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Experimental Investigation on Fiber Glass Concrete with Partial Replacement of Coarse Aggregate by E- Plastic Waste

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Abstract: Electronic waste is an emerging issue causing serious pollution problems to the human and the environment. The disposal of which is becoming a challenging problem. For solving the disposal of large amount of E-waste material, reuse of E-waste in concrete industry is considered as the most feasible application. Due to increase in cost of normal coarse aggregate it has forced the civil engineers to find out suitable alternatives to it. E-waste is used as one such alternative for coarse aggregate. Owing to scarcity of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse aggregate was attempted. The work was conducted on M30 grade mix. The replacement of coarse aggregate with E-waste in the range of 0%, 10%, 20%, and 30%.The mechanical properties obtained from the addition of these materials is compared with control concrete mix. Then keeping the optimum replacement glass fiber is added to the replaced concrete in the range of 0%,0.3%,0.6%,0.9%,1.2%. Finally, the mechanical properties and durability of the concrete mix specimens obtained from the addition of these materials is compared with control concrete mix. The test results showed that a significant improvement in strength was achieved in the glass fiber concrete in which E- waste as a partial replacement to CA compared to conventional concrete and can be used effectively in concrete. The reuse of E-waste results in waste reduction and resources conservation.
Keywords: E -plastic waste, Glass fiber

I. INTRODUCTION

Utilization of waste materials and byproducts is a partial solution to environmental and ecological problems. Use of these materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. In this study partial replacement of coarse aggregate using e-plastic waste in fiber glass concrete.

A. E- Plastic waste

The management and recycling of E plastic waste is rapidly growing as it is a valuable resource of IT industries and it is very hazardous substances and with low recycling rate. The Utilization of e plastic waste materials is a partial solution to environmental and ecological problems. As the use of E plastic waste will reduces the Aggregate cost and provides a good strength for the structures and roads. It will reduces the landfill cost and it is energy saving. The e plastic waste consists of discarded plastic waste from the old computers, TVs, refrigerators, radios; these plastics are non-biodegradable components of E plastic waste as a partial replacement of the coarse or fine aggregates.

B. Glass fiber

A fiberglass is a form of fiber-reinforced plastic where glass fiber is the reinforced plastic. This is the reason perhaps why fiberglass is also known as glass reinforced plastic or glass fiber reinforced plastic. The glass fiber is usually flattened into a sheet, randomly arranged or woven into a fabric. Fiberglass is lightweight, strong and less brittle. The best part of fiberglass is its ability to get molded into various complex shapes. This pretty much explains why fiberglass is widely used in bathtubs, boats, aircraft, roofing, and other applications. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes. Glass is the oldest, and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s.

II. NEED FOR THE STUDY

The production of cement. The globalized trade of this complex and toxic electronic waste poses a challenging task for its management and causes hazardous environmental concerns in both developed and developing nations. Most of the nations have evolved stringent norms for recycling these electronic wastes to avoid adverse impact on environment and human health. However, the absence of facilities for recycling as well as stringent norms in developing nations is posing serious threats. The large-scale unethical export of electronic waste from the western countries to Asian and African nations has increased the burden on the later nations, since they are poorly equipped to deal with such waste.

The problem accompanied with fiberglass is that it creates airborne fibers after few years. These airborne fibers cause respiratory problems. So a best alternative to these issues is reuse these materials along with other materials such as concrete. Then it may result in increasing their properties and reduces the cost.

III. SCOPE AND OBJECTIVES

The scope of the present study is to investigate the properties on concrete by partial replacement of coarse aggregate by e-plastic waste on fiber glass concrete.

The objectives of the study are the following, To estimate the optimum percentage of met kaolin, nylon and sisal fiber

A. To evaluate the utility of e-plastic waste as a partial replacement of coarse aggregate and addition of fiber glass in concrete.
B. To compare and study the performance of conventional concrete and partially replaced fiber glass concrete.
C. To understand the effectiveness of fiber glass and e-plastic waste in strength enhancement.

IV. METHODOLOGY

In this study M30 grade concrete is used. In this materials are cement, fine and coarse aggregate, e-plastic waste, glass fiber. The project conducted on two tier. In first tier CA is partially replaced with EP-waste in varying percentage. The varying percentages are 0%, 10%, 20% and 30%.The concrete blocks are casted and compressive strength and flexural strength test is conducted. Based on these optimum percentage is found out.

In second tier based on the optimum percentage of EP-waste and glass fiber is added separately in varying percentage to different concrete mix and concrete blocks are casted. The percentages used are 0%,0.3%,0.6%, 0.9% and 1.2%.Based on the tests optimum percentage is found out. Durability properties are found out by carbonation, bulk diffusion and sulphate resistence tests. Ultimate load of control beam and optimum specimen is found out by load deflection test.

A. Compression Test

The compressive strength of any material is defined as the resistance to failure under the action of compressive forces. The compressive strength of any material is defined as the resistance to failure under the action of compressive forces. Especially for concrete, compressive strength is an important parameter to determine the performance of the material during service conditions. Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.

B. Flexural Strength Test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It will measure by breaking load under two point loading on concrete beams.

C. Split Tensile Strength Test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

D. Durability

Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. The tests conducting on the specimen are bulk diffusion,carbonation and sulphate resistence.

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1) *Bulk Diffusion Test:* In bulk diffusion test, cylinder of 100 mm diameter and 200mm length will be used as test specimen. After 7 days of water curing, the concrete specimens will be exposed to 1.8 Molar NaCl solution for 56 days. After 56 days and of exposure the specimens will be split by applying splitting tensile force. To the split face, 0.1 Molar Silver Nitrate (AgNO3) solution will be sprayed to observe the colour changes.
2) *Sulphate Resistence Test:* In sulphate resistence test cube specimens of dimension (10 x 10 x 10) cm are to be casted. The concrete specimens are to be water cured for 3 days and then it will be introduced into magnesium sulphate solution and cured for another 56 days. The weight loss and changes in strength are to be noted and compared with that of specimens that are water cured. This will be conducted at the end of 56 days.
3) *Carbonation Test:* Concrete Carbonation is tested with the straightforward use of a chemical indicator; the most commonly used indicator is a solution of phenolphthalein in alcohol and/or water. The cylinder specimen of (12x20) cm will be casted and split into halves in longitudinal direction using UTM. The broken face is sprayed with a solution of phenolphthalein diluted in alcohol. The uncoloured area will indicate the carbonated region.

E. Load Deflection Test

The beam specimen is casting and placing on the loading frame apparatus to measure the deflection characteristics of the beam. The flexural behavior of under reinforced RCC beams were studied under two-point loading at 28th day. The experimental set up consists of a loading frame with a maximum load capacity of 100T equipped with a data acquisition system. The specimen can be mounted into the equipment for any specified support and loading conditions. A calibrated load cell with a maximum load capacity of 200 KN controls the loading in a loading frame. The data acquisition unit records the load and corresponding displacement at mid span. The downward displacement is measured using a linear variable displacement transducer (LVDT) placed at mid span at bottom of the beam specimens. The dimensions of the beam were 200mm wide, 300mm deep and 1500mm length. High yield strength deformed bars of 16mm diameter and 12mm diameter were used as tension reinforcement and hanger bars respectively. Two-legged stirrups of 8mm diameter were provided at 140 mm center to center distance as shear reinforcement.

V. RESULTS AND DISCUSSION

The results obtained are,

A. Partial Replacement of CA by EP-waste

Partial replacement of CA by EP-waste in varying percentages like 0%, 10%, 20% and 30%.Compressive strength, flexural strength and split tensile strength is shown in Fig. 1, Fig. 2 and Fig. 3.

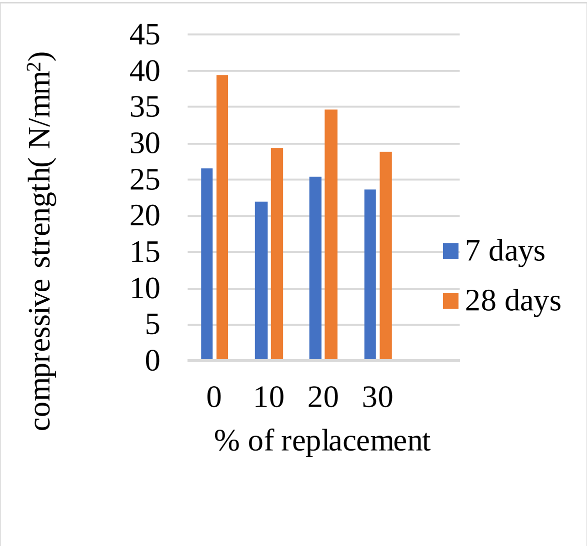

Fig. 1 Compressive strength with percentage of addition

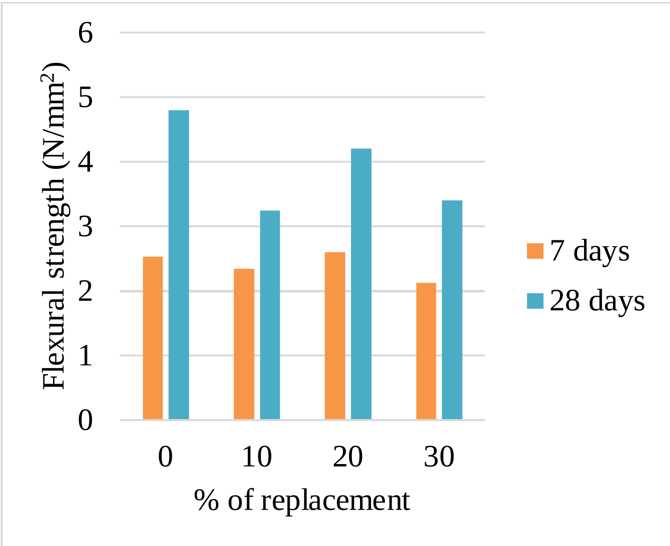

Fig. 5 Flexural strength with percentage of addition

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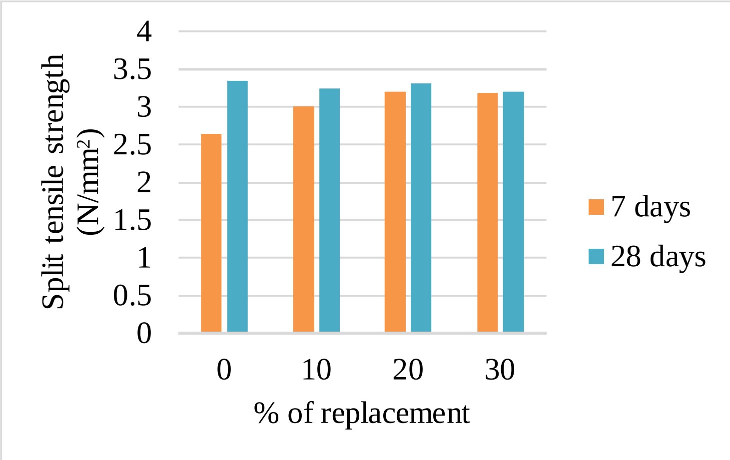

Fig. 3 Split tensile strength with percentage of addition

B. Glass Fiber Addition

Nylon and sisal fiber is added to the partially replaced concrete in varying percentages of 0%,0.3%,0.6%,0.9% and 1.2%. Compressive strength, flexural strength and split tensile strength results are shown in Fig. 4, Fig.5, Fig.6.

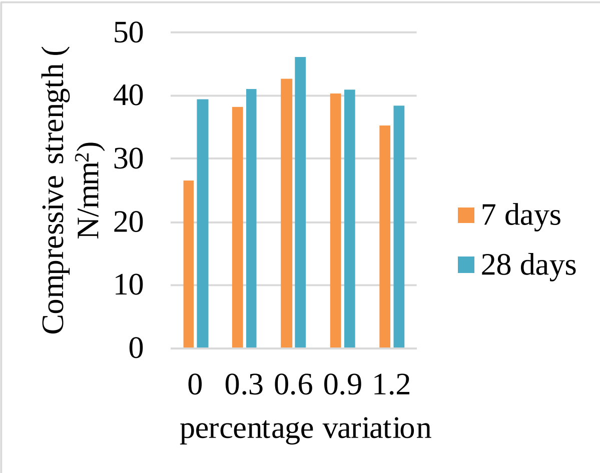

Fig. 4 Compressive strength with percentage of glass fiber addition

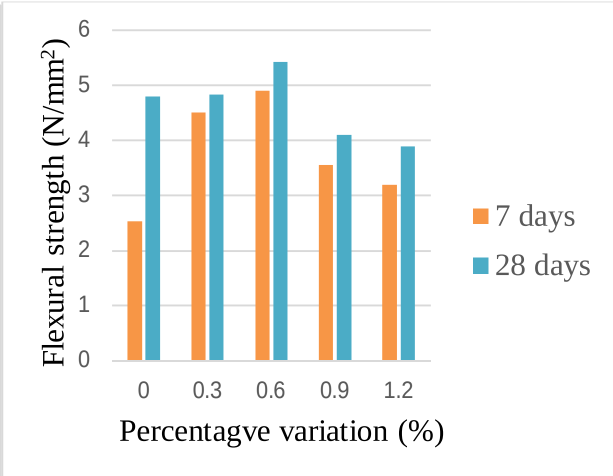

Fig. 5 Flexural strength with percentage of glass fiber addition

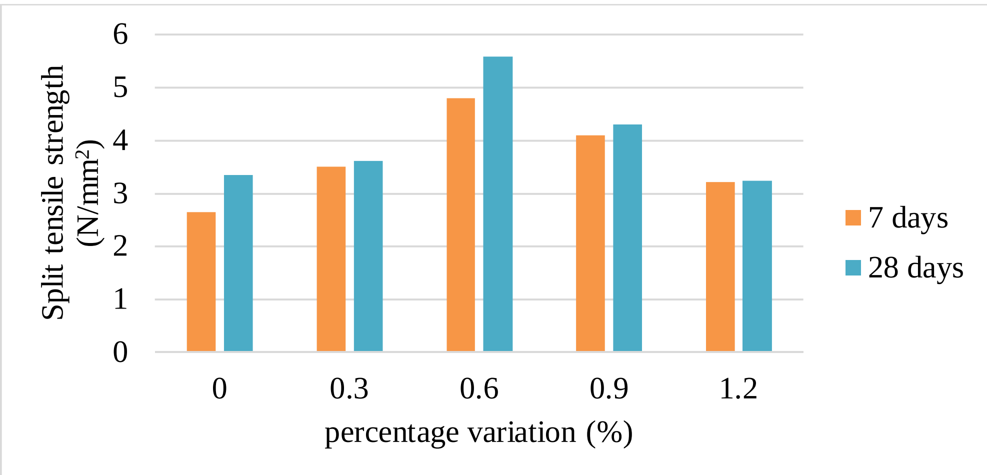

Fig. 6 Split tensile strength with percentage of glass fiber addition

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C. Durbility

Carbonation results is Shown in Fig. 7.

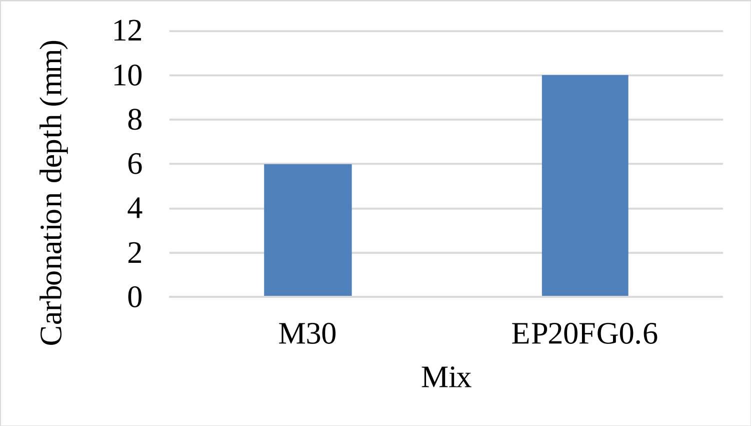

Fig. 7 Carbonation depth

After sulphate resistence tests, Fig.8 and Fig. 9 shows variation in strength and mass.

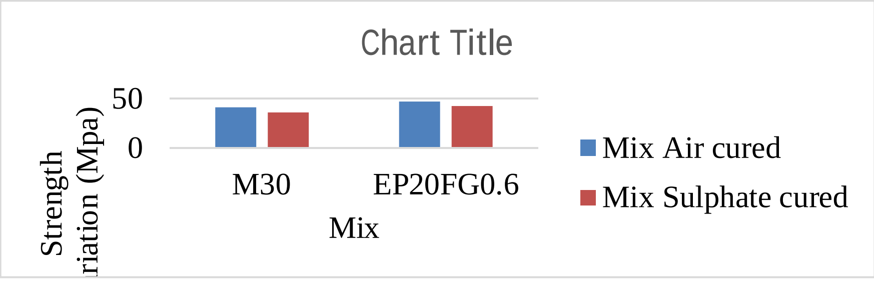

Fig.8 Variation in compressive strength

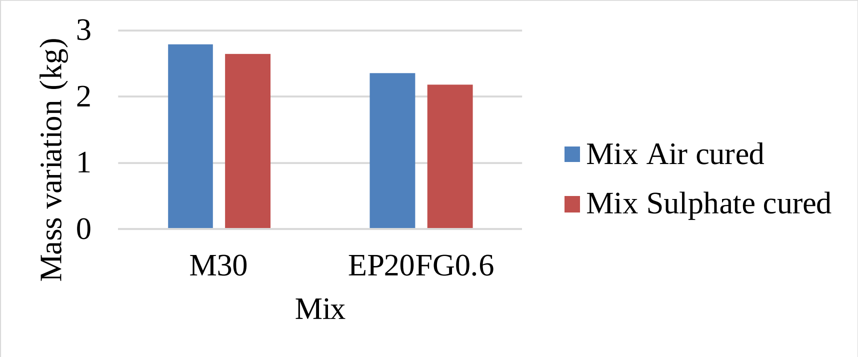

Fig 9 Changes in mass of different specimens

Bulk diffusion results is shown in table 1

Table 1 Depth of penetration of chloride ions

Mix	Depth of penetration (mm)	Diffusion coefficient ($10^{-12}m^2/s$)
M35	16	3.33
MK15NF1	5	0.32

Based on the result it was analyzed that the control mix is in the range of average permeability based on concrete society recommendations, that is in the range of (1 to 5) x 10^{-12} m^2/s. The partially replaced fiber concrete mix is in the range of low permeability that is less than $1x10^{-12}$.

D. Load Deflection Tests

The ultimate load and deflection of control beam and fiber reinforced concrete beams were shown in table 2 and results obtained from load deflection test were shown in Fig.10.

Table 2 Ultimate load and deflection of control and optimum specimen

MIX	Specimen Ultimate load (KN)	Maximum deflection (mm)
M30	210.4	12.4
EP20FG0.6	240.54	12.2

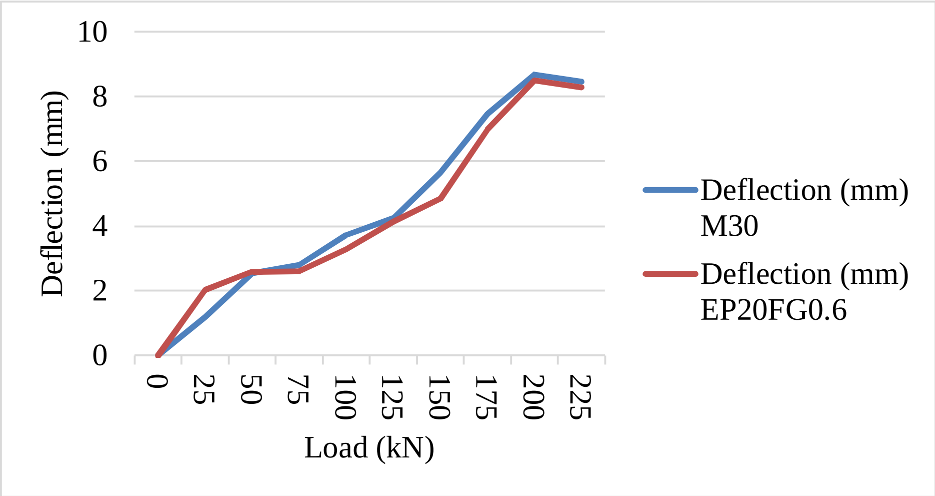

Fig 10. Load deflection curve

E. Crack Pattern

For crack pattern study the specimen of M30 mix were compared with EP20FG0.6 mix specimens. The crack developed on specimens after two point loading is described in this section. In all specimens the first crack developed is due to the flexural failure and the complete failure of specimen is due to shear. Fig 11 shows the cracks developed in the specimen. The cracks developed in the middle of the beam are due to flexure. These are the first cracks developed. By the increase of load the shear crack at the support get widens. The failure of control beam occurred at lower loads and greater cracks were developed.

The cracks developed in EP20FG0.6 specimen were also by flexure and shear failure. There were only small flexural cracks as compared with control specimen. The width of the flexural cracks was less than control specimen. At the ultimate load shear failure and shear cracks are developed. The ultimate load carrying capacity of EP20FG0.6 was higher than control specimen.

Fig. 11 crack in the specimen

VI. CONCLUSIONS

Experimental investigations were carried out to study the properties of concrete in which CA is partially replaced with EP-waste. Properties include compressive strength, flexural strength, split tensile strength and durability properties such as carbonation, bulk diffusion and sulphate resistance. Glass fibers were further added to the optimum mix in varying percentage and properties are again checked to find the optimum percentage of fiber addition. The optimum mix was then subjected to load deflection test. Based on the observations the following conclusions can be arrived.

A. The compressive, splitting tensile and flexural strength were reduced with increase in E-plastic as compared to ordinary concrete.
B. The addition of E-waste shows increases in compressive strength up to 20% replacement and along with fiber glass addition (0.3%) it shows good strength.
C. From the durability study the sulphate attack and chloride attack, which does not affect the strength of concrete and the optimum mix is more durable than the control mix. It can be used in marine conditions but carbonation is high.
D. The use of E-waste in concrete is possible to improve its mechanical properties as well as it results in light weight concrete and can be one of the economical ways for their disposal in environment friendly manner.
E. The ultimate load obtained for the concrete containing 20% EP- waste and 0.6% fiber (EP20FG0.6) shows 14.33 % higher strength than ordinary concrete mix (M30). Fig. 4.14 shows the load deflection curve.

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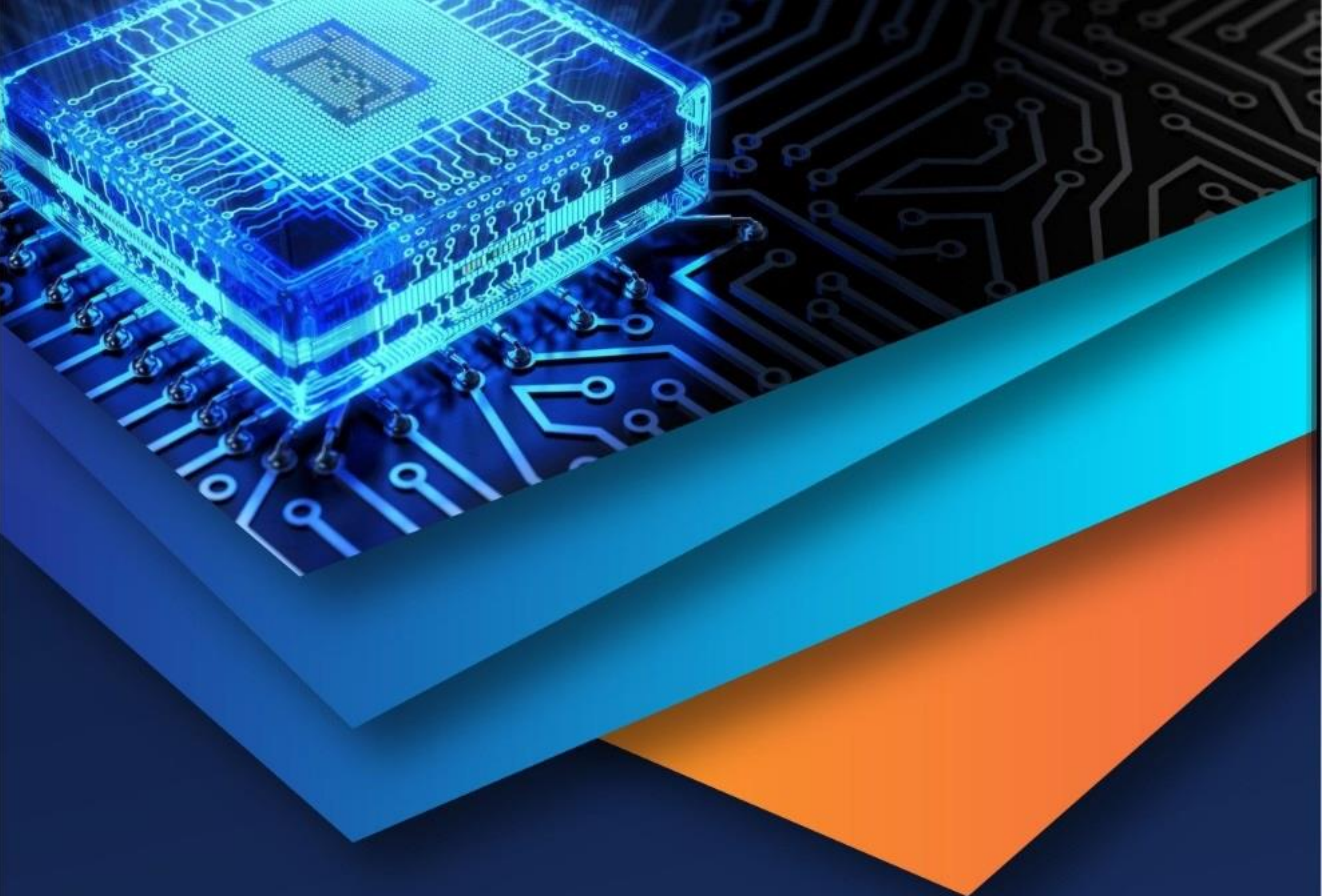

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