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Utilization of Ceramic Tile Waste and Quarry Dust as Partial Replacement of Aggregates in Medium Grade Concrete

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Abstract— This study investigates the utilization of quarry dust and ceramic tile waste as partial replacements for fine and coarse aggregates, respectively, in concrete production. To address the challenges related to quarry dust was used to replace fine aggregate and ceramic tile waste were used to replace coarse aggregate at replacement levels of 0%, 10%, 20%, and 30%. Medium (M35 & M40) grade concrete will be adopted; a constant water cement ratio of 0.370 for M35& 0.423 for M40 will be maintained for all the concrete mixes. The performance of concrete was assessed through compressive strength and splitting tensile strength tests of hardened concrete will be found out in this study at 7 and 28 days for each percentage of replacement. 3 numbers specimens for each replacement percentage will be casted and tested with corresponding tests and finally compared with conventional M35 and M40 concrete.
Keywords— Ceramic tile waste, quarry dust, sieve analysis, compressive strength, split tensile strength

I. INTRODUCTION

Concrete is one of the most widely used construction materials in the world and plays a crucial role in infrastructure development. Aggregates constitute approximately 70–75% of the total volume of concrete and significantly influence its strength, durability, and overall performance. The increasing demand for concrete in modern construction has led to excessive consumption of natural resources such as river sand and crushed stone aggregates, resulting in environmental degradation and depletion of available reserves. Ceramic products are manufactured at extremely high temperatures between 1000°C-1250°C which results in very hard, highly resistant to chemical, freezing and thermal shock. Ceramic tile industries generate a substantial amount of waste during manufacturing, transportation, and installation processes. The use of stone dust as a partial replacement for natural sand can reduce the dependence on river sand and contribute to sustainable construction practices. The incorporation of ceramic waste and quarry dust in concrete not only helps in waste management but also conserves natural resources and reduces the environmental impact associated with aggregate extraction.

The development of concrete properties was observed by replacement of crushed stone coarse aggregate with ceramic tile waste aggregate and sand fine aggregate with stone dust aggregate. Compressive strength was unchanged when ceramic tile waste and stone dust are used partially to replace conventional crushed natural stone coarse aggregate and sand fine aggregate.

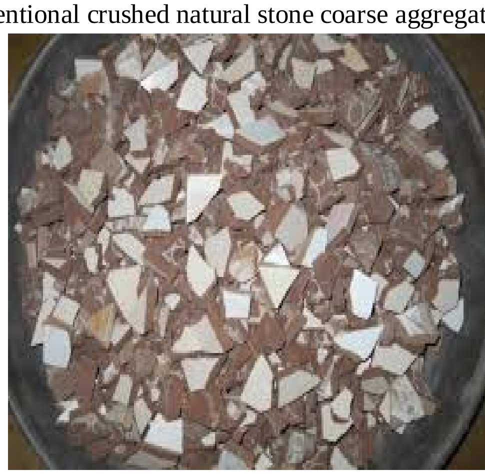

Fig 1: Ceramic tile waste Aggregate

Fig 2: Stone/Quarry dust Aggregate

II. REVIEWS OF LITERATURE WORKS

Numerous researchers have investigated the use of ceramic waste and quarry dust as sustainable alternatives to natural aggregates in concrete production. Studies by Abdullah et al. (2006, 2008, 2013) demonstrated that ceramic waste can effectively replace coarse aggregates, producing concrete with strength characteristics comparable to conventional concrete. Although ceramic aggregate concrete generally exhibited lower density and slightly reduced workability due to higher water absorption, its compressive strength remained within acceptable limits for structural applications.

Senthamarai and Manoharan (2005, 2011) reported that concrete containing ceramic waste aggregates showed mechanical and durability properties similar to conventional concrete. While permeability-related characteristics such as water absorption and chloride penetration were slightly higher, the overall performance remained satisfactory. Sekar et al. (2011) also observed that concrete produced with ceramic tile waste exhibited compressive, tensile, and flexural strengths comparable to conventional concrete.

Several researchers identified optimum replacement levels for ceramic waste aggregates. Hemanth Kumar et al. (2015), Marwein et al. (2016), and Subedi et al. (2020) found that replacing natural aggregates with ceramic waste up to 20–30% improved or maintained compressive strength. Similarly, Giridhar et al. (2015) concluded that up to 40% replacement of coarse aggregate with ceramic waste could be adopted without significant loss in strength, while Singh and Singla (2015) reported satisfactory performance up to 20% replacement. Mandavi et al. (2015) observed enhanced strength and durability when ceramic waste was used as a fine aggregate replacement, with an optimum replacement level of approximately 40%.

Research on quarry dust has also shown promising results. Borsare et al. (2021), Prasath et al. (2019), Balamurugan and Perumal (2013), and Chauhan and Bondre (2015) reported that partial replacement of natural sand with quarry dust improved compressive strength, particularly within the range of 30–50%. However, excessive replacement levels tended to reduce workability due to the higher water absorption and finer particle size of quarry dust. Poonam et al. (2015) further noted that quarry dust could replace up to 75% of natural sand while maintaining satisfactory strength characteristics.

Other studies have explored alternative waste materials such as marble dust and construction and demolition waste. Demirel (2010) found that waste marble dust enhanced compressive strength and reduced environmental pollution when used as a fine aggregate substitute. Ramadevi (2017) highlighted the economic and environmental benefits of utilizing ceramic waste as a replacement for natural sand in concrete.

Most previous studies have focused on the individual use of either ceramic tile waste or quarry dust as a replacement for natural aggregates. Research on the combined utilization of these two waste materials in concrete is limited, particularly regarding their combined influence on strength, workability, and durability characteristics.

III. OBJECTIVE OF THE PRESENT STUDY

1) To investigate the physical parameters of using ceramic tile waste and quarry dust as partial replacements for aggregates in concrete.
2) Design medium grades of concrete with partial replacement of fine aggregates and coarse aggregate with variable percentages of ceramic tile waste and quarry dust.
3) To determine the effects of varying percentages of ceramic tile waste and quarry dust on the workability, compressive strength, and tensile strength of concrete.
4) To compare the performance of concrete mixes with ceramic tile waste and quarry dust.As substitutes with conventional

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concrete (without these replacements) for grades (M35 and M40).

IV. EXPERIMENTAL WORK

The concrete mix was designed using conventional aggregates and ceramic tile waste aggregates with a maximum aggregate size of 20 mm graded aggregate. The study investigated the variation in the strength properties of hardened concrete by partially replacing conventional coarse aggregates with ceramic tile waste and sand fine aggregate with stone dust at replacement levels 10%, 20%, 30%.

Concrete was prepared in the laboratory using a concrete mixer. Initially, cement, fine aggregate (sand), coarse aggregate (natural crushed stone) was thoroughly mixed in a dry state. The required quantity of water was then added, and the mixture was further mixed to obtain a homogeneous concrete mix. Similarly concrete mixes were prepared with mixing of cement, fine aggregate and coarse aggregate replacement with stone dust and ceramic tile waste with replacement level 10%, 20% and 30%.

The fresh concrete mixes were placed into moulds and compacted in three layers using a tamping rod to eliminate air voids. Cube specimens of size 150 mm × 150 mm × 150 mm and cylinder specimens of size 100 mm x 300 mm were cast for compressive strength and split tensile strength testing respectively. The moulds were tightly secured during casting to maintain the required dimensions and shape of the specimens.

After 24 hours, the specimens were demoulded and immersed in a water curing tank. The cubes were cured for periods of 7and 28 days and cylinders were cured for periods of 28 days. At the end of each curing period, the specimens were removed from the curing tank and tested for compressive strength and split tensile strength. The obtained results were compared with those of conventional concrete to evaluate the effectiveness of the partial replacement of aggregates with ceramic tile waste and stone dust materials.

Table 1: Mix Proportions for M35 grade Design Mix

Mix	Coarse Aggregates kg/m3		Fine Aggregates kg/m3		Cement (OPC) (kg/m³)	W/C Ratio	Admixture (Conplast SP430G8, Fosroc) (kg/m³)
	Natural Coarse Aggregate (kg/m³)	Ceramic Tile Waste Aggregate (CTWA) (kg/m³)	Sand (kg/m³)	Stone Dust (kg/m³)			
Mix$_{0.370}$ (C_0S_0)	1247.07	—	634.26	—	443.9	0.37	4.439 @1%
Mix1 ($C_{10}S_{10}$)	1122.32	124.71 @10%	570.83	63.43 @10%			
Mix2 ($C_{20}S_{20}$)	997.66	249.41 @20%	507.41	126.85 @20%			
Mix3 ($C_{30}S_{30}$)	872.95	374.12 @30%	443.98	190.28 @30%			

Table 2: Test result of 7 & 28 days Compressive strength at w/c ratio of 0.370 of M35 grade Design Mix

S.No	Mix	Replacement of C.A by CTWA in (%)	Replacement of F.A by S.D in (%)	7 days avg. comp. strength in (MPa)	28 Days Avg. comp. strength in (MPa)
1	C_OS_0	0	0	26.4	37.82
2	$C_{10}S_{10}$	10	10	27.05	39.5
3	$C_{20}S_{20}$	20	20	28.24	42.36

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4	$C_{30}S_{30}$	30	30	26.48	38.04

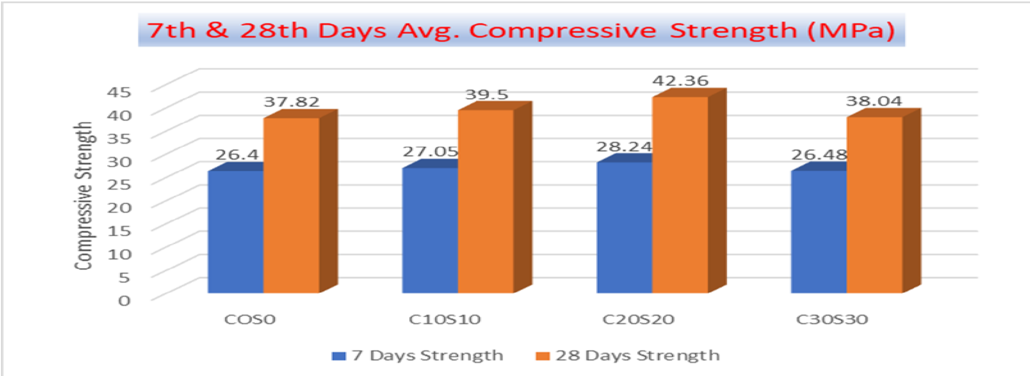

Fig 3: 7- & 28-days Compressive strength test result of **M35**

Table 3: Test result of 28 days Split tensile strength at w/c ratio of 0.370 of M35 grade Design Mix

S.No	Mix	Replacement of C.A by CTWA in (%)	Replacement of F.A by S.D in (%)	28 days avg. Split Tensile strength in (MPa)
1	C_OS_0	0	0	3.26
2	$C_{10}S_{10}$	10	10	3.32
3	$C_{20}S_{20}$	20	20	3.44
4	$C_{30}S_{30}$	30	30	3.12

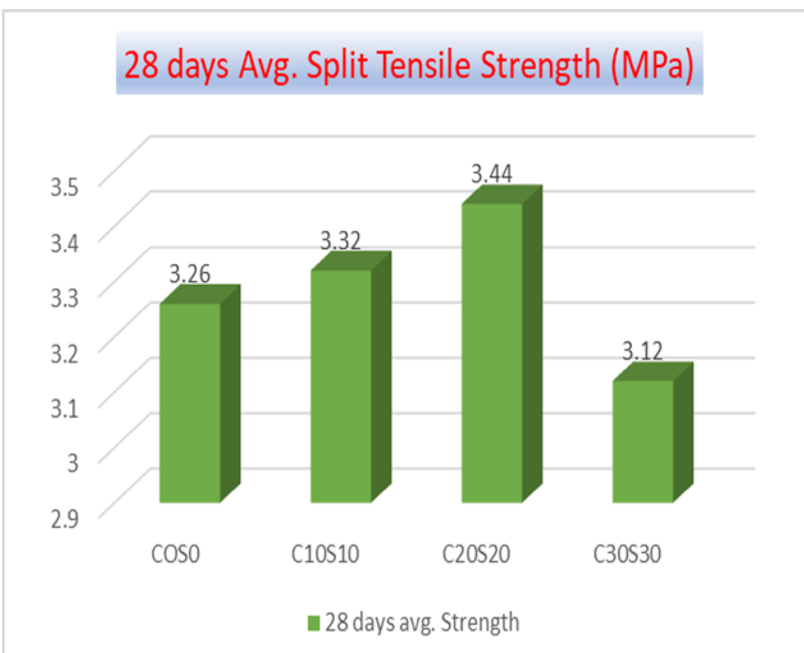

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Fig 4: 28-days split tensile strength test result of M35

Table 4: Mix Proportions for M40 grade Design Mix

Mix	Coarse Aggregates kg/m3		Fine Aggregates kg/m3		Cement (OPC) (kg/m³)	W/C Ratio	Admixture (Conplast SP430G8, Fosroc) (kg/m³)
	Natural Coarse Aggregate (kg/m³)	Ceramic Tile Waste Aggregate (CTWA) (kg/m³)	Sand (kg/m³)	Stone Dust (kg/m³)			
$Mix_{0.423}$ (C_0S_0)	1176.49	—	627.87	—	448.08	0.423	4.4808 @1%
Mix1 ($C_{10}S_{10}$)	1058.84	117.65 @10%	565.08	62.79 @10%			
Mix2 ($C_{20}S_{20}$)	941.19	235.30 @20%	502.3	125.57 @20%			
Mix3 ($C_{30}S_{30}$)	823.54	352.95 @30%	439.51	188.36 @20%			

Table 5: Test result of 7 & 28 days Compressive strength at w/c ratio of 0.423 of M40 grade Design Mix

S.No	Mix	Replacement of C.A by CTWA in (%)	Replacement of F.A by S.D in (%)	7 days avg. comp. strength in (MPa)	28 days avg. comp. strength in (MPa)
1	C_OS_0	0	0	31.64	42.53
2	$C_{10}S_{10}$	10	10	32.07	44.24
3	$C_{20}S_{20}$	20	20	33.75	47.15
4	$C_{30}S_{30}$	30	30	31.24	42.96

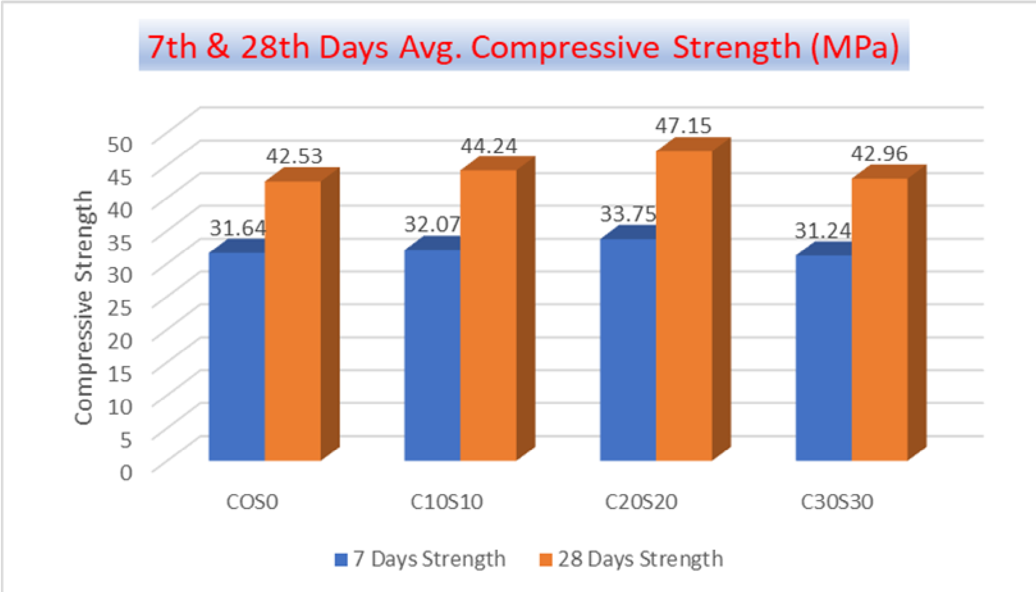

Fig 5: 7- & 28-days Compressive strength test result of **M40**

Table 6: Test result of 28 days Split tensile strength at w/c ratio of 0.423 of M40 grade Design Mix

S.No	Mix	Replacement of C.A by CTWA in (%)	Replacement of F.A by S.D in (%)	28 days avg. Split Tensile strength in (MPa)
1	C_OS_0	0	0	3.52
2	$C_{10}S_{10}$	10	10	3.86
3	$C_{20}S_{20}$	20	20	4.31
4	$C_{30}S_{30}$	30	30	3.56

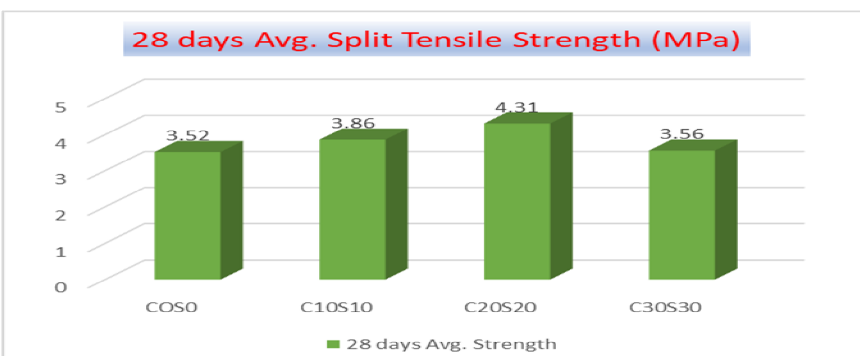

Fig 6: 28-days split tensile strength test result of **M40**

V. RESULTS AND DISCUSSIONS

These inferences were made considering the test findings.

- The compressive strength and split tensile strength of concrete increased up to optimum percentage 20 % replacement of ceramic tile waste and stone dust with coarse aggregate and fine aggregate respectively.
- The compressive strength and split tensile strength increase when stone dust and ceramic tile waste replace fine aggregate and

coarse aggregate respectively up to a maximum of 20%; after that, they decrease for both M35 & M40 grade concrete.

- The study further established that the optimum replacement percentage of ceramic tile waste and quarry dust can produce concrete with mechanical properties comparable to or even better than conventional concrete.
- The use of ceramic tile waste and quarry dust reduces the demand for natural aggregates, minimizes environmental degradation caused by quarrying activities, and helps in the management of industrial and construction waste.
- The utilization of ceramic tile waste and quarry dust in concrete is a sustainable and eco-friendly approach that supports green construction practices and promotes resource conservation in the construction industry.
- The replacement materials are locally available and economical, thereby reducing the overall cost of concrete production.

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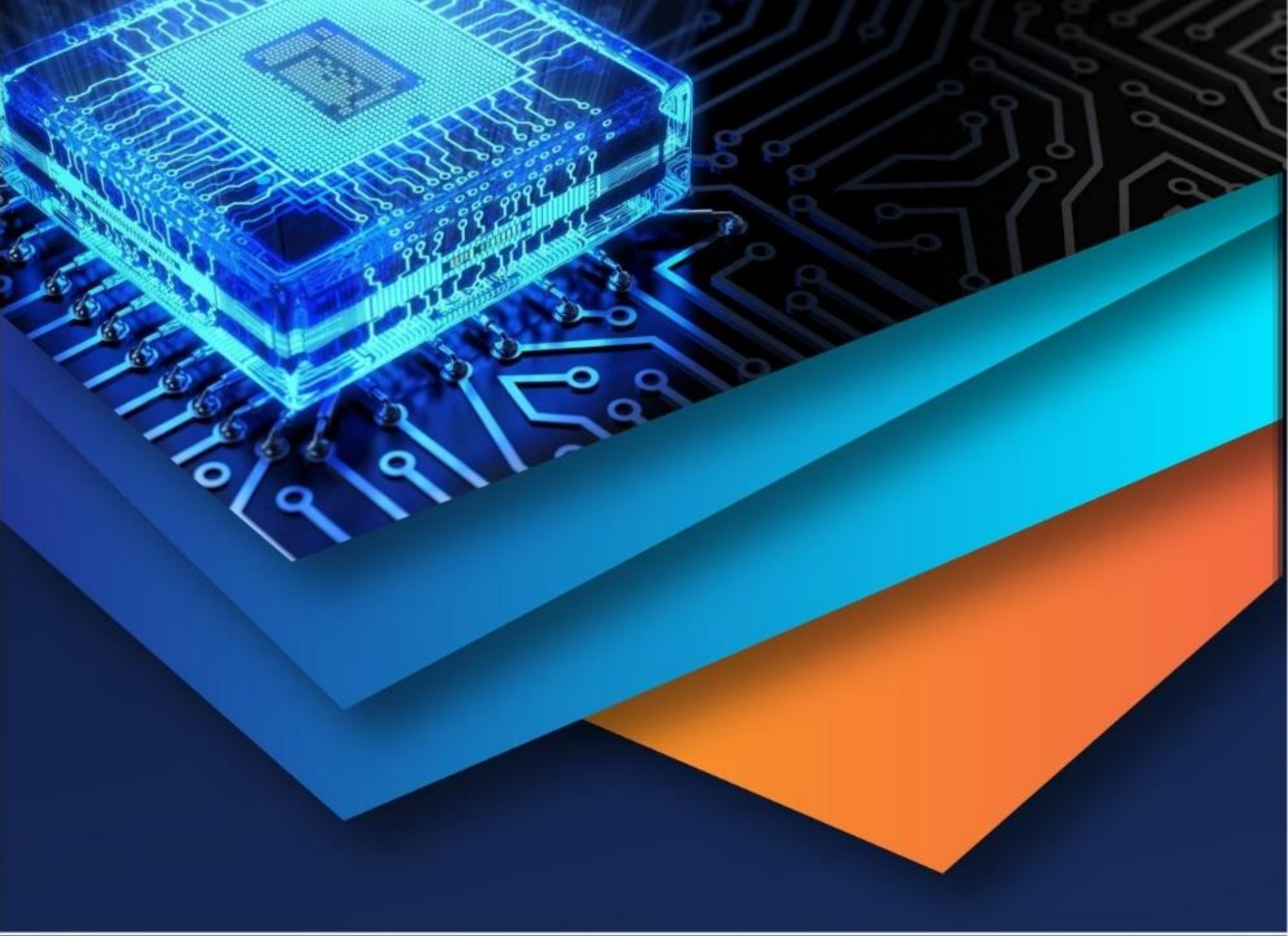

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