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Enhance the Strength Characteristics of Concrete through the Incorporation of Waste Foundry sand and Metakaolin as Partial Substitutes for Cement and Fine Aggregate

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Abstract: Concrete is recognized as the most extensively utilized and adaptable construction material globally. Natural sand or river sand is a critical component of conventional concrete, and its availability is nearing depletion due to extensive utilization. In India, conventional concrete is produced utilizing natural sand sourced from riverbeds as the fine aggregate component. This investigation involves the partial replacement of cement with metakaolin at varying percentages of 0%, 5%, 10%, and 15%, alongside a 50% replacement of natural sand with ROBO sand. The mechanical properties of concrete, specifically compressive strength, split tensile strength, and flexural strength, are analyzed for concrete incorporating MK-RS as a replacement material, with results compared to those of conventional concrete. In this study, a total of six concrete mixes were prepared using M20 and M25 grades. The average of three specimens was tested at intervals of 7 days, 14 days, and 28 days for each mix.
Keywords: ROBO sand, compressive strength, split tensile strength and flexural strength, , Ground Granulated Blast Furnace Slag

I. INTRODUCTION

Currently, there are numerous advancements in concrete technology that can enhance the application of cement in concrete mixtures. In the event that there is a substitution of fine aggregates, specifically sand, with quarry dust or alternative materials. At that point, there will be reduced emissions of CO2 in the environment. We are utilizing manufacturing waste material to produce high-quality concrete. The environmental problem can be understood through the replacement of industrial waste and by products. The replacement of fine aggregates (sand) with the incorporation of waste materials (quarry dust) can be beneficial for structural integrity and environmental sustainability. Subsequently, the characteristics of concrete change, including workability, pressure test results, elongation index, and others. The primary material resembling concrete developed in history was produced when Greek and Roman manufacturers discovered that by combining crushed limestone, lime, water, sand, and aggregate, a solidifying mixture could be achieved. Engineers have investigated the flexibility of materials that possess various attributes, allowing them to be produced in a plastic state and subsequently solidified into a durable and robust product. The implementation of these development materials relies on the specific characteristics of each segment. Concrete information has evolved and progressed in response to changing circumstances and new identifications. During the late 19th century, concrete was typically placed in a nearly dry state and compacted using significant force. The reinforcement was not employed at that time in concrete. With the advancement of reinforced concrete in the early part of this century, extremely wet blends became prominent, and a significant portion of the concrete was indeed incorporated into the structures without any checks.

II. LITERATURE SURVEY & BACKGROUND

Dhakulkar P. S., Malkhede S. D. (2023) chemical characteristics differ with species of quarry but chiefly contain silica. Incorporation of as partial replacement of cement adversely decreases the slump of concrete. Due to decrease in slump it indicates increase in water absorption. There was marginal decrease in strength with increasing , percentage in concrete , at replacement percentage up to 15% of the weight of binder can be successfully used as additive in place of cement. Compressive strength of , concrete is found to be optimum at 15%(26.16 N/MM2) Tensile strength of , concrete is found to be optimum at 15%(1.89 N/mm2) Flexural strength is also found to be optimum at percentage of 15%(13 N/mm2)

Aginam C. Nwakaire, Onah, B. (2020) this experimental investigation on the possible replacement of coarse aggregate with Quarry Dust in Concrete, it could be concluded that the workability of concrete decreases with increasingly percentage of Quarry Dust in the mix and workability test being a pointer to the consistency of the mix does not imply the final strength characteristics of the same.

Dr. suji D., Narayanan M., Kumar. M, Perarasan M. (2016) Sawdust and quarry dust are partially utilized as substitutes in the production of fine aggregate for concrete. Quarry dust proportions of 0%, 10%, 20%, 30%, and 40% were employed in this investigation to assess the effects of sawdust and quarry dust. Furthermore, the fine aggregate was observed to have been developed and formed, as evidenced by the particulate concentrations of 0%, 5%, 10%, 15%, and 20%. The result comprises the following:

III. OBJECTIVE

The general objectives of this dissertation work is to search out the properties of fresh and hardened concrete for M-25 grade of concrete for cement replacement at various percentages of quarry dust and MK.

In this experimental study compressive strength, and work ability of concrete has been found out.

IV. RESULT

A. Workability Test

Slumps of M-20 and M-25 with Metakolin and Robo sand

The slump test is used to assess the workability of this project. When the concrete is freshly mixed, it is put through its paces by filling the slump cone with it. The workability of the concrete is determined by removing the slump cone and measuring the concrete's subsidence. This is referred to as the concrete's slump value.

The effect of Metakaolin and ROBO sand on fresh property concrete i.e. workability (Slump value) of different mixes with varying Metakaolin content by weight of cement and natural sand with ROBO sand have been shown in table 5.1

Table 1 Slump Value of the Different mix M-20 & M-25 Concrete

Designation	Ingredients					Slump Value in M20	Slump Value in (mm) M25
	Coarse Aggregate %	Fine Aggregate %	Robo Sand %	Cement %	Metakaolin %		
M0R0	100	100	0	100	0	90	82
M0 R50	100	50	50	100	0	78	65
M5R50	100	50	50	95	5	69	60
M10R50	100	50	50	90	10	59	52
M15R50	100	50	50	85	15	48	43

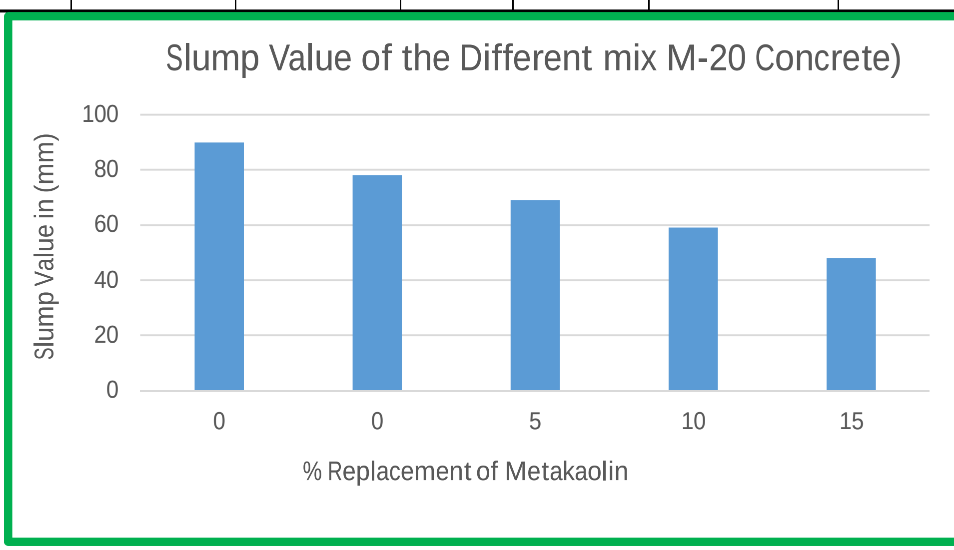

Figure 1 Slumps of M-20 at different percentage of MK and RS

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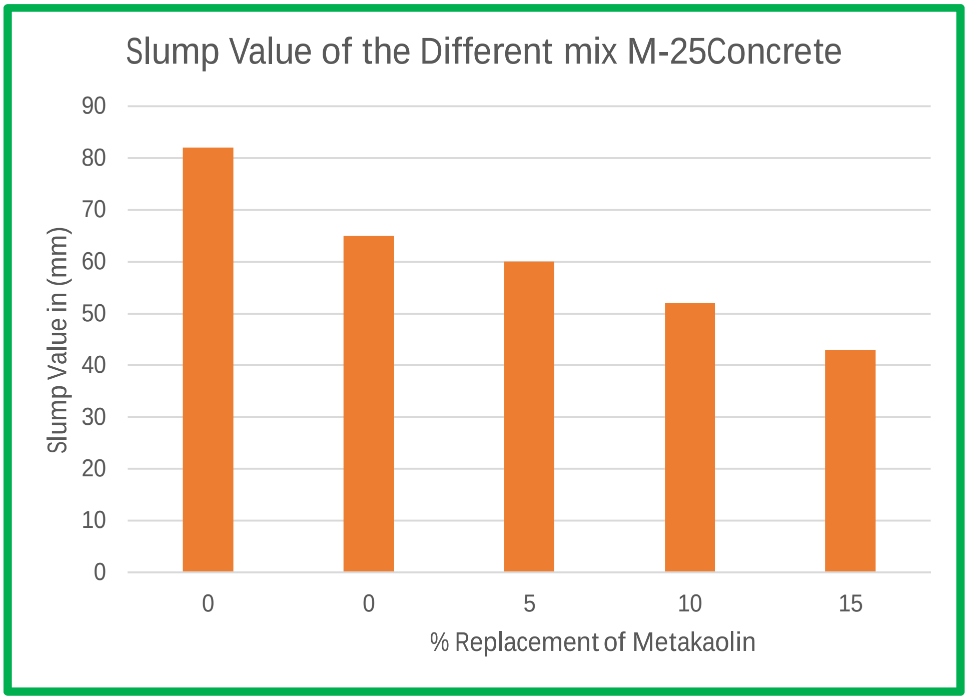

Figure 2 Slumps of M-20 at different percentage of MK and RS

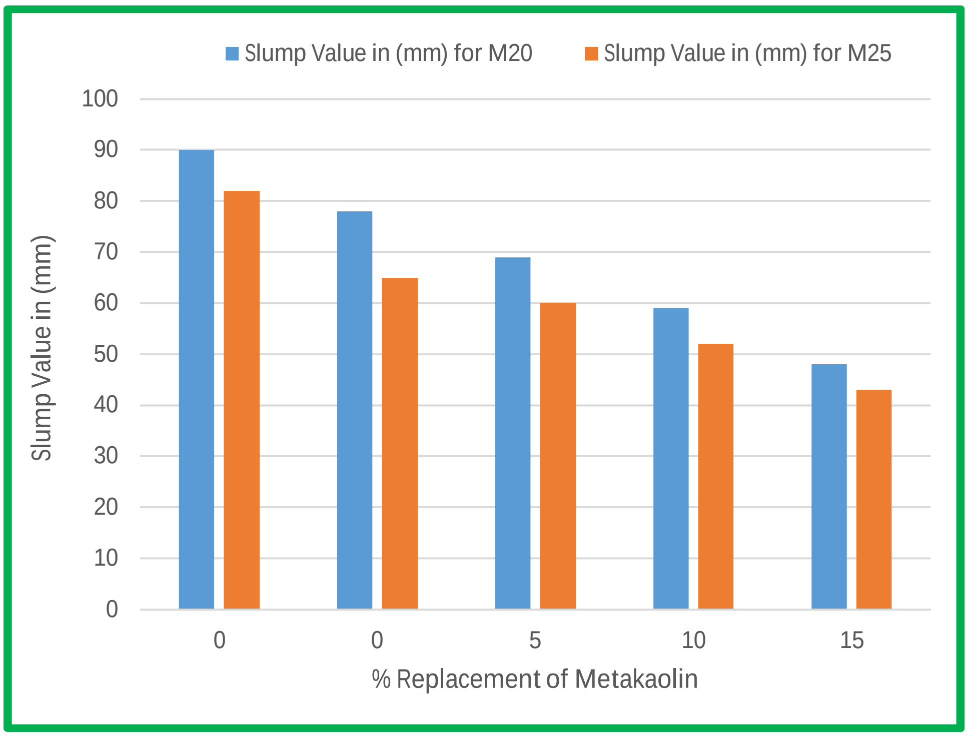

Figure 3 Slumps of M-20&M-25 at different percentage of MK and RS

Discussion: According to the results of the experiment, the workability of various concrete mixes decreases as compared to the control mix. Since Metakaoin is finer, it improves the workability of various concrete blends. Metakolin serves as a material to occupy the voids present in concrete. The experimental results indicated that Robo sand does not influence the workability of concrete.

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V. COMPRESSIVE STRENGTH

The influence of Metakaolin and ROBO sand on the compressive strength of M20 and M25 grade concrete, with varying dosages of Metakaolin substituting cement by weight and incorporating 50 percent ROBO sand in place of natural sand, is presented in Table 5.3 for M20 concrete and Table 5.4 for M25 concrete at 7 days, 14 days, and 28 days.

.Table 2 Compressive Strength of Different Mix of M-20 Concrete

Designation	Compressive Strength in N/mm^2			Robo sand	Sand	Cement	Metakaolin
	7 Days	14 Days	28 Days	%	%	%	%
M0R0	16.2	23	27.5	0	100	100	0
M0 R50	17.5	24.56	29.2	50	50	100	0
M5R50	19.3	25.6	31.2	50	50	95	5
M10R50	20.5	27.9	32.8	50	50	90	10
M15R50	18.6	25.8	30.5	50	50	85	15

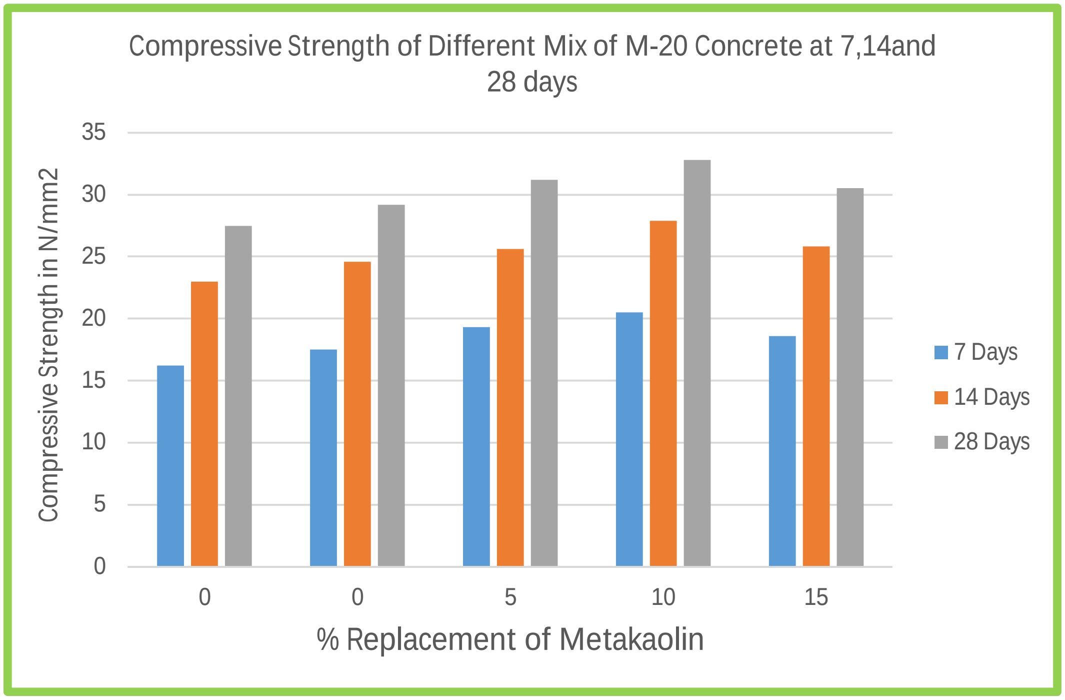

Fig 4 Effect of Metakaolin and ROBO sand on compressive strength of concrete at 7-days, 14-days and 28 days

Table 4.3 Compressive Strength of Different Mix of M-25 Concrete

Designation	Compressive Strength in N/mm^2			Robo sand	Sand	Cement	Metakolin %
	7 Days	14 Days	28 Days	%	%	%	
M0R0	18.5	27	31.6	0	100	100	0
M0 R50	19.5	28	33.2	50	50	100	0
M5R50	23.5	28.7	34.5	50	50	95	5
M10R50	25	29.9	35.2	50	50	90	10
M15R50	22.5	27.24	34.1	50	50	85	15

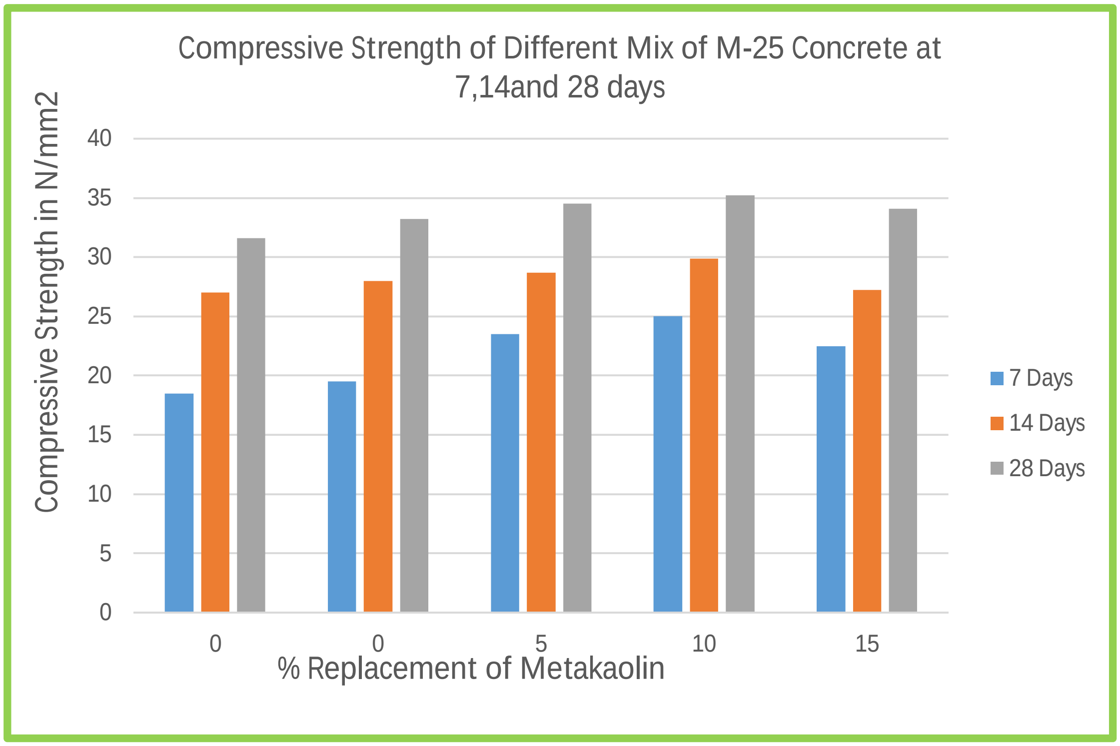

Fig 5 Effect of Metakaolin and ROBO sand on compressive strength of concrete at 7-days, 14-days and 28 days

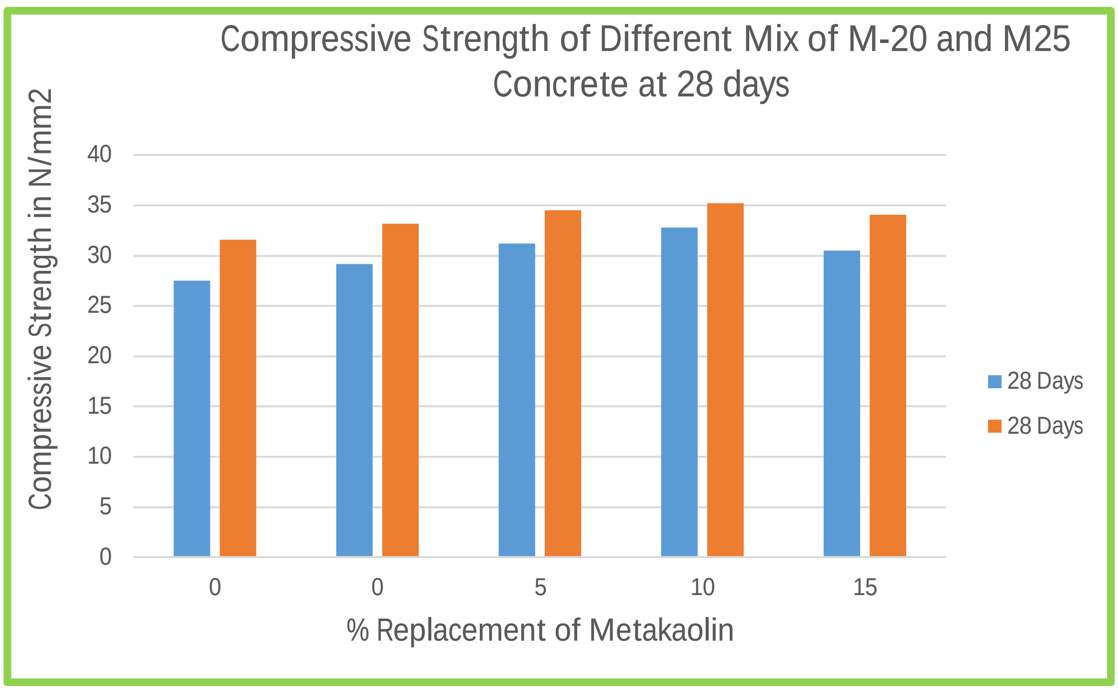

Fig 6 Effect of Metakaolin and ROBO sand on compressive strength of concrete at 28 days for M20 and M25

Discussion -. The compressive strength of M 20 and M 25 grade concrete at 7, 14, and 28 days exhibits an increase when the percentage of Metakaolin is raised from 0% to 10% in conjunction with 50% ROBO sand, as indicated in the table above. The peak intensity of Metakaolin was recorded at a 10% replacement level, after which a decline was noted. The strength increase for M20 grade concrete at 28 days is up to 18%, while for M25 grade concrete, the increase is noted as well. grade concrete, the strength increase at 28 days is up to 11%.

VI. CONCLUSION

1) The workability of various concrete mixes is reduced when compared to the control mix. The finer nature of MK enhances the workability of different concrete mixes. MK is utilized to occupy the voids present in the concrete. The ROBO sand does not affect the workability.
2) The test results indicate that the compressive strength of different concrete mixes shows improvement at all ages when compared to the control mix. The results indicate that the compressive strength of M 20 and M 25 grade concrete exhibits an increase at 7, 14, and 28 days as the percentage of Metakaolin is raised from 0% to 10%, in conjunction with 50% ROBO sand. The peak intensity of Metakaolin was recorded at a 10% replacement level, after which a decline was noted. The strength increase for M20 grade concrete at 28 days is observed to be up to 18 percent, while for M25 grade concrete, the strength increase at the same duration is up to 11 percent.
3) At 28 days The maximum compressive strength for M20 and M25 grades of concrete is 32.2 N/mm^2 and 35.2 N/mm^2, respectively, when incorporating 10% Metakaolin and 50% Robo Sand.

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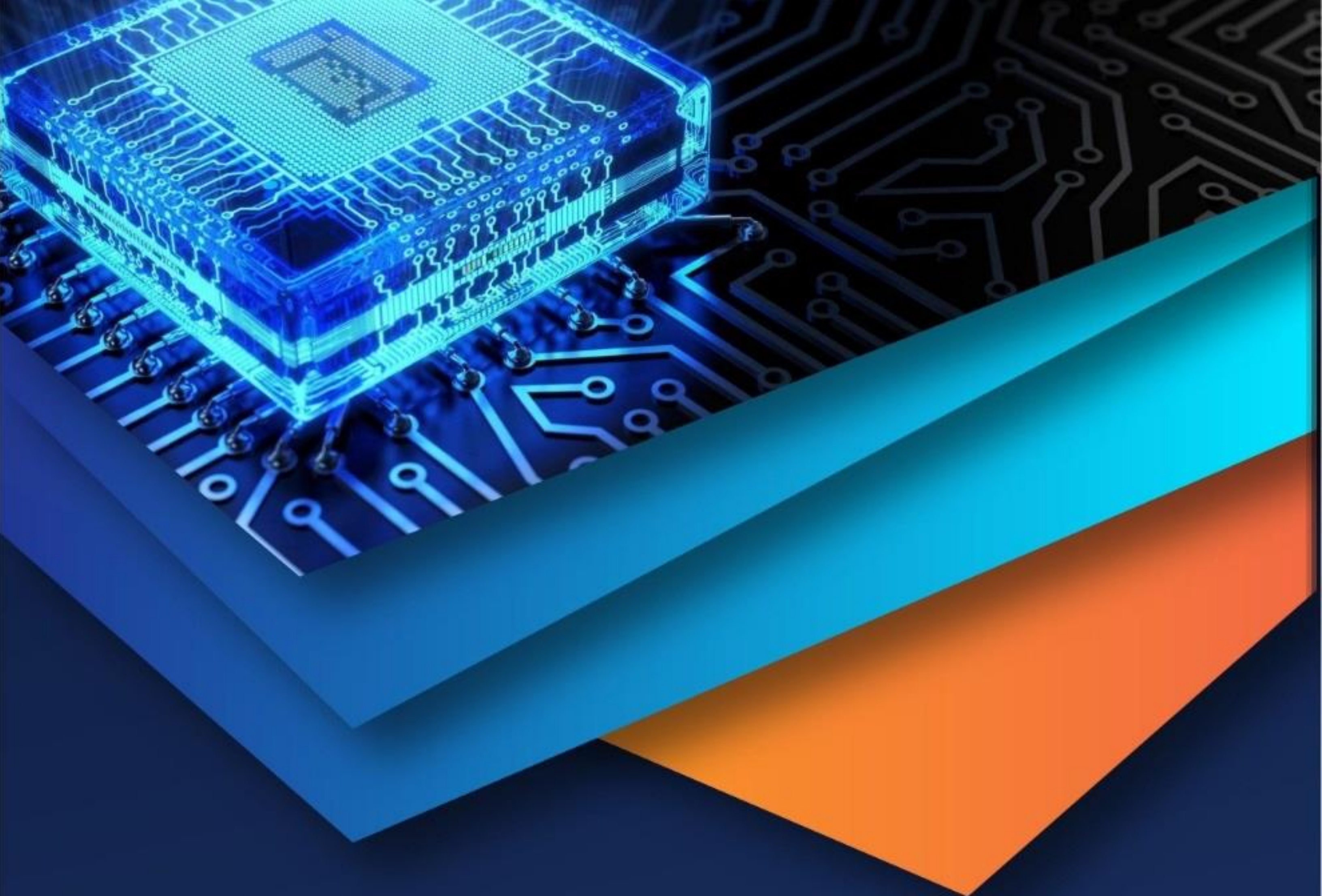

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