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Experimental Study on Mechanical Properties of Concrete Containing Plastic Waste and Waste Glass Powder

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Abstract: ***Due to rapid Increase in industrialization and urbanization, the use of buildings also increased which results in continuous usage of construction material leads to scarcity of the concrete materials. To overcome the issue many, research was done to use many industrial waste as alternative or substantial material for concreting. In this dissertation project control concrete is casted for M20 and M30 grade and the partial replacement of concrete materials were decided to re-use industrial waste such as plastic waste powder as fine aggregate replacement in range of 0%,2.5%,5%,7.5%,10%,12.5% & 15% by weight of sand and the waste glass powder as cement replacement in 0%,5%,10%,15%,20%,25% & 30% by weight of cement. The cubes, cylinders, beams were casted and tested for compression, Split tension, Flexural strength at 7 & 28 days curing of concrete. The obtained results are compared with M20 and M30 grade conventional concrete.***
Keywords: Waste glass powder, Plastic powder, Mechanical property, Durability, Concrete strength

I. INTRODUCTION

Steel, Cement, Glass, Aluminum, Plastics, Bricks, etc. are energy-intensive materials, commonly used for building construction. Generally, these materials are transported over great distances. Extensive use of these materials can drain the energy resources and adversely affect the environment. On the other hand, it is difficult to meet the ever-growing demand for buildings by adopting only energy efficient traditional materials (like mud, thatch, timber, etc.) and construction methods.

Hence, there is a need for optimum utilization of available energy resources and raw materials to produce simple, energy efficient, environment friendly and sustainable building alternatives and techniques to satisfy the increasing demand for buildings. Need for building materials will grow at an alarming rate in future, in order to meet the demand for new buildings. In order tosustain the construction activity in future, it becomes inevitable to explore the following possibilities: Use of energy-efficient alternative building technologies. Efficient utilization of natural resources/raw materials. Optimal designs and planning practices. Recycling of building wastes Utilization of industrial/mine wastes for the manufacture of building materials. Adopting energy-efficient process in manufacturing processes of building materials. Use of renewable energy sources and technologies.

A. Plastic Powder

Plastics are synthetic chemicals extracted mainly from petroleum and composed of hydrocarbons (compounds made from chains of hydrogen and carbon atoms). Most plastics are polymers, long molecules made up of many repetitions of a basic molecule called a monomer; in effect, the monomers are like identical railroad cars coupled together to form a very long train.

Fig. 1 Collection of plastic wastes

The amount of plastic waste is increasing and occupies a large part of solid waste. This type of waste is a serious problem for environment because of its non-biodegradable nature. Recycling of this type of waste to produce new materials like concrete or mortar appears as one of the best solution, due to its economic and ecological advantages. For that plastic bottles converted into powder form by using grinding machine to use of powder as partial replacement of sand in concrete.

Plastic waste is mostly collected from plastic toys, buckets, mug, mix body parts, grinder body parts which is reusable. Crushing the plastic waste to make powder form. Making smaller size using machine into size suitable for fine aggregate. Above all, the fast depleting reserves of conventional. So, it is necessary to make powder form of waste plastic by using grinding machine to reduce the plastic waste formation on earth to reduce the land pollution.


Fig. 2 Grinding Machine   Fig. 3 Plastic Powder

B. Glass Powder

Glass is one the most versatile substances on Earth, used in many applications and in a wide variety of forms, from plain clears glass to tempered and tinted varieties, and so forth. After its usage it is generally dumped in landfills. Since glass is a non-biodegradable material, landfills do not provide a friendly environment. Many attempts were made to use waste glass in concrete industry as a replacement of coarse aggregate and fine aggregate but the performance was unreliable because of strength regression. As glass powder with particle size less than 75µ possess pozzolanic properties, past investigation reveals that glass powder can be effectively use as a partial replacement of cement. Glass is a product of the supercooling of a melted liquid mixture consisting primarily of sand (silicon dioxide) and soda ash (sodium carbonate) to a rigid condition.


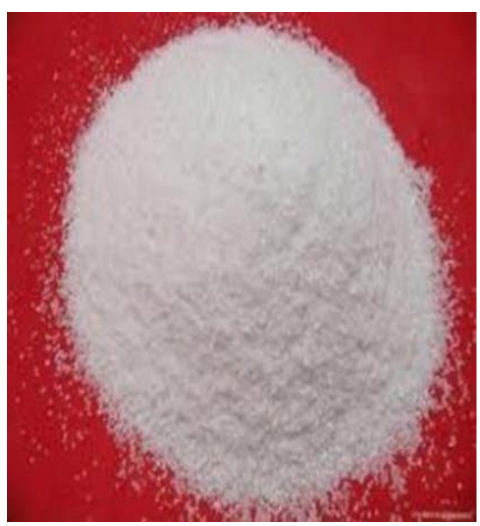

Fig. 4 Glass Waste   Fig. 5 Glass Powder.

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II. MATERIALS AND PROPERTIES

A. Cement

Cement is a binding material in concrete with adhesive and strong properties and it is to an extraordinary degree fine grounded material. The ordinary Portland cement grade 53 is used. Cement brand is Hathi cement.
Specific gravity of cement = 3.15 fineness of cement = 6%.

B. Coarse Aggregate

Aggregates are one of the imperative constituents of concrete and they constitute about 75 to 80% of total volume of concrete. They help in decrease of shrinkage and influence economy as it were. Coarse aggregate is the most grounded and scarcest penetrable part of concrete. In the present examination, provincially accessible smashed rock of size 20mm and 1.5mm in the degree of 67% and 33% exclusively by volume were used. The larger size of aggregate affects the thickness of rib.

C. Fine Aggregate

The fraction of particles which pass through 4.75 mm sieve and retained on 150 microns is termed as fine aggregate. River sand is use as a fine aggregate. According to particle size the fine aggregate is divided into four zones as per IS: 383(1970). Fine aggregate screened through 4.75 mm sieve to remove larger particles.

D. Water

Water is a crucial component of concrete as it is viably included in chemical responses with cement, particularly hydration. In the present examination consumable water is used according to IS 456: 2000 was used for preparation of cement, the water concrete proportion chooses the quality of cement. The workability of the concrete is controlled by various components, for instance, the beginning measure of water, the reactivity of cement and its level of comparability with the particular concrete.

E. Chemical Properties of Materials

Table 1 Chemical composition of waste glass powder & Plastic Powder

Compounds	Waste Glass Powder	Plastic Powder
Sio2	67%	73.68%
Al_2O_3	2.62%	11.69%
Fe_2O_3	1.42%	2.63%
CaO	18.94%	2.79%
MgO	2.66%	1.62%
Na_2O	5.23%	2.42%
K_2O	0.93%	3.36%
Loss of ignition	1.20%	1.81%

III. MECHANICAL PROPERTIES

A. Compressive Strength Test

The test used for determining the strength of concrete under applied load. The test is done on compression testing machine. It was done as per IS 516-1959. For the cube compression test, the specimens used generally are of two types either cubes of size having 150x150x150mm or 100x100x100mm are used based on the consideration of the aggregate size. Generally, for the most of the work, the moulds of size having 150x150x150mm are used for the test. Sometimes the cylindrical specimens are adopted for the compression test having 150mm diameter and 300mm height. A tamping rod of steel bar having 16mm diameter and 60cm long and bullet pointed at lower end should be use for compaction. The compressive strength can be calculated as the following formula.
Compressive Strength (MPa) = (Failure load) / (C/S area of cube specimen)

Fig. 6 Compression testing machine

B. Split Tensile Strength Test

The determination of tensile strength can be done by split tensile strength test of concrete. This test was done as per IS 5816-1970. A cylindrical mould of having standard size of 300mm length and 150mm diameter is used for the test. For the casting procedure, the cylindrical mould is filled by concrete mix in 3 layers of having equal depth approximately. A tamping rod of steel bar having 16mm diameter and 60cm long and bullet pointed at lower end should be use for compaction.

The splitting tensile strength is calculated by using the following formula:

$$\text{Split Tensile strength (MPa)} = (2 \times P) / (\pi \times D \times L)$$

Where, P = failure load, D = diameter of cylinder, L = length of cylinder.

Fig. 7 Split tensile test

C. Flexural Strength Test

Generally, the standard size of beam specimen is 150x150x750mm but another size of beam specimens 100x100x500mm are used for the testing purpose when the aggregate size is lower. The beam failure occurs in bending when the acting stress at the bottom surface of the beam exceeds the limit and it is termed as modulus of rupture.

D. Four Point Flexure Test

In this type of test, loads are applied equally at the distance of 1/3rd part from the both supports of the testing specimen. Therefore, it has the same reaction at both of the supports. Under such type of loading, beam is subjected to pure bending at the 1/3rd portion of centre of beam as shown in figure.

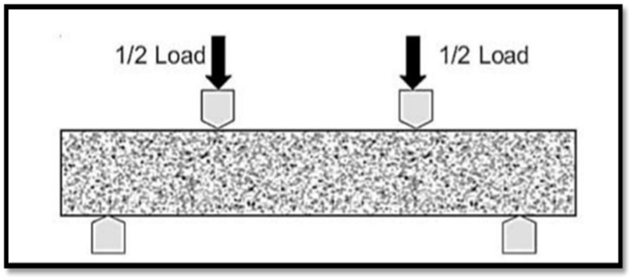

Fig. 8 Four-point test setup

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The flexural strength of beam for this can be calculated as the following formula.

$$\text{Flexural strength (MPa)} = (P \times L) / (b \times d^2)$$

Where, P = Failure load, L = Centre to Centre distance between the support, b = width of specimen, d = depth of specimen at point of failure.

Fig. 9 Flexure strength test

IV. DURABILITY

We have carried out four durability tests in this experimental work and their names are as following:(a) Hydrochloric acid attack test {HCL}, (b) Sulphuric acid attack test {H_2SO_4}, (c) Sodium sulphate attack test {Na_2SO_4},(d) Magnesium sulphate attack test {$MgSO_4$} and the results of all the tests are discussed below.

V. METHODOLOGY

In the methodology carried out the concrete mix design For M20 and M30 grade of concrete using IS 10262:2009.

Data of Mix design for M20 grade of concrete as per IS 10262:2009 is shown in table 2. Data of Mix design for M30 grade of concrete as per IS 10262:2009 is shown in table 3.

Table 2 Mix design of M20 grade

Water	Cement	F.A.	C.A.
186	388	600	1093
0.48	1	1.54	2.82

Table 3 Mix design of M30 grade

Water	Cement	F.A.	C.A.
186	443	585	1065
0.42	1	1.32	2.40

VI. EXPERIMENTAL STUDY

For compressive strength test, cube specimens of dimensions 150x150x150 mm are casted for M20 and M30 grade of concrete. For Split tensile strength test, cylinder specimens of dimensions 150 mm diameter and 300 mm height are casted for M20 and M30 grade of concrete. For flexural strength test, beam specimens of dimension 150x150x750mm are casted for M20 and M30 grade of concrete.

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Table 4 List of different mix proportions

Type	Cement	Sand	P.P.	G.P.
M1	100%	100%	0%	0%
M2	85%	97.5%	2.5%	15%
M3	85%	95%	5%	15%
M4	85%	92.5%	7.5%	15%
M5	85%	90%	10%	15%
M6	85%	87.5%	12.5%	15%
M7	85%	85%	15%	15%

A. Casting & Testing Of Various Specimens

Fig. 10 Casted cubes

Fig. 11 Testing Cubes

Fig. 12 Casting and Testing of Cylinder

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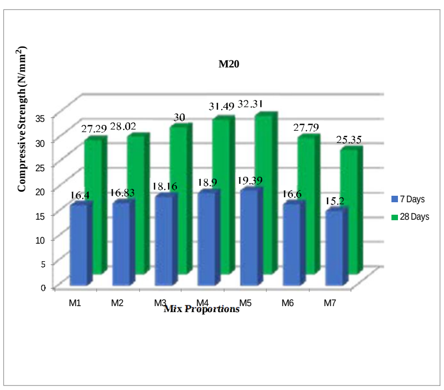
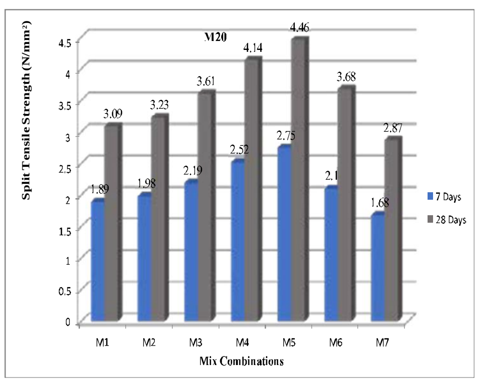
Fig. 13 Curing of specimen at specified days

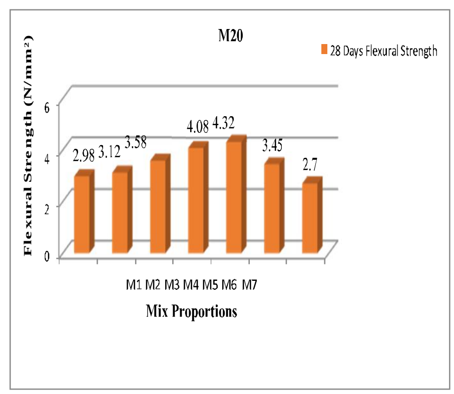
Fig. 14 Casting and testing of beam

VII. RESULTS

Results of M20 grade concrete for compression test, split tensile test and flexural test is expressed and shown below in graphs respectively







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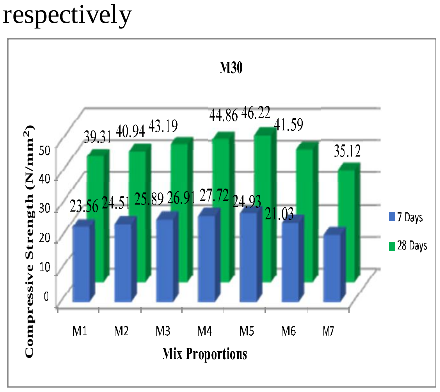

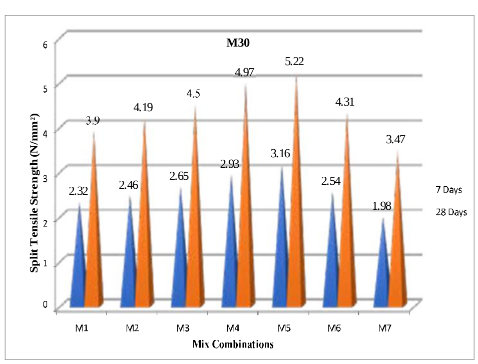

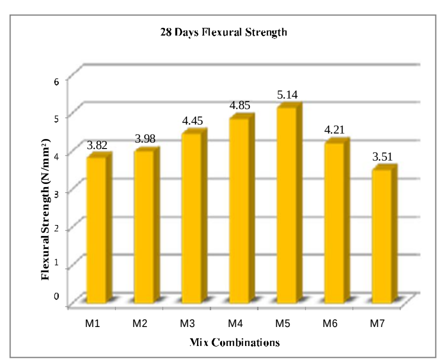

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VIII. DURABILITY TEST RESULTS

Elements of all types of concrete have been left exposed for future assessment of durability but some preliminary tests have been carried out.

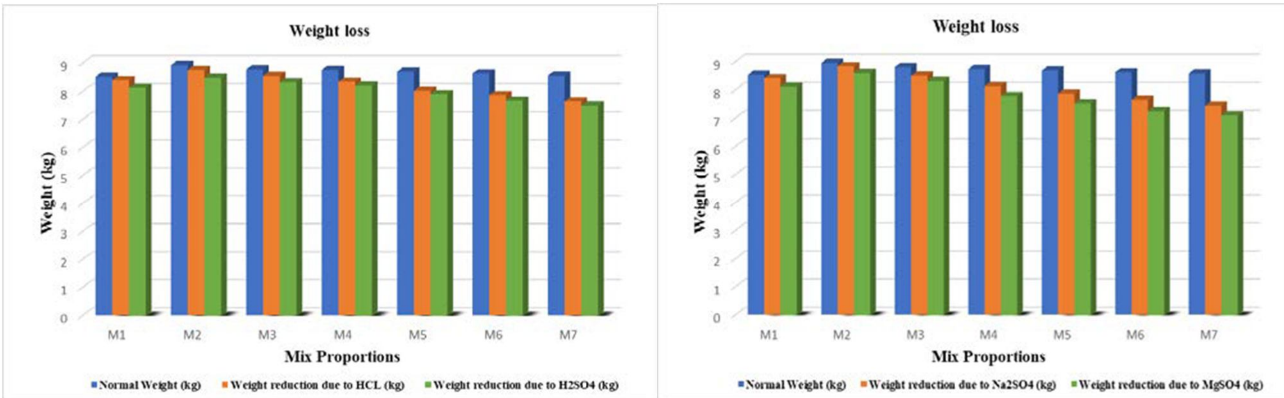
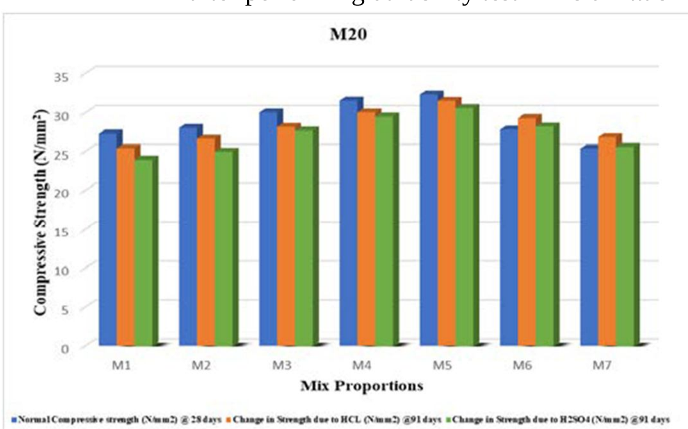
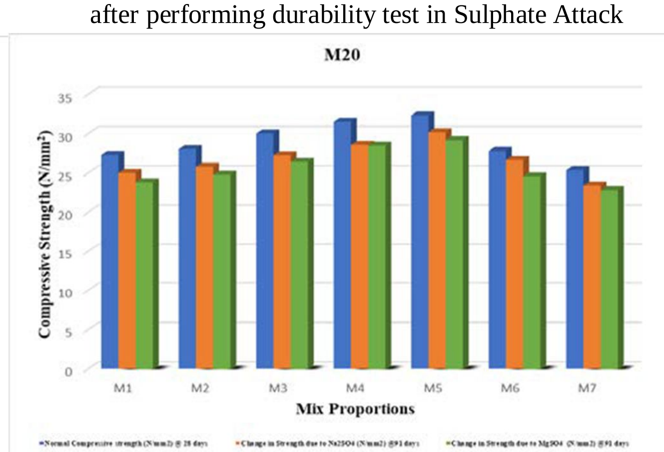


Fig. 15 Weight Reduction of Cubes

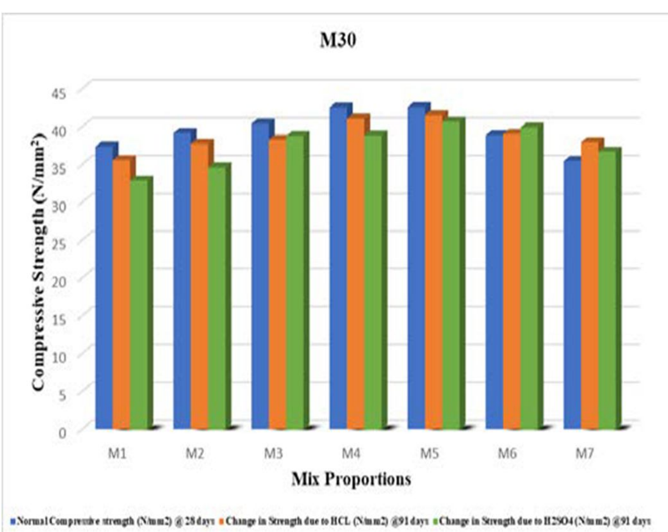
Compressive Strength of M20 grade cubes after performing durability test in Acid Attack



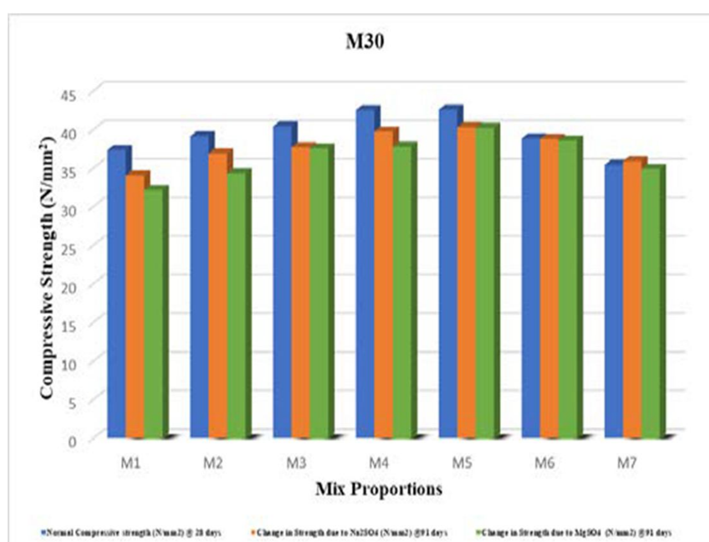
Compressive Strength of M20 grade cubes after performing durability test in Sulphate Attack



Compressive Strength of M30 grade cubes after performing durability test in Acid Attack



Compressive Strength of M30 grade cubes after performing durability test in Sulphate Attack



IX. CONCLUSIONS

A. Compressive strength of the concrete should be increased when the percentage of replacement is increased up to 15% and replacement increased compressive strength become reduced. Compressive strength increased when cement replaced with waste glass powder.

B. As waste glass powder percentage increases compressive strength and split strength increases. The compressive increased up to 15% addition of waste glass powder and further increased in waste glass powder the strength decreased gradually.

C. Un-till the result obtained, the percentage increase in Compressive strength of 19% & 17.5% is achieved for M20 & M30 grade of concrete respectively at 10% replacement with plastic powder & at 15% replacement with glass powder.

D. For Split tensile strength, the percentage increase is 15% & 13% is achieved for M20 & M30 grade of concrete respectively at 10% replacement with plastic powder & at 15% replacement with glass powder.

E. For Flexure strength, the percentage increase is 18% & 14.5% is achieved for M20 & M30 grade of concrete respectively at 10% replacement with plastic powder & at 15% replacement with glass powder.

F. In the durability test, the compression strength of concrete decreasing as compared to the normal M20 and M30 grade of concrete. From the durability results, it is observed that the strength due to H_2SO_4 and $MgSO_4$ is lesser than the strength due to HCL and Na_2SO_4.

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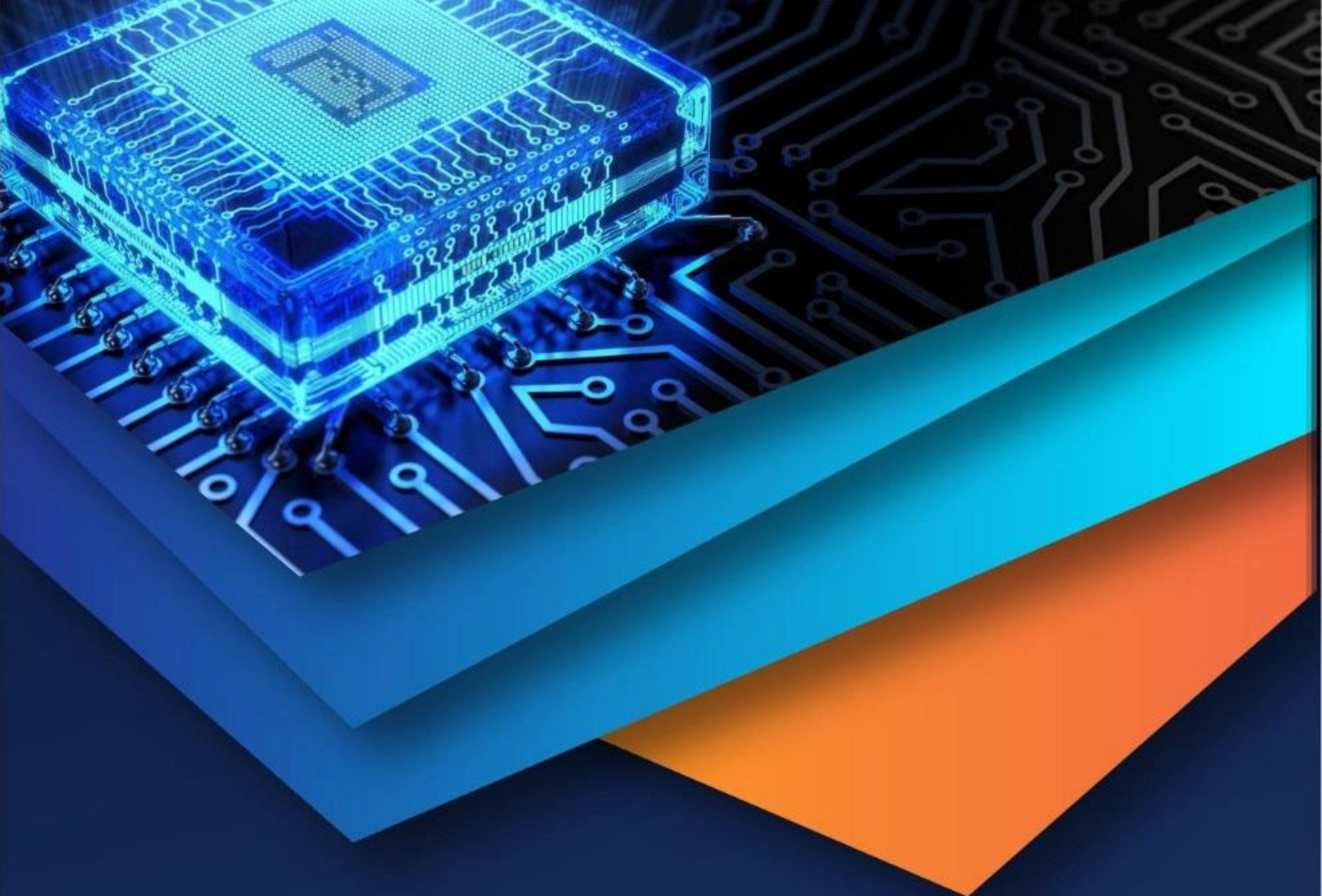

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