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Laboratory Analysis of Silica Fume and Fly Ash in Concrete

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Abstract: ***With increased environmental awareness and its potential hazardous effects, utilization of industrial by products has become an attractive alternative to disposal. The effect of using silica fume and fly ash as partial replacement of cement has been studied in this thesis. The ordinary Portland cement is one of the main ingredients used for the production of concrete involves emissions of large amounts of carbon dioxide gas into the atmosphere a major contributor for greenhouse effect and global warming hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material which can be used as an alternative or as a supplementary for cement should lead to sustainable development. Silica fume is the material which takes place the cement replacing material. Silica fume (SF), which is by product of the smelting process in the silicon and ferrosilicon industry. In present study analysis of results were conducted to study the compressive behavior of composite concrete with varying percentage of such fibres added to it. The concrete mix adopted were M30 with varying percentage of silica fume and fly ash ranging from 0, 2.5, 5, 7.5 & 10% by weight of cement. The investigation revealed that the partial replacement of cement by silica fume and fly ash will develop compressive strength sufficient for construction purposes. Its use will lead to a reduction in cement quantity required for construction purposes and hence sustainability in the construction industry.***

Keywords: Silica Fume, Fly ash, Compressive Strength, flexural Strength

I. GENERAL

Concrete is a basic building block of our everyday world. It's used in almost every type of structure that we build today. Concrete is a widely used material for various types of structures due to its structural stability and strength. It is the second largest material used after water in the world. The durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self destruction. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Fly ash, ground granulated blast furnace slag, rice husk ash, high reactive met kaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. In present study we use silica fume and fly ash with different percentage like 2.5 %, 5 %, 7.5% and 10 % to replace the cement in concrete and find various properties.

II. OBJECTIVES

The use of silica fume is most commonly used to obtain high strength of concrete in these days. The uses of silica fume in the concrete have attracted the attention of researchers throughout the World. In the same way fly is also used worldwide to replace the cement upto some extent. The following are the objectives of using silica fume with fly ash in concrete:

A. To determine the effect of silica fume with fly ash on the compressive strength of concrete.
B. To study the effect of silica fume and fly ash on workability of concrete.
C. To study the some physical property like initial setting time, final setting time, consistency etc.

III. LITERATUR EREVIEW

The review deals with the significant developments regarding performance and applications of silica fume and fly ash based concrete that have taken place separately in recent past. An extensive literature review pertaining to different aspects of concrete containing micro silica also known as silica fume has been carried out with fly ash in order to identify the areas

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of future studies in concrete. Many studies have been reported in literature on the performance of the concrete containing silica fume and fly ash some of important studies are briefly presented below:

(Baspinar et al. 2012) Study showed that the concrete samples were produced defect free standard aerated from fly ash/cement mixture. A high amount of cement in the mixture resulted in an extensive ettringite formation during the early hydration period. Decreasing the amount of cement resulted in an increase in the compressive strength at autoclaving curing conditions.

(Chengdon et al. 2010) The influences of fly ash and silica fume on water-resistant property were investigated by SEM and EDS..The influences of fly ash and silica fume on the properties of MOC were investigated. By incorporating fly ash or silica fume in the MOC, the water resistance improved, although the compressive strength decreased.

(Tan, Gungormus et al, 2014) In this study the preparation of the injection blends, Bentonite (B), Fly Ash (FA) and Silica Fume (SF) were used at the ratios of 0-0.5-1-3%, 10-20-30-40% and 0-5-10-20%, respectively. In results of the experiments it was observed that the most effective parameter over the uniaxial compressive strength of 7, 14 and 28 days was silica fume. Optimum blending conditions have been defined as 3% Bentonite, 10% fly ash and 20% silica fume. These proportions improve the characteristics of injection blend such as workability, water desorption, viscosity, homogeneity and setting time.

(Urkel et al. 2008) In this study, the effect of limestone powder (LP) on the properties of SCRM has been compared with other mineral additives (silica fume (SF) and fly ash (FA). Fresh properties, flexural and compressive strengths and water absorption properties of mortars were determined. The use of SF in mortars significantly increased the dosage of superplasticiser (SP). Maximum compressive strength was obtained for 30% SF replacement ratio of cement.The increase in strength can be attributed to the improved aggregate-matrix bond resulting from the formation of a less porous transition zone in the SF mortar.

Xiaosheng et al. , 2007) showed that When 50% fly ash with combination of 5% silica fume (Mix F50SF5), the concrete compressive strength is also markedly increased by SF and the compressive strengths of sample F50SF5 are higher than those of sample F50-0 at the ages. Compared with the control sample, F0-0, the strength values of F50SF5 are close to those of sample F0-0 and a little higher at ages of 7 days and 28 days.

(Kennouche et.al, 2013) Stated that Self-compacting concrete (SCC) was elaborated using local materials and silica fume (SF) as admixture in 15% of cement quantity, two different Portland cements (PC) and two different superplasticizer . The mechanical characterization was conducted by compressive strength and splitting compression testing procedure, results values are in the range higher than 20 Mpa at the seven day by the compressive test for the all compositions, and the highest value was 40.93 MPa at the 28 day bay compressive test of the fourth's formulation specimens, the values of splitting compressive tests of al formulation specimens at 7, 14 and 28 days, was situated between 2.01 and 4.40 MPa.

(Dilip Roy and Amitava Sil, 2012) In the present study, an attempt has been made to investigate the strength parameters of concrete made with partial replacement of cement by SF. Very little work has been carried out using silica fume as a replacement of cement. Moreover, no such attempt has been made in substituting silica fume with cement for low/medium grade concretes (viz. M20, M25). Properties of hardened concrete viz Ultimate Compressive strength, Flexural strength, Splitting Tensile strength has been determined for different mix combinations of materials and these values are compared with the corresponding values of conventional concrete.

IV. MATERIAL USED IN STUDY

A. Cement

Portland cements are hydraulic cements, meaning they react and harden chemically with the addition of water. Cement contains limestone, clay, cement rock and iron ore blended and heated to 1200 to 1500 C°. The resulting product "clinker" is then ground to the consistency of powder. Gypsum is added to control setting time. It is collected from nearby market.

Figure 1: Cement

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B. Aggregates

These are the granular materials, such as sand, gravel, crushed stone, or iron blast- furnace slag, used with cementing medium to form concrete or mortar. Aggregates act as relatively inexpensive inert filler, providing stability against volume changes and influencing strength and stiffness. Throughout the experiment, river sand and basaltic crushed stone from local market were used as fine and coarse aggregate.

C. Fly Ash

The fly ash used in the present study is collected from Rajiv Gandhi Thermal Power Plant. The specific gravity of the used fly ash is obtained as 2.25.

Figure: 2 Fly ash

D. Water

Throughout the investigation, tap water supplied for drinking consumption is used for curing the hardened concrete samples. For all physical and chemical analysis distilled water is used. Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

E. Silica Fume

Silica fume or Micro silica is co-product of the ferrosilicon and silicon alloy industry which is very rich in amorphous silicon dioxide nearly 90%. realizing the pozzolanic potential of the materials, this has been used successfully as an admixture in producing concrete. It is collected from Buildcon Infra-Chemical Technology.

Figure: 3 Silica Fume

V. ANALYSIS OF RESULTS AND DISCUSSION

An Experimental study on the behavior of Silica fume and fly ash based concrete has been conducted for various loading conditions and silica and fly ash contents. The results of the present investigation are compared with the other investigation. The results of the present investigation are discussed under the following heads:-

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VI. DISCUSSION OF RESULTS

A. *Consistency Test*

Normal consistency tests, for the blended cements, were conducted, by Vicat apparatus, to observe the changes in water requirement of pastes due to the silica fume and fly ash. Figure 4 show the results for consistency of silica fume and fly ash based paste. The consistency of the mix paste is more then fresh paste.

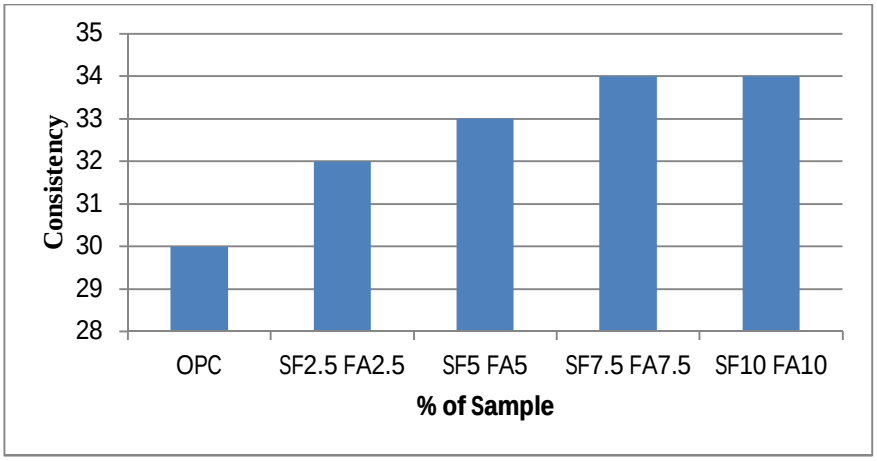

Figure 4 Consistency Graph

B. *Setting Time Test*

Tests for setting time were conducted to compare the setting time of the blended cements with standards and also with the control paste. The initial and final setting time for fresh paste is 40 and 262 minutes and initial and final seetting time for mix based paste is 90 and 254 minutes.

C. *Soundness Test*

In the research Le-Chatlier expansion tests were conducted for soundness test. The expansion recorded is within the standard limits for Ordinary Portland cement set by Indian standard. The result revealed that the addition of silica and fly ash on Ordinary Portland cement has no remarkable effects on the soundness of cement pastes. During the investigation, sound produced by colliding dried pastes were observed and was uniform and thin light which indicates that there is no problem in expansion or no sign of cracking. The absence of expansion in silica fume and fly ash blended cement like the OPC cement reveals that the amount of free lime and MgO is controlled in clinkerization step and the free lime and MgO in the additive are little in quantity to affect late expansion. The below figure 5 shows the result of soundness test. There is a little bit change in soundness after addition of silica fume and fly ash.

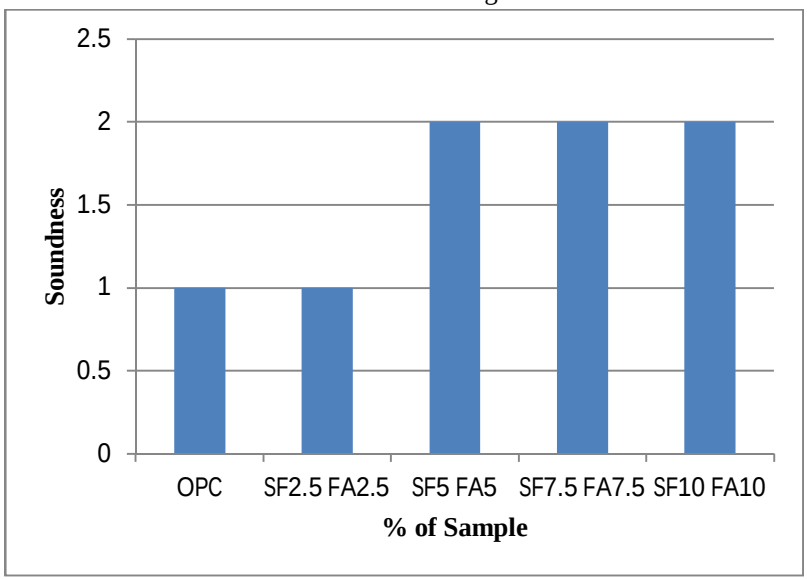

Figure 5: Soundness Graph

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D. Specific Gravity Test

The ratio of the density of a substance to a density of a standard substance, usually water for a liquid or solid and air for gas. Specific gravity of cement is depending upon the particle size of cement. The test is done as per IS: 2386. We find the specific gravity of silica fume, fly ash and cement is 2.27, 2.25 and 3.01. All these value are in permissible limit.

E. Workability Test

Workability is affected by every component of concrete and essentially every condition under which concrete is made. A list of factors include the properties and the amount of cement, grading, shape, angularity and surface texture of fine and coarse aggregates, proportion of aggregates, amount of air entrained, type and amount of pozzolana, type and amount of chemical admixture, temperature of the concrete, mixing time and method, and time since water and cement are in contact. These factors interact so that changing the proportion of one component to produce a specific characteristic requires that other factors be adjusted to maintain workability In this experiment slump of all mixes with constant water to cementious material (w/cm) ratio for the same group were measured to get information about workability changes due to the micro silica and fly ash content. The figure 6 show the workability of fresh and mix based concrete.

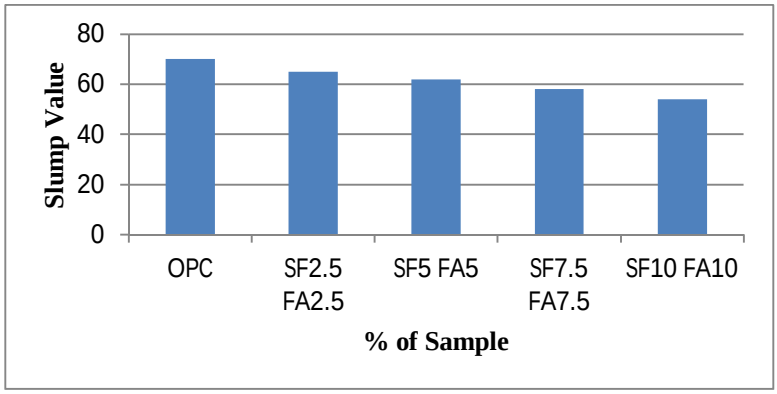

Figure 6 Graph for Slump Value

F. Compressive Strength Test

The compressive strength was conducted on various specimens as per the guidelines given in IS 516-1959. The specimens were surface dried before testing the same on Universal Testing Machine of 100 tonnes capacity. The compressive strength of plane mortar and silica fume and fly ash based concrete for various percentages of micro silica content has been illustrated in figure given below which shows the compressive strength after 7 and 28 days respectively. The compressive strength of plane mortar has been obtained as 18.55 N/mm^2 after 7 days. This strength has been obtained as 19.50 N/mm^2, 20.09 N/mm^2, 21.38 N/mm^2, and 18.47 N/mm^2 for 2.5,5, 7.5and 10 percent silica fume and fly ash contents respectively in the case of silica fume and fly ash based concrete. The compressive strength of plane mortar has been obtained as 29.87 N/mm^2 after 28 days. This strength has been obtained as 30.51 N/mm^2, 31.35 N/mm^2, 31.60 N/mm^2, 29.48 N/mm^2 for 2.5,5, 7 .5 and 10 percent silica fume and fly ash contents respectively in the case of Silica fume and fly ash based concrete.

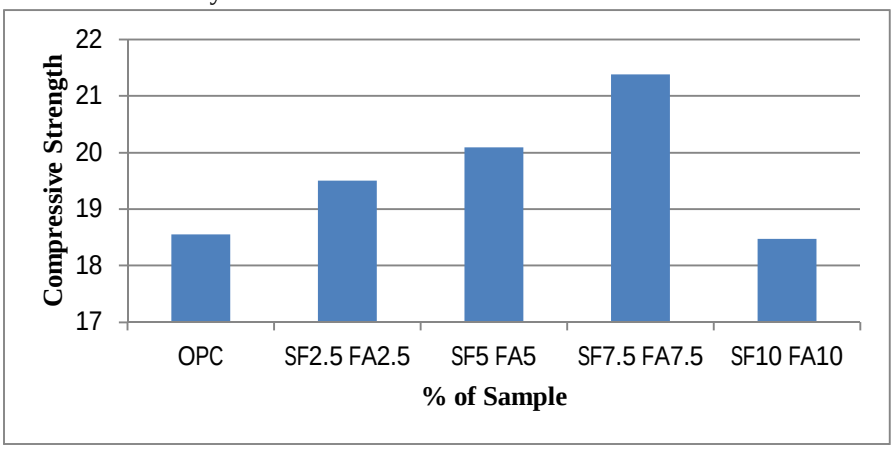

Figure 7: Compressive Strength after 7 Days

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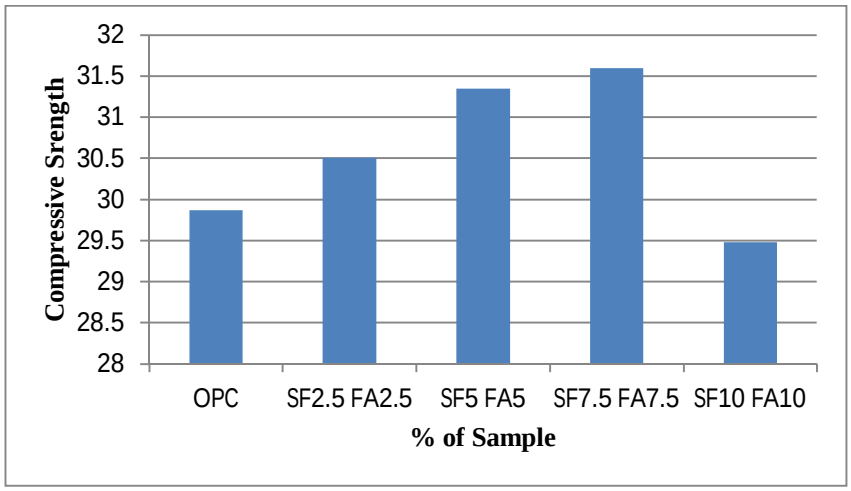

Figure 8: Compressive Strength after 28 Days

It can be seen from the above tables and figures that the incorporation of silica and fly ash resulted in increase in compressive strength of concrete up to 44 % at the curing age of 7 days and up to 14 % curing age of 28 days respectively. Hence, these results show that silica fume also known as micro silica possesses good compressive behavior with fly ash and helps in improving the properties of the M30 concrete.

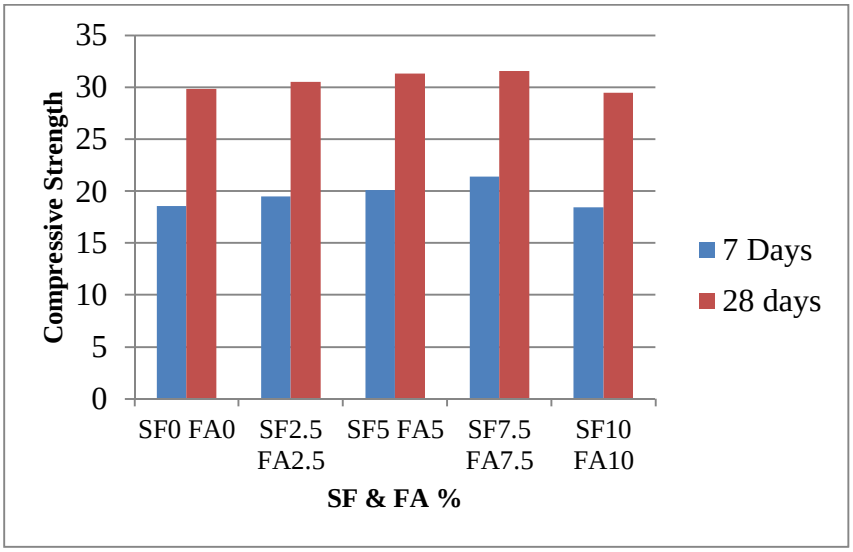

Figure 9: Comparison of Compressive Strength at 7 and 28 days

VII. CONCLUSIONS

The present study was undertaken to find the effect of silica fume and fly ash on strength characteristic strength of concrete. To achieve the objectives of the present study, the cement were replaced 2.5%, 5%, 7.5% and 10% respectively. The compressive strength test were determined for the mixes at the curing age of 7 days and 28 days. The results obtained for the above mixes were compared to investigate the effects of partial replacement of cement by silica fume and fly ash on the above strength parameters of concrete. The conclusion drawn from this study is presented in this chapter.

Based on the results obtained in the present investigation, the following conclusion can be drawn-

A. The results obtained in the present study indicates that it is feasible to replace the cement by silica fume and fly ash for improving the strength characteristics of concrete for M30 mix design, thus the silica fume and fly ash can be used as an alternative material for the production of concrete to address the waste disposal problems and to minimize the cost of construction with usages of silica fume.

B. The Experimental work shows that properties of concrete M30 get improved due to incorporation of silica fume and fly ash.

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C. M30 concrete produced from cement replacement upto 7.5% silica fume and fly ash leads to increase in compressive strength of concrete at the end of 7 & 28 days respectively. Beyond 7.5 %there is a decrease in compressive strength of concrete.

D. The workability of the concrete decreases as the silica and fly ash content increases

E. The initial and final setting time of cement paste blended with silica and fly ash content increases as silica content increases.

F. The consistency of the cement paste mix with silica and fly ash content increases.

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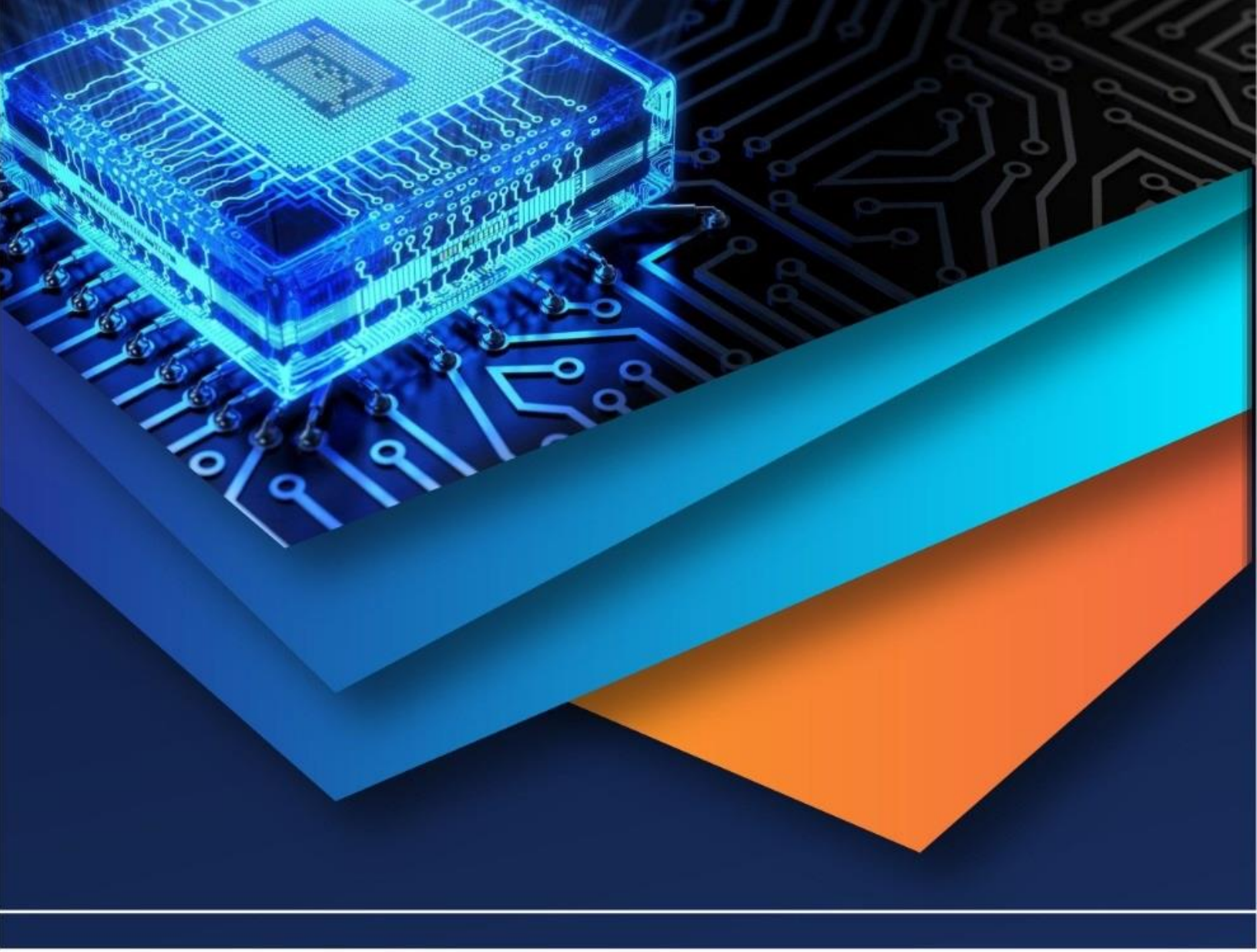

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