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Influence of Sand Particles on Strength and Durability of Mortar (1:3)

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Abstract: ***In recent years, research has been devoted for the improvement of the masonry mortar in order to achieve the optimum results towards the strength and durability. An experimental programme is presented in order to evaluate the influence of sand grading for the mortar mix (1:3) keeping the water cement ratio 0.5 constant. Six types of mortar mixes were prepared in the form of 70.6mmx70.6mmx70.6mm cubes confirming IS-10086-1982. Mortar specimens were cured for 7, 28 and 90 days through which compressive strength was tested for 7, 28 and 90 days, Drying shrinkage test was conducted on 250mmx25mmx25mm bar for 3, 7 and 35 days of moisture curing. Water absorption for 28 days and 90 days were observed and rest of the specimens were immersed in fresh water with solution of 3% HCL and 1% H_2SO_4 and tested at 30 days and 90 days from the day of immersion. Mix 04 with 60 % coarse and 40 % fine sand showing the optimum results toward the strength and durability.***

Keywords: ***Cement Mortar, Sand grading, Compressive strength, water absorption, shrinkage, HCL, H_2SO_4.***

I. INTRODUCTION

Mortar for the masonry work is a combination of cement, river sand and water. The mortar provides a level bed for the masonry. Study of different parameters like water cement ratio and particle size gradation is important. Every batch of sand receive is different from the previous supply [1]. Engineers have been looking for mortar which is ever stronger and more durable against aggressive environment. Mortar during its service life may expose to sulfate and acid attacks [2]. Fine aggregates (sand) make up the main bulk of masonry mortar therefore having the significant effect on the properties of product in both fresh and hardened state. The selection of suitable aggregate which are capable of producing a product with the optimum properties is very essential [3].

It has been found that mortar is influenced greatly by the type of sand and particle size grading of the sand. A preliminary study has been made to obtain information of the influence of sand grading on the properties of mortar .properties like Compressive strength and water absorption and durability has been studied to understand the effect of sand grading [4]. Modern mortars are typically made with a mixture of sand, a binder such as cement, pozzolanic materials and water. Engineers have been looking for mortar which is ever stronger and more durable against aggressive environments [5].

II. EXPERIMENTAL PROGRAMME

Under this programme different materials were selected. The cement was of OPC (43 grade) and physical, chemical properties of cement were determined. Similarly natural sand or river sand was used as a fine aggregate. These observations are described in the following sections.

A. Basic Materials and Their Properties

Ordinary Portland cement (OPC):- Ordinary Portland cement (ACC) brand comply with the Indian standards specification for 43 grade confirming IS-8112(2013) and tested as per IS – 4031.

1) *River Sand (Fine aggregate)*: Fine aggregate is classified in two categories according to the Particle size Fine sand (FS) is natural sand which is passing through both 2.36mm and 600µ IS-Sieves and retaining in the pan in oven dried condition. Second type is coarse sand (CS) which is natural sand which is passing through 2.36mm and retaining on 600µ IS-Sieve and retaining on the pan in oven dry condition. Concentrated acids HCL and H_2SO_4 were used for the durability test.
2) *Water:* Portable water was used for the mixing as well as curing purpose of the mortar.

TABLE I
CHEMICAL COMPOSITION OF OPC (43 GRADE)

Characteristics	Result Obtained	Requirement Confirming IS
% Soluble silica	22.5	---
% Alumina	5.0	---
% Iron oxide	2.9	---
% Lime	61.6	
% Magnesia	2.1	Not more than 6%
% Insoluble residue	2.6	Not more than 4%
% SO3	2.2	Not more than 3.5%
% loss of ignition	2.4	Not more than 5%
Lime saturation factor	0.847	Between 0.66 to 1.02
Proportion of alumina to iron oxide	1.72	Not less than 0.66
C3A	8.3	
% chloride	0.016	Not more than 0.1 %

B. Preparation of Samples

Six types of mixes (1:3) were casted. The water cement ratio was maintained constant at 0.5 for all six mortar mixes. The sand cement was mixed thoroughly to ensure the homogeneity of mixes and each sample were prepared taking the quality and method of the mixing into consideration.

Table ii
Physical properties of opc (43grade)

Test Conducted	Results Obtained	Requirement Confirming IS
Fineness m2/Kg	270	Not less than
Compressive Strength 3 days 7 days 28 days	 34.5 40 53.5	 Not less than23 Not less than33 Not less than Min43/Max58
Setting time (minutes) Initial Final	 190 260	 Not less than30 Not more than 600
Soundness Le-chatelier experiments. (mm) Autoclave expansion. (%)	 0.00 0.033	 Not more than 10mm Not more than 0.8%
a) Normal consistency (%) b) Temperature during testing (^{0}C) c) % fly ash added	26.8 27+/-2 2.9	 Not more than 5%

C. Different Mortar Mixes and Combination for (1:3) Cement Sand Mortar

TABLE III DIFFERENT MORTAR MIXES FOR 1:

Mixes	% Cement	W/C ratio	Sand (%)	
			Coarse Sand	Fine Sand
M31	100 %	0.5	100 %	0 %
M32	100 %	0.5	100 % passing 2.36 mm IS- sieve	
M33	100 %	0.5	70 %	30 %
M34	100 %	0.5	60 %	40 %
M35	100 %	0.5	50 %	50 %
M36	100 %	0.5	100 %	0 %

III. TESTING METHODOLOGY

Six types of mortar mixes were tested to evaluate compressive strength water absorption, drying shrinkage and acid attack test (durability). These tests were conducted on 70.6mmx70.6mmx70.6mm size cubes and 250mmx25mmx25mm shrinkage bar. The specimens were tested at different ages 7, 28 and 90 days compressive strength, water absorption for 28 and 90 days and drying shrinkage test for 3, 7, 35 and 90 day. The acid attack test conducted after initial water curing of 28 days. Durability test were determined by the compressive strength test. All six types of mixes were immersed in the solution of 3% HCL and 1% H_2SO_4 solution and were tested for 30 days after 28 days of initial water curing.

IV. RESULTS AND DISCUSSION

Following are some test results for the sand samples as well as other test conducted on the mortar mixes.

TABLE IV SPECIFIC GRAVITY OF FINE AGGREGATES

Sand Grading	Test Value
100 % CS	2.63
2.36 mm passing (conventional)	2.58
70 % CS + 30 % FS	2.64
60 % CS + 40 % FS	2.46
50 % CS + 50 % FS	2.48
100 % FS	2.42

Table 4 shows Specific gravity of fine aggregates calculated as per IS-2386 (part-3) for each mortar mix and for different sand grading.

TABLE V FINENESS MODULUS OF FINE AGGREGATE

Sand Grading	Test Value
100 % CS	2.72
2.36 mm passing (conventional)	3.36
70 % CS + 30 % FS	2.96
60 % CS + 40 % FS	2.80
50 % CS + 50 % FS	2.65
100 % FS	1.82

Table 5 shows the fineness modulus of different sand grading having value higher for coarser sand and lower for the finer sand as per the requirement of the Indian Standards.

Table 6 shows the compressive strength of different mixes which is average of three samples M31 shows poor results toward the compressive strength for 7, 28 and 90 days but M34 shows better compressive strength.

TABLE VI AVERAGE 7, 28 AND 90 DAYS COMPRESSIVE STRENGTH

Mortar Mix	Compressive Strength (N/mm^2)			Mix
	7 days	28 days	90 days	
M31	10.46	17.35	18.19	C:S
M32	15.82	17.98	19.41	C:S
M33	10.73	21.15	23.95	C:S
M34	20.81	28.67	34.86	C:S
M35	15.51	25.48	27.72	C:S
M36	16.58	26.23	28.33	C:S

In mortar mix M34, maximum values obtained are 20.81, 28.67 and 34.86 N/mm^2. Similarly Figure 1 shows the graded sand passing through 2.36 mm retained on 600 micron and passed through 600 micron. Figure 2 showing the Compressive strength test conducted in a concrete laboratory.

Fig.1 Sand Grading

Fig.2. Compression Test

TABLE VII
AVERAGE WATER ABSORPTION FOR 30 AND 90 DAYS

Mortar Mix	Average Water Absorption (%)	
	30 Days	90 Days
M31	7.01	4.71
M32	5.52	6.06
M33	6.06	3.83
M34	6.42	4.53
M35	6.42	3.31
M36	8.11	3.73

Average water absorption (%) is more for M36 after 30 days. Maximum average absorption value for M32 after 90 days was found.

TABLE VIII

Average Drying Shrinkage ΔLx (%)						
Age of Bar (Days)	M31	M32	M33	M34	M35	M36
3 Day	0.00	0.00	0.00	0.00	0.00	0.00
7 Day	0.0564	-0.0652	-0.084	-0.0263	0.0119	-0.0137
35Day	0.0245	0.031	-0.039	0.0984	0.0496	0.0825
90Day	0.0023	0.008	-0.077	0.0169	0.0695	0.0488

AVG. % DRYING SHRINKAGE FOR 3, 7, 35 AND 90 DAYS (1:3)

M31 shows the expansion or increase in the length for all three duration of testing. M33 shows the continuous reduction in the length at all ages. M32 shows initial shrinkage at 7 days and then expansion at 35 and days of moisture curing.
M35 is showing the expansion in length for 7, 35 and 90 days of curing and the values are 0.0119, 0.0496 and 0.0695 respectively. Initially mortar M34 shows shrinkage value -0.0263 but after 35 and 90 days it goes on increasing in length.

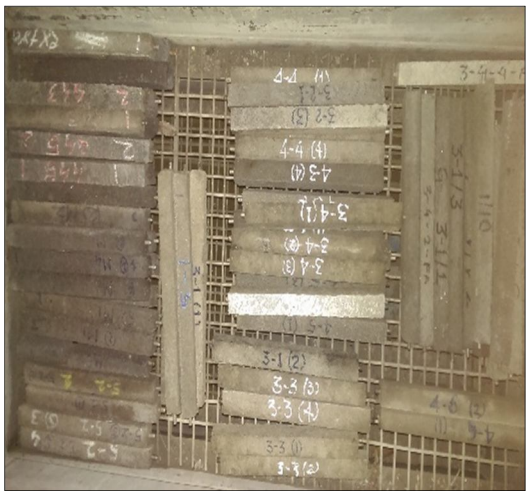

Fig.3. Drying Shrinkage Test

Fig. 4 Acid boxes with mortar

TABLE IX
AVG. COMPRESSIVE STRENGTH AFTER 30 & 60 DAYS IN ACIDS (1:3)

Following are the some observations for compressive strength after 30 and 60 days of immersion in acids. After 30 days of immersion in HCL strength of M31 reduced drastically from 17.35 to 11.55 N/mm^2. After 60 days the strength gets increased for M31 in H_2SO_4 solution. For M34 strength increases after 30 days of immersion from 28.67 to 30.53 N/mm^2 in H_2SO_4 solution and reduced after 60 days of immersion to 19.26 N/mm^2.

Mixes	Avg. Compressive Strength after 28 days Water Curing (N/mm2)	Avg. Compressive Strength (N/mm2)			
		After 30 Days Immersion		After 60 Days Immersion	
		3 % HCL Solution	1% H_2SO_4 Solution	3 % HCL Solution	1% H_2SO_4 Solution
M31	17.35	11.55	17.34	11.09	18.16
M32	17.98	18.57	17.93	20.73	19.15
M33	21.15	19.84	18.67	17.25	19.52
M34	28.67	27.33	30.53	21.94	19.26
M35	25.48	21.45	23.93	20.98	22.48
M36	26.23	23.66	23.47	23.12	22.14

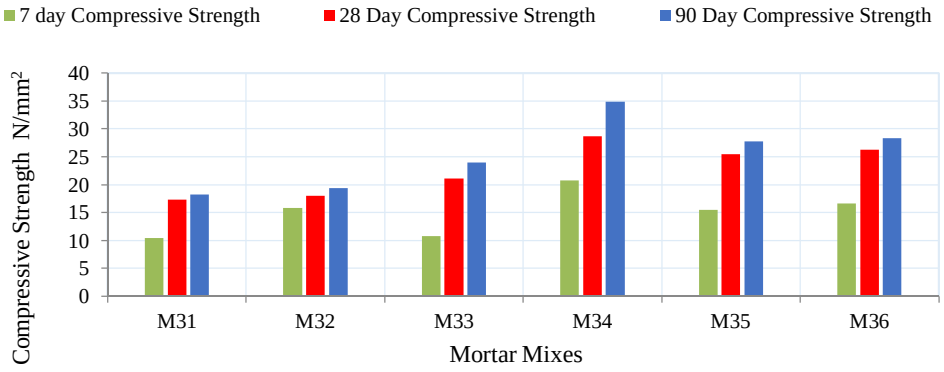

Fig.5 Average compressive strength for 7, 28 and 90 days (1:3)

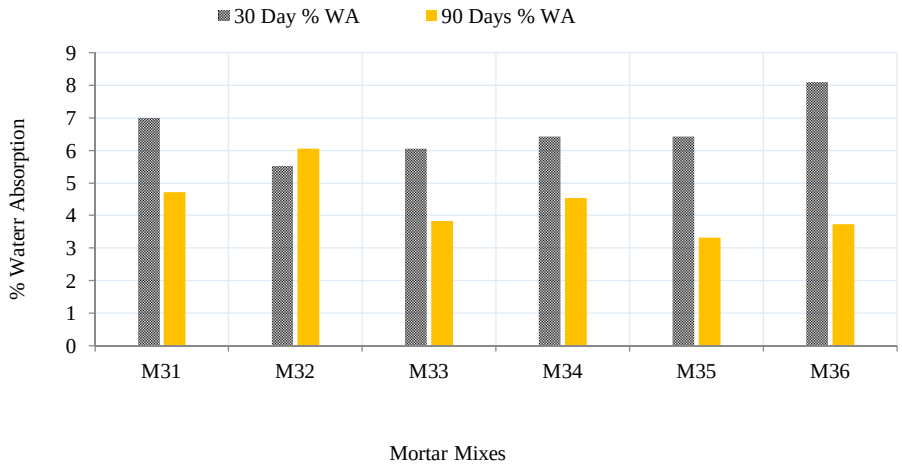

Fig.6 Average % water absorption for 30 and 90 days (1:3)

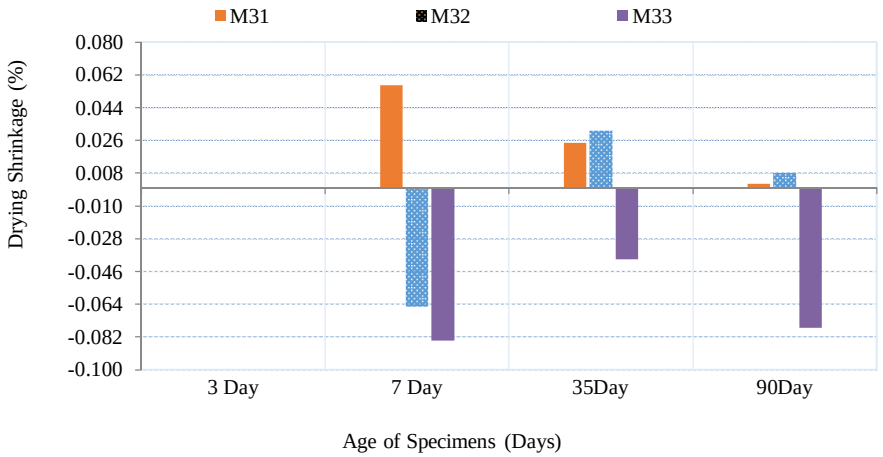

Fig.7 Average drying shrinkage for M31, M32 and M33 (1:3)

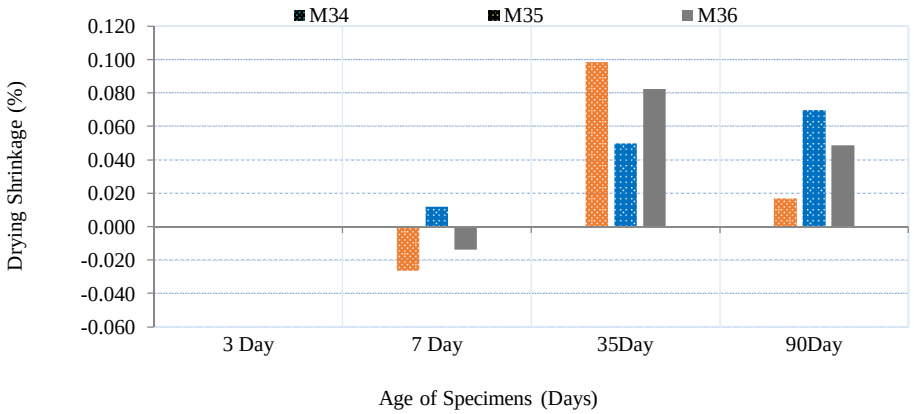

Fig.8 Average drying shrinkage for M34, M35 and M36 (1:3)

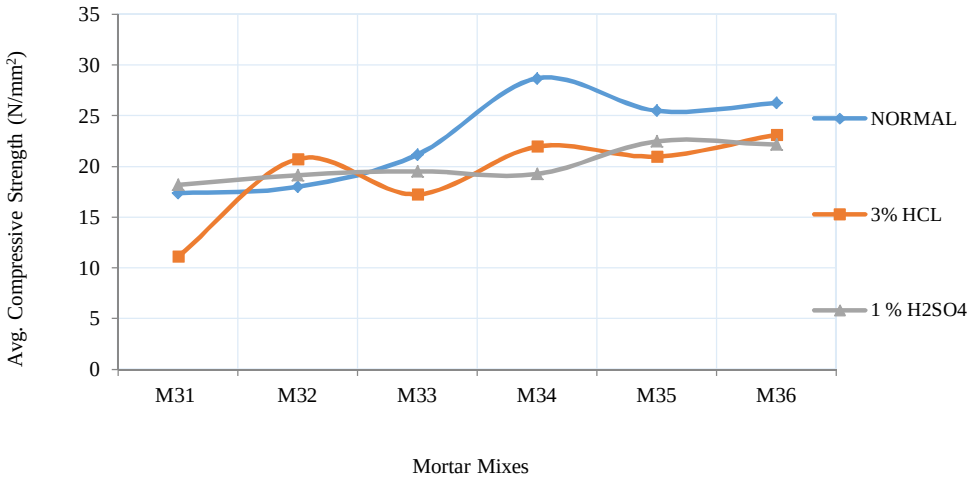

Fig.9 Comp. Strength after 30 days of immersion in Acids (1:3)

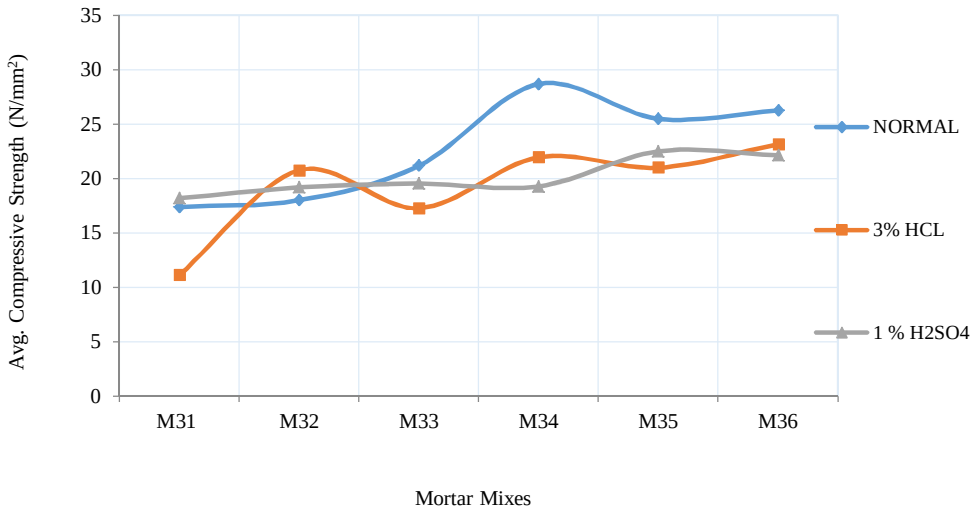

Fig.10 Comp. Strength after 60 days of immersion in Acids (1:3)

V. CONCLUSIONS

Mortar mixes with sand gradation showed the variation in compressive strength for 1:3 cement sand mortar. M31 (100 % CS + 0 % FS) have the least 7, 28 and 90 day strength as 10.46, 17.35 and 18.19N/mm^2. M34 (60 % C + 40 % FS) showed maximum 28 day strength 28.67 N/mm^2. More water is absorbed after 30 days by M36 which is 8.11% and minimum water absorption was for M32. After 90 days there is reduction in absorption capacity of all the mortar mixes. M31 showed the expansion or increase in the length for 7, 35 and 90 days curing.

M35 shows the expansion in length for 7, 35 and 90 days of curing and the values are 0.0119, 0.0496 and 0.0695 respectively. Initially mortar M34 showed shrinkage value -0.0263 but after 35 and 90 days it showed expansion. After 30 days of immersion in HCL strength of M31 reduced drastically from 17.35 to 11.55N/mm^2. After 60 days the strength gets increased for M31 in H_2SO_4 solution.

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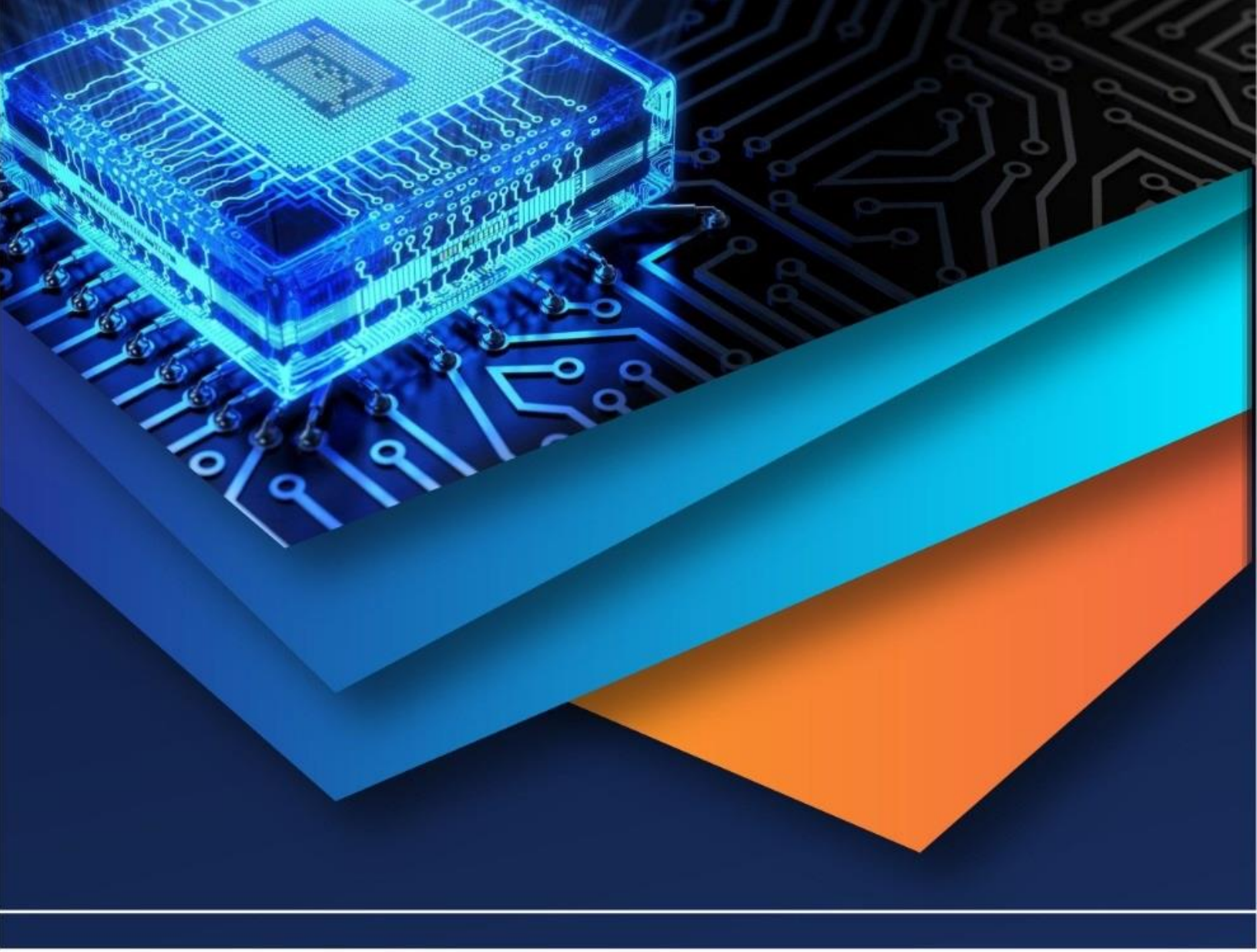

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