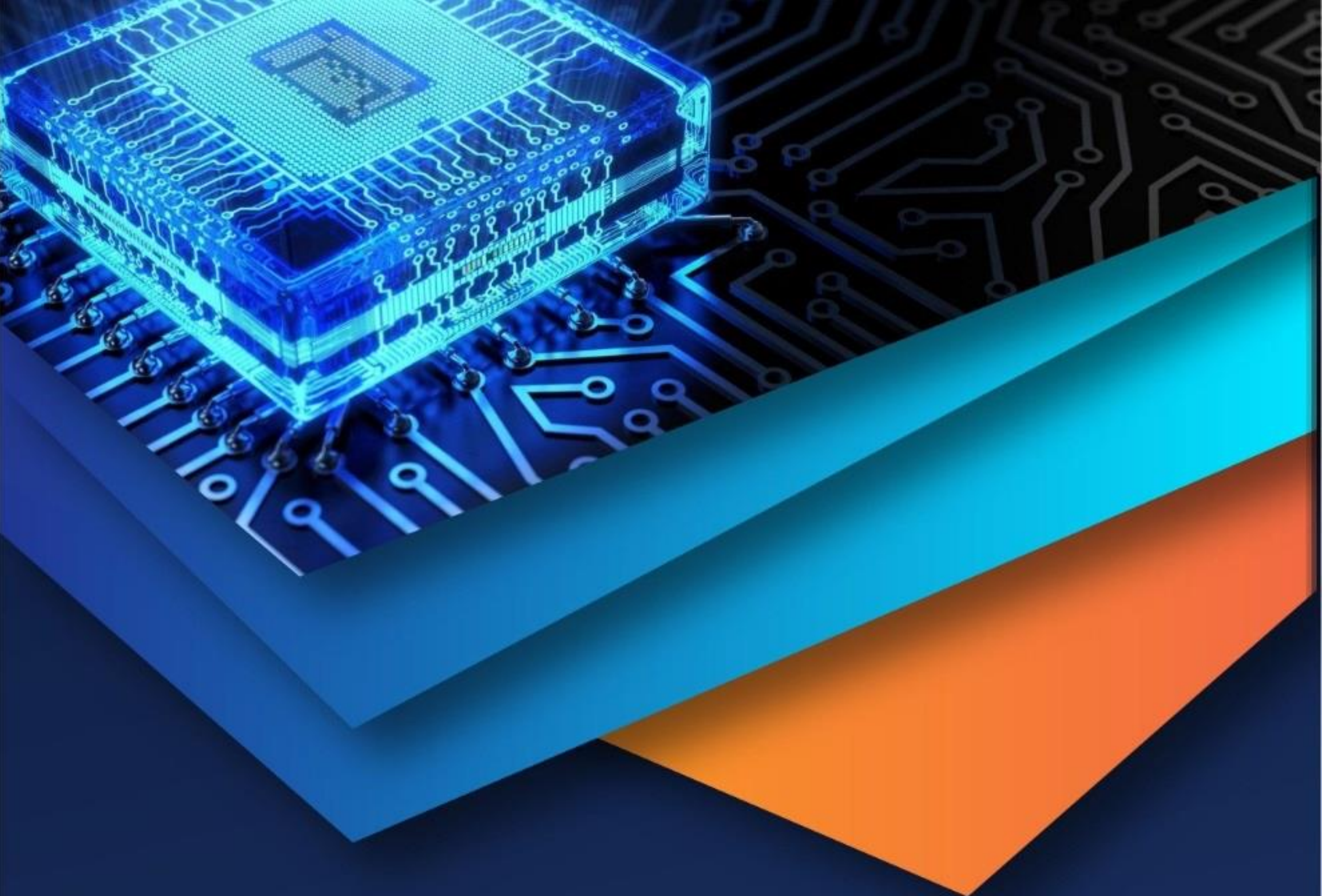

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