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Experimental Study Light Weight Concrete Using LECA, Silica Fumes, and Limestone as Aggregates

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Abstract: This dissertation determines the mix proportions of high-strength lightweight concrete, which uses expanded aggregate clay to decrease the weight of the concrete (LECA). Mineral and chemical admixtures have been used to reduce porosity and enhance strength in order to create light weight concrete. With that some percentage of silica fumes is added to enhance the properties of concrete and to make workability stable. On the specimens, specific gravity, compressive, indirect tensile, and flexural strengths were determined. By exposing certain specimens to air, the impact of curing on compressive strength was studied The findings indicate that by including Leca, a lightweight concrete with a dry density of 1,600–1,960 kg/m3 and a compressive strength of 35–66 MPa may be produced, based on cube specimens with a 150mm side length. When used with lightweight particles, limestone significantly improved the mechanical characteristics of concrete.

Keywords: Light weight concrete, light weight aggregates, LECA, High strength concrete, Silica fumes, Limestone.

I. INTRODUCTION

Concrete, typically Portland concrete cement, is a composite material composed of fine and coarse aggregate fortified with a liquid concrete (concrete glue) that solidifies after some time — most commonly a lime-based concrete folio, for example, Portland concrete, but occasionally with other pressure-driven concretes, for example, calcium aluminates concrete. It is distinguished from other, non-cementitious types of substantial all limiting some form of total together, for example, black-top cement with a bitumen folio, which is often used for street surfaces, and polymer cements, which use polymers as a fastener.

Concrete is a well-known building material. Since the material has been regarded a replacement material, specialists have worked to improve its quality and appearance. The relevance of flexibility and the use of cement in the construction industry cannot be overstated. For over two decades, experts have sought to coordinate focus on ordinary, standard, and high strength concrete.

When total is mixed with dry Portland concrete and water, the result is liquid slurry that can be easily emptied and moulded into shape. The concrete reacts synthetically with the water and other fixes to form a hard network that binds the ingredients together into a strong stone-like substance with several applications.

Added ingredients (such as pozzolons) are frequently recognised for the blend to work on the real characteristics of the wet blend or the finished material. The majority of concrete is layed with supporting components (like reinforced bar) implanted to give flexibility, resulting in built-up concrete.

The Hoover Dam, the Panama Canal, and the Roman Pantheon are all notable designs. The ancient Romans were the first large-scale users of significant technology, and cement was widely used across the Roman Empire. The Colosseum in Rome was built entirely of cement, and the Pantheon's substantial vault is the world's largest unreinforced significant arch. Today, massive architectural designs (such as dams and multi-story car leaves) are often composed of RCC.

Following with fall of the Romanian Government, the usage of cement remained uncommon until it was revived in the seventeenth century. Concrete has surpassed steel in terms of weight of material used all over the world.

II. LITERATURE REVIEW

1) In 5th may 2022 M.Ramya and S.Keerthipriyan studied on experimental study on light weight concrete using leca (light weight expanded clay aggregate) and concluded that From the results arrived from the experimental study conducted on Self compacting concrete specimens with varying percentage replacement of fine aggregate by LECA, At 7 and 28 days, the impact strength of LWSCC 0 was 24.667 N/mm2 and 30.074 N/mm2, respectively, and it steadily rose to 26.074 N/mm2 and 33.778 N/mm2 for LWSCC 5. This was attributed to the spherical form of LECA aggregates, which contributed to improved self-compaction and hence increased strength. Depending on the outcomes of this experiment, 5% is deemed optimal for substituting fine aggregate in self-compacting concrete with Light Expanded Clay Aggregate (LECA).

2) Manish Yadav and Shakti Kumar studied on "preparation of lightweight concrete by using of leca aggregates" and concluded that. The objective of the research was 2 eliminate the weight of structure using lightweight concrete expanded clay aggregate (LECA). LECA is a line and clay mixed material that observes more water in compare to conventional aggregate. And the properties also changes with different water cement ratio. So the study is carried out for water cement ratio 0.35, 0.4 and 0.42 as the water cement ratio increases. The workability of mixture increases, with good density and as density increases.
3) Khaled Heiza, FatmaEid and Taha Masoud have studied on lightweight self-compacting concrete with light expanded clay aggregate (leca) and concluded that

Based on the experimental study's findings and observations, the following conclusions may be drawn:

a) Using expanded clay aggregate, it is feasible to produce structural light weight concrete with low density and high self-compacting properties (LECA).
b) The thickness of the reinforcing mesh layers utilised in the slab affects the flexural loads at the first fracture and the ultimate loads.
c) Increasing the reinforcing ratio from 0.6% for slab No. (A1) to 0.81% for slab No. (A2) raised the flexural loads by 13%.
d) Increasing the reinforcing ratio from.81% for slab No. (A2) to 1% for slab No. (A3) increased the flexural loads by 46.15%.

4) In Indian Journal of Science and Technology, April (2018), R. Vijayalakshmi and S. Ramanagopal have studied on a review on structural concrete using expanded clay aggregate and concluded that Previous literature was evaluated to determine the viability of expanded clay LWA in the production of structural concrete. The expanded clay manufacturing method as well as many production parameters that have a substantial impact on aggregate qualities has been fully addressed. Also examined were the physical and mechanical properties of expanded clay LWAC. The following findings can be drawn from the review:
5) Particles are spherical in form, with specific gravity ranging between 0.66 and 1.35. The gross bulk density ranged from 334 to 800 kg/m3. Although the literature reports absorption capacities ranging from 0.7 to 33.9%, commercially accessible aggregates have water absorption capacities ranging from 10 to 25%.
6) It is feasible to create concrete with compressive strengths ranging from 23 to 60 MPa and densities ranging from 1290 to 2044 kg/m3. Tensile strength and e-modulus also ranged around 1.86 to 2.77 MPa and 13.1 to 23 GPa, including both. All of these ranges contribute to the formation of structural concretes. These concretes have significantly greater structural efficiency than typical standard density concretes.
7) In August 2012, Dilip Kumar Singha Roy, Amitava Sil have studied on "Effect of partial replacement of cement by silica fume on hardened concrete" and concluded that It may be concluded that According to the study, maximum compressive strength (both cube and cylinder) is noted for 10% replacement of cement with silica fume, and the morals are higher (by 19.6% and 16.82% respectively) than those of the normal concrete (for cube and cylinder), whereas divided tensile strength and flexural strength of the SF concrete (3.61N/mm2 and 4.93N/mm2 respectively) are raised by approximately 38.58% and 21.13% respectively over those (2.6 N/mm).

III. MATERIALS AND PROPERTIES

A. Cement

Cement is a binder, a chemical used in construction that binds things together by setting, hardening, and adhering to them. In most cases, cement is used to bond sand and gravel (aggregate), not on its own. Concrete is made from cement mixed with sand and gravel or fine aggregate for use in masonry. The second most utilised resource on the globe, after water, is cement, which is the most frequently used substance ever created.

B. Fine aggregate (Sand):

Sand is a granular substance made up of tiny pieces of rock and mineral. Its size distinguishes it as being finer than gravel and coarser than silt. Sand can also refer to a type of soil based on its texture. Sand composition varies based on the local rock sources and circumstances, but silica, typically in the form of quartz, is the most prevalent component in land continental settings and non-tropical coastal settings. Over the course of human history, sand is a finite resource, and it is particularly sought-after for use in concrete production. Although abundant, desert sand is unsuitable for concrete, hence 50 billion tonnes of beach and fossil sand are required annually for construction.

The aggregate that passes through a sieve with a 4.75mm opening is referred to as fine aggregate. In addition to silt and clay, natural sand is frequently used as fine aggregate. Loam is the name for the soft deposit made up of sand, silt, and clay. The function of the fine aggregate is to act as a workability agent and to fill the gaps in the matrix of the coarse aggregate.

C. Coarse Aggregate
The aggregate that is retained after being sieved through a 4.75mm sieve is referred to as coarse aggregate. They may fall under the category of unevenly fragmented stone or naturally occurring gravel, cobble, or boulders. The use of an aggregate of the maximum size may be subject to certain restrictions. For concrete with average strength, 40mm aggregate is often used, while concrete with high strength uses 20mm aggregate, and as per our project study in SCC we are using 12.5mm size coarse aggregare.

D. Lightweight Expanded Clay Aggregate (LECA):
LECA is a versatile material that is finding new applications. It is widely used in the industrial sector to produce lightweight cement, blocks, and precast or incast underlying components (boards, allotments, blocks and light tiles). Warming earth to roughly 1,200 °C (2,190 °F) in a revolving oven produces lightweight soil overall. The mud is grown by a large number of little air pockets framing it during warming, resulting in a honeycomb structure. Because to the circular development in the oven, LECA has a roughly round or potato form & is available in a variety of dimensions and volumes. LECA is put to use to manufacture lightweight substantial substances as well as for other reasons.

Fig 1: Light weight expanded clay aggregate

E. Silica Fumes
Silica fumes, also referred to as silica rage, is a – anti (nebulous) polymorph of silica, which is silicon dioxide. It is an ultrafine powder derived from the synthesis of silicon and ferrosilicon composites & contains round atoms with a diameter of approximately of molecular width of 150.00 nano. The primary usage is as a pozzolanic material for HPC.

It's occasionally remains unanswered with seethed silica (otherwise called pyrogenic silica). Nonetheless, the formation cycle, molecular properties, and fields of use of smouldered silica differ from those of silica rage.

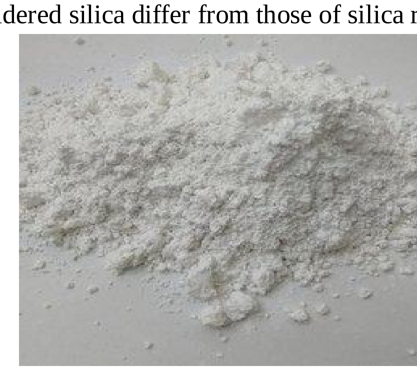

Fig 2: Silica fumes

F. Limestone
One frequent Limestone is a form of carbonate shale, that's primary source chemical lime. Usually, it's made up of elements calcite and aragonite, both of major calcium carbonate stone kinds ($CaCO_3$) as soon as these minerals accelerate water containing broken up Ca, they form limestone formations. This can occur through both organic and non-biological processes; however, natural cycles, such as coral and shell aggregation in the ocean, are thought to have been more prominent during the previous 540 million years. Limestone typically contains fossils, which provide researchers with information about ancient environments and the evolution of life. Carbonate rock accounts for 20% to 25% of sedimentary stone, with limestone accounting for the majority of this. The remaining carbonate rock mostly dolomite, an almost identical stone with a huge concentration of the aggregate dolomite, Ca-$Mg(CO_3)_2$.

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Magnesium limestone an ancient and poorly defined condition that alludes to dolomite, limestone containing a lot of dolomite, or some other limestone with high magnesium content. The majority of limestone was sculpted in shallow sea settings, such as central area racks or stages, while smaller quantities were described in other situations. Many dolomites are optional dolomites, defined by limestone compound alteration. Limestone may be found all over the Earth's surface, & because limestone a good solvent in water, these gaps are frequently erased to form karsts landscapes. The majority of cave constructions have been discovered in limestone bedrock. The majority of dolomite is optional dolomite, defined by the compound alteration of limestone. Limestone is distributed all throughout the holes are frequently filled with debris to create karst vistas on the surface of the Earth even though limestone is only marginally soluble in water. The majority of cave systems have been discovered in limestone bedrock.

IV. METHODOLOGY

In this chapter we are discussing about preparation of concrete and tests on constituents required for concrete mix.

The following materials are utilized for the formation of concrete mix:

Cement of 53 grade, Fine aggregate (sand), coarse aggregate, LECA, Silica fumes, Limestone and chemical admixture.

Making and testing specimens were part of the experimental programme of standard maximum size of 150mm x 150mm x 150mm, M20 grade of concrete is considered in this study. In this study we tested conventionally prepared concrete, LECA partially replaced with Coarse aggregate, Silica fumes (Nano silica) partially replaced with cement and Limestone is partially replaced with coarse aggregate. In this study we prepared Specimens for 7 days, 14 days and 28 days with different percentages of constituents (LECA, Silica fumes and Limestone). And different tests are carried on constituents of concrete (Cement, Fine aggregate and Coarse aggregate), tests on Freshly mixed concrete and Tests on Hardened concrete.

Hand mixing or machine mixing is used for preparation of concrete cubes. Cement, aggregates, LECA, Silica fumes (nano silica), Limestone and water along with admixture is mixed on a non-absorbent platform until the mixture is thoroughly blended and is of uniform colour.

Coarse aggregate is mixed uniformly and it is mixed in such a way that it is distributed throughout the batch and water-cement ratio plays crucial role for the better strength.

Based on the Indian standard design mix for M20 grade of concrete was prepared by partially replacing coarse aggregate with different percentages by weight of LECA (10%, 30%, and 50%), partially replacing coarse aggregate with different percentages by weight of Limestone (10%, 30%, and 50%), and partially cement with different percentages by weight of Silica fumes (5%, 10%, and 15%) and as per Indian standard the water cement ratio was 0.5. for is used along with the plasticizer to increase the flow ability. Too much water will result in segregation for the sand and aggregate components from the cement paste.

High range water reducing admixture is used along with water. The dosage of admixture used is 1000ml for every 20 litres of water used in a mix. Before the admixture used in a mix it is diluted with water.

V. RESULT AND DISCUSSION

A. Results Of Cement Sample

S.NO	Characteristics	Values obtained
1.	Consistency	32%
2.	Initial setting time	45min
3.	Final setting time	500min
4.	fineness	5%
5.	Specific gravity	3.05

TABLE I Results of Cement Sample

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B. Tests Results Of Fine Aggregate

S.NO	TEST	RESULTS
1.	Zone	II
2.	Specific gravity	2.6
3.	Fineness modulus	3.75
4.	Water absorption	0.6%

TABLE 2 Results of Fine Aggregate

C. Tests Results of Coarse Aggregate

S.NO	Test	Result
1.	Specific gravity	2.66
2.	Fineness modulus	6.23
3.	Water absorption	0.3%

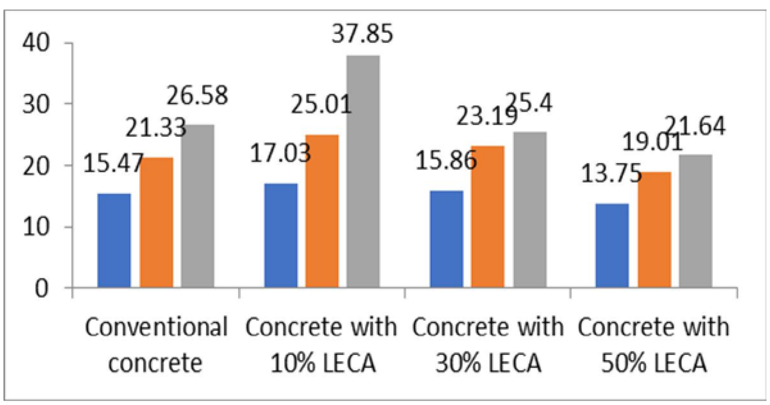
TABLE 3 Results of Coarse Aggregate

D. Compressive Strength Of Hardened Concrete For 7 Days, 14 Days And 28 Days

1) Partially replacing coarse aggregate with different percentages by weight of LECA (10%, 30%, and 50%).

MIX code	compressive strength in N/mm^2 in 7 days	compressive strength in N/mm^2 in 14 days	compressive strength in N/mm^2 in 28 days
Conventional concrete	15.47	21.33	26.58
Concrete with 10% LECA	17.03	25.01	37.85
Concrete with 30% LECA	15.86	23.19	25.40
Concrete with 50% LECA	13.75	19.01	21.64

Table 4 : Compressive strength of hardened concrete with different percentages of LECA

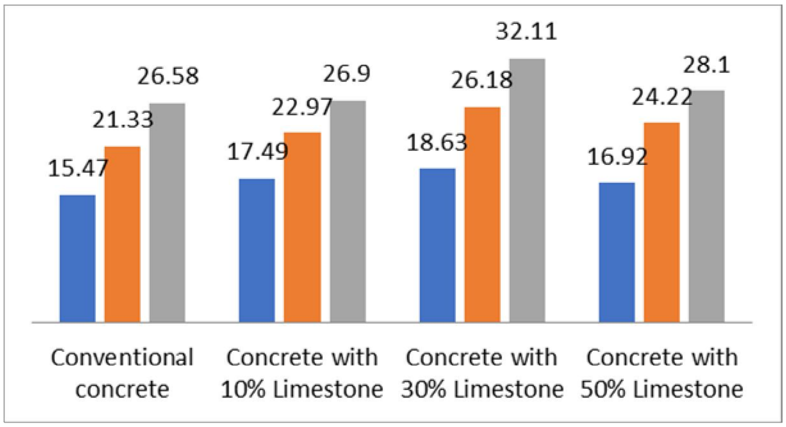


Graph 1 : Graphical representation of Compressive strength of hardened concrete with different percentages of LECA

2) *Partially replacing coarse aggregate with different percentages by weight of Limestone (10%, 30%, and 50%).*

MIX code	compressive strength in N/mm^2 in 7 days	compressive strength in N/mm^2 in 14 days	compressive strength in N/mm^2 in 28 days
Conventional concrete	15.47	21.33	26.58
Concrete with 10% Limestone	17.49	22.97	26.90
Concrete with 30% Limestone	18.63	26.18	32.11
Concrete with 50% Limestone	16.92	24.22	28.10

Table 5 : Compressive strength of hardened concrete with different percentages of Limestone



Graph 2 : Graphical representation of Compressive strength of hardened concrete with different percentages of Limestone

3) *Partially replacing cement with different percentages by weight of silica fumes (5%, 10%, and 15%).*

MIX code	compressive strength in N/mm^2 in 7 days	compressive strength in N/mm^2 in 14 days	compressive strength in N/mm^2 in 28 days
Conventional concrete	15.47	21.33	26.58
Concrete with 5% Silica fumes	19.34	23.40	31.44
Concrete with 10% Silica fumes	21	29.65	34.93
Concrete with 15% Silica fumes	18.3	26.68	30.20

Table 6: Compressive strength of hardened concrete with different percentages of Silica fumes

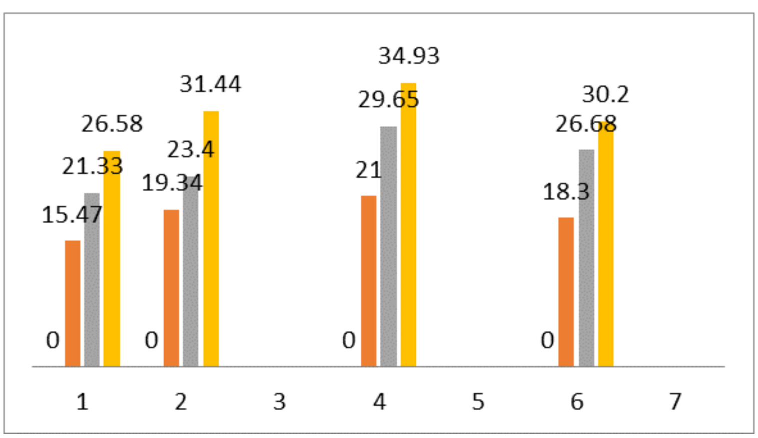


Fig 3: Graphical representation of Compressive strength of hardened concrete with different percentages of Silica fumes

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E. Comparision of tests after 28 days

MIX code	Compressive strength in N/mm^2 in 28 DAYS	MIX code	Compressive strength in N/mm^2 in 28 DAYS	MIX code	Compressive strength in N/mm^2 in 28 DAYS
Conventional concrete	26.58	Conventional concrete	26.58	Conventional concrete	26.58
Concrete with 10% LECA	37.85	Concrete with 10% Limestone	26.9	Concrete with 5% Silicafumes	31.44
Concrete with 30% LECA	25.4	Concrete with 30% Limestone	32.11	Concrete with 10% Silicafumes	34.99
Concrete with 50% LECA	21.64	Concrete with 50% Limestone	28.1	Concrete with 15% Silicafumes	30.2

Table 7: Compressive strength of hardened concrete with different percentages of Limestone, Silica fumes, and LECA in 28 days.

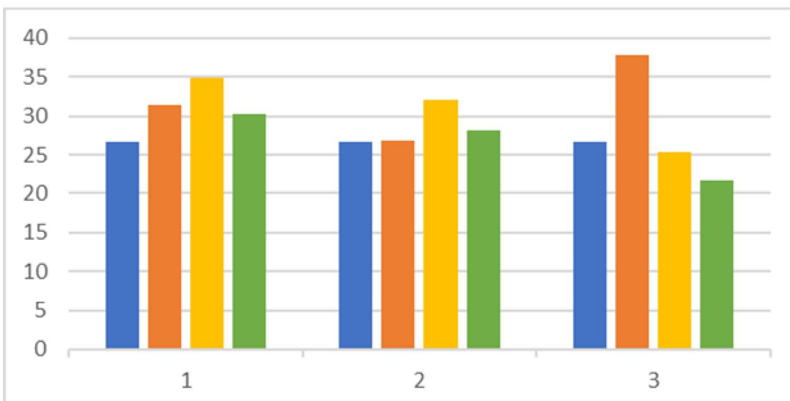

Fig 4: Graphical Representation Compressive strength of hardened concrete with different percentages of Limestone, Silica fumes, and LECA in 28 days.

VI. CONCLUSIONS

In order to make high-strength lightweight concrete that is lighter than conventional concrete, this thesis calculates the mix proportions. LECA. to make lightweight concrete, mineral and chemical admixtures have been employed to minimise porosity and increase strength. Additionally, a little amount of silica fumes (micro silica) is added to the mixture to improve the characteristics of the concrete and stabilise its workability.

1) When coarse aggregate is partially replaced with 10 percentage of LECA, it gives the higher compressive strength which is 37.8 in 28 days and which gives the 42.40% more than the conventional concrete.
2) When coarse aggregate is partially replaced with 10 percentage of Limestone, it gives the higher compressive strength which is 32.11 in 28 days and which gives the 18.84% more than the conventional concrete.
3) When cement is partially replaced with 10 percentage of Silica fumes, it gives the higher compressive strength which is 34.93 in 28 days and which gives the 27.15% more than the conventional concrete.

From the study we can derive that, when Leca is burned and partially replaced with Coarse aggregate, it give the higher compressive strength when comparing to Lime stone partially replaced bt coarse aggregate and silica fumes with cement.

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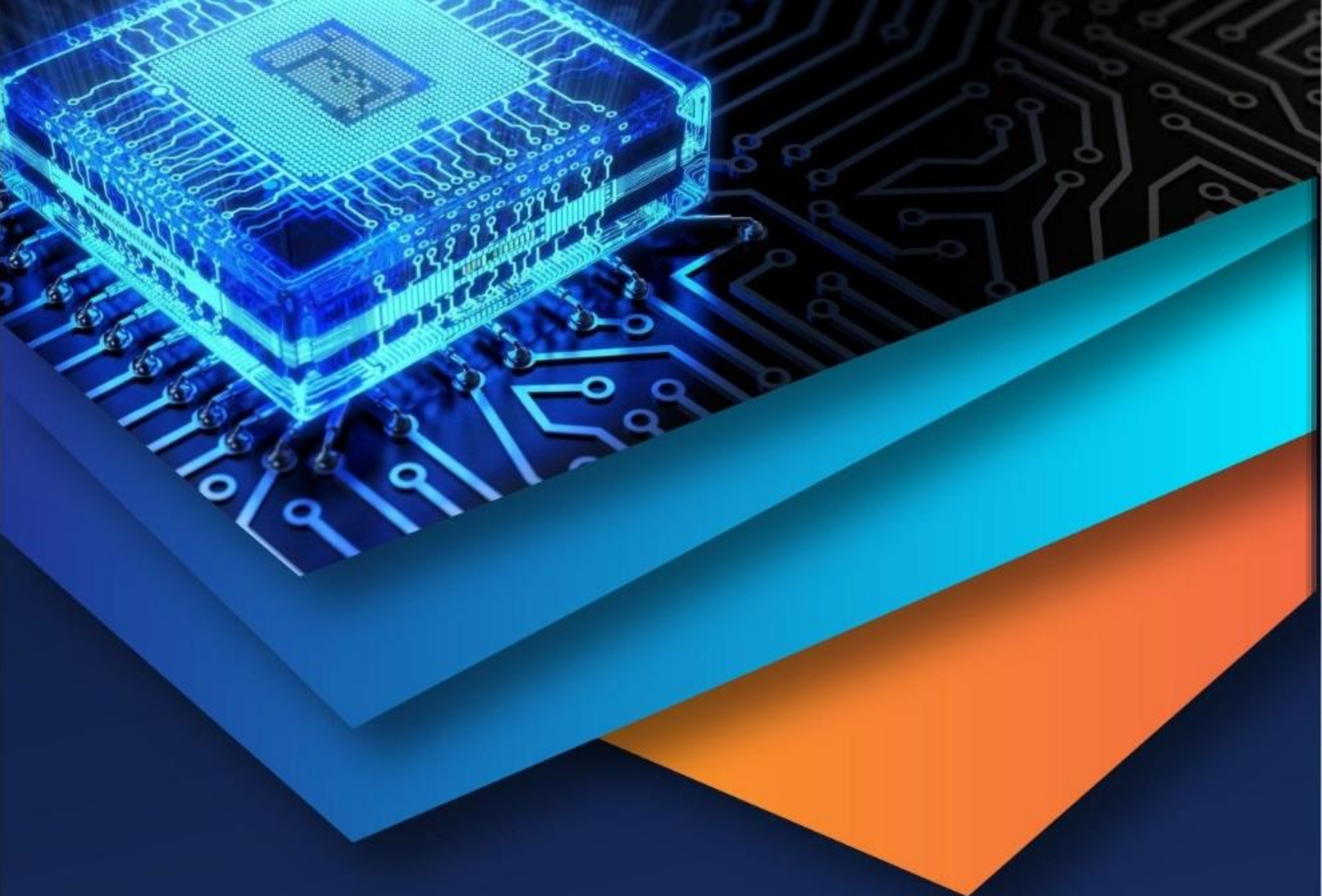

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