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Durability Behavior of Nano-Silica and OMMT Nano-Clay In High Performance Concrete

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Abstract: ***In this work here the nanomaterials are colloidal and one is in aqueous state and other one is powdered form, so the materials are in liquid form so the usage of water for the mix is also decreases and the as the mix design is done for M60 so the water use is also limited or designed and the additional use is restricted for the water. Here in this work study as a durability behaviour study in high performance concrete the 30% GGBS is used here as the admixture and the cement content is also reduced and the superplasticizer of epoxy based is used for the sitting of the concrete and the strength increasing liquid are used. This work carried out for the testing of the specimens with days of curing of 7, 14 & 28 days for the mechanical properties here flexure testing is not done due to usage of highly expensive nanomaterials in actions. In this testing determines the dosage of the nano silica. Firstly 2, 4 & 6% nano silica are added in respectively mixed in concrete and casted and cured and tested and the result shows the 2% as the optimum dosage in the mechanical properties as well as the durability properties. Secondly keeping 2% nano silica as the constant and the OMMT nano clay 2, 4 & 6% are added and mixed and casted and cured and mechanical properties are determined and as well as durability is determined as the objective of the work is defined and scope of the work also states the experimental analysis of the work with microstructure analysis like SEM and EDX are done with samples to determine the additional compositions in the concrete and the conclusions is also done with concluding the project work.***
Keywords: Nanomaterials, OMMT Nano-clay, Mechanical properties, Durability properties, Microstructure of specimen etc*.*

I. INTRODUCTION

Concrete is the second most used material after consumption of water. Continuous use of concrete constituents leads to scarcity of natural materials. To avoid this problem many researchers came with alternative solutions like adding admixtures, fibres, waste materials etc. nano-silica has potential for use in concrete and its application. Combination of slag and silica helps to gain more strength in less interval of time. Addition of 2% of nano-silica gives better strength properties [1]. The reduction in the size of the silica inclusions at an early age often boosted the strength of the slag mortars [2]. The test was conducted by [3] and observed that, the compressive and flexural strengths of both NS and NC were increased when compared to traditional mortar. The structural behaviour was studied by [4] and concluded that interaction of nanomaterials with calcium hydroxide Ca (OF) 2 crystals, which are arranged in the interfacial zone (ITZ) between cured cement paste and aggregates, is responsible for this enhancement this result in the formation of C- S-H gel and the filling effectof nanoparticles, which intensify microstructure. The durability properties were studied by [5] and noticed that adding nanoparticles to cementitious materials would increase their durability by changing the physicochemical characteristics of the binder.

The corrosion analysis were conducted and test findings were used to evaluate which nanomaterial concrete had the best mechanical characteristics and durability [6]. It has been discovered that nano silica, which ispozzolanic in nature and has a nice microstructure, would make an excellent substitute for cement [7]. And The results of X-ray diffraction (XRD) and scanning electron microscopy (SEM) have also been utilised to determine the particle distribution in the concrete specimen. The complete experiment demonstrates that using the right number of nano-composite components improves concrete specimen performance [8]. From various literatures it has been noticed that, the Nano materials based concrete structure fill all micro holes because it's thousand times smaller than in the case of conventional concrete materials.

The use of Nano materials helps in modifying properties and thus results into a more durable concrete. Increasing the content of binder improves the performance of the concrete mixture. Strengths and characterization there are optimal contents of NS & NC mass replacement of HPC matrix to obtain dense microstructure and highest mechanical strengths respectively. Strength of cement concrete increases proportionally with increasing the amount of Nano materials.

From above considerations an attempt is made to study the mechanical properties of nano-silica and nano-clay in HPC along with durability and microstructural properties.

II. MATERIALS AND METHODOLOGY

1) *Cement:* Here OPC 53 grade of cement is used and basic tests are conducted as per IS standards. The obtained results are tabulated below,

Fig 1: Cement.

Table 1: Cement properties.

Materials	Specifications	Values
Cement	Uniformity	29%
	Fineness,kg/m^3	275
	Specific gravity	3.15
	Soundness,mm	0.5-10

2) *GGBS:* GGBS was collected from RMC Plant used in the manufacturing of Concrete.

Fig 2 GGBS

Table2: GGBS properties.

GGBS	Colour	Off white/cream white
	Specific gravity	2.9
	Consistency	34%
	Fineness	382
	Residue on 45 micron	4.6%

3) *Fine Aggregates:* This test is done for the fineness modulus and classification on IS 2386 part 3 – 1963, 383-1970, 460-1962. For this test it required dry fine samples and sieve analysis apparatus of 4.75mm, 2.36mm, 1.18mm, 600Microns, 300microns, 150microns and pan and weighting scale.

Table3: Fine aggregate properties.

Fine Aggregates	Specific gravity	2.59-2.6
	Fineness	5.16-5.2
	Zone	I
	Bulk Density g/cc	1685

4) *Coarse Aggregates:* This test is done for the fineness modulus and classification on IS 2386 part 3 – 1963, 383- 1970, 460-1962. For this test it required dry fine samples and sieve analysis apparatus of 20mm, 16mm, 12.5mm, 10mm, 4.75mm and pan and weighting scale.

Table4: Coarse aggregate properties.

Coarse Aggregates	Water absorption	0.28-0.32
	Specific gravity	2.63
	Elongation index	9-10
	Flakiness	7.6-9.6

5) *Nano-Particles:* Nanoparticle dispersions are collections of nanoparticle suspensions in organic or inorganic solvents. Dispersions often have hardness, dimensional stability, and phase stability, which may be utilized to improve the characteristics of nanoparticles and regulate their functions. The mix design was calculated for M60 grade of concrete. The properties are tabulated below,

Table 5: Nano-particle properties

Nano Silica	Purity	99.9%
	Avg.particle size	20-50nm
	SSA	-220m3/g
	Bulk density	0.25g/cc
	Form	Liquid
	Dispersed in	Water
	Colour	White
Nanoclay	Appearance	Light Yellow
	Volatile Matter	2-4%
	Specific gravity	1.7
	Loss content	30%
	Code	250-84-090

Nomenclatures used in the project

- S1 – 100 % Cement mix (Conventional or Control Mix)
- S2 – 70% Cement + 30% GGBS
- S3 – 68% Cement + 2% Nano Silica + 30% GGBS
- S4 – 66% Cement + 4% Nano Silica + 30% GGBS
- S5 – 64% Cement + 6% Nano Silica + 30% GGBS
- S6 – 66% Cement + 2% NS + 2% Nano Clay + 30% GGBS
- S7 – 64% Cement + 2% NS + 4% Nano Clay + 30% GGBS
- S8 – 62% Cement + 2% NS + 6% Nano Clay + 30% GGBS

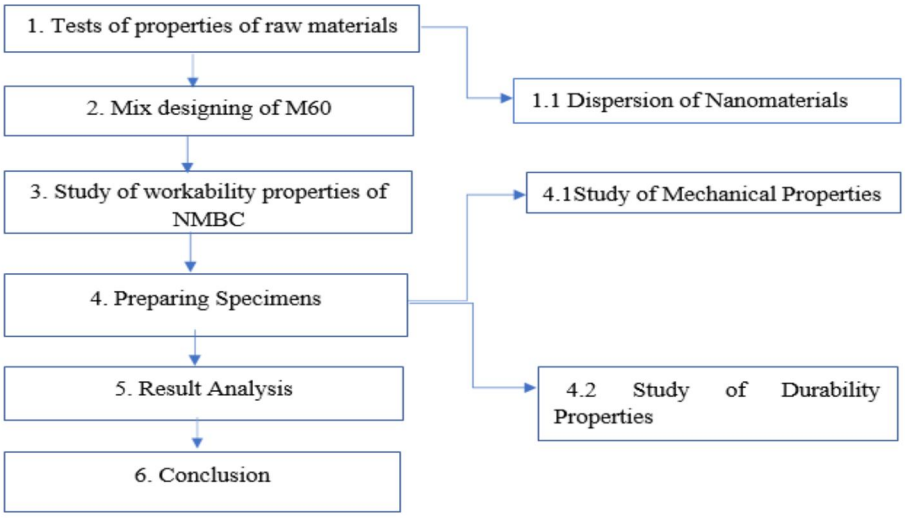


Fig3. Methodology followed

This above flowchart shows the study methods of used and the theories behind them in order to develop an approach this main is on the tests properties of the sample materials which are going to be used in the experiment study.

III. STRENGTH PROPERTIES

A. *Mechanical Properties*

1) *Compressive Strength:* The test specimens must be administered at known ages, with 7-14 and 28 days being the most common ranges.

Fig4. Compressive test

2) *Split Tensile Test:* It involves placing moulded under a load at a pace that stays within a set range until failure. The test specimens must be administered at known ages, with 7-14 and 28 days being the most common ranges.

Fig5. Split tensile test

3) *Durability Test*

a) *Water Absorption:* The quantity of water a material absorbs is known as its water absorption, and it is measured as the weight of the water absorbed divided by the weight of the dry material.

Fig 6. Water absorption test

b) *RCPT (Rapid Chloride Permeability Test):* In order to conduct the test, a 100mm diameter by 50mm thick slice of vacuumconditioned concrete is exposed to a potential of 60V DC. The samples are submerged in sodium chloride on one end and sodium hydroxide on the other. The entire test would take around three days to complete, with the actual test taking six hours.

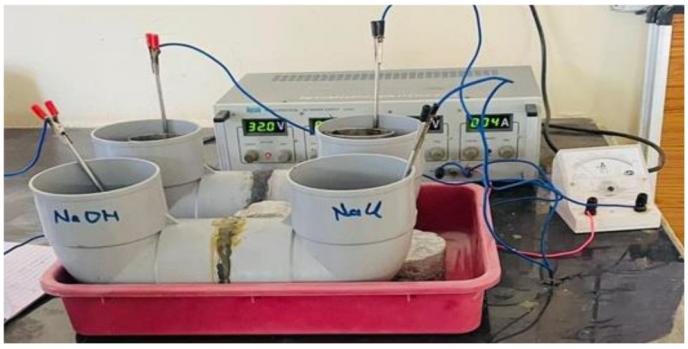


Fig7. RCPT setup

c) *Sorptivity Test:* It is the capacity of a material to absorb and transfer water through it by capillary suction. Sorptivity is a more and more common way to quantify concrete resistance to exposure to hostile settings.

Fig 8. Sorptivity test

4) *Microstructural Properties*

a) *SEM (Scanning Electron Microscope):* Using an electron beam to scan a material, scanning electron microscopy (SEM) creates a magnified picture that may be used for examination.

b) *EDAX (Energy Dispersive X-Ray Analyser):* Is a method for characterising a sample's chemical make-up or elemental composition. It depends on a sample and an X-ray excitation source interacting. The fundamental idea that every element has a different atomic structure, allowing for a different set of peaks on its electromagnetic emission spectrum, is a major factor in its ability to characterise things (which is the main principle of spectroscopy).

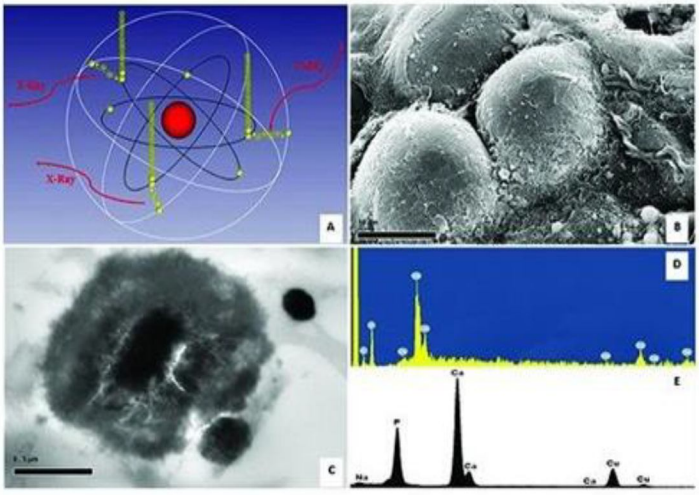


Fig9. EDX with SEM

IV. RESULT AND DISCUSSIONS

A. *Compressive Strength*

The compressive strength of samples with nanomaterials and conventional or control samples are been tested with curing period with respective days and was determined the results.

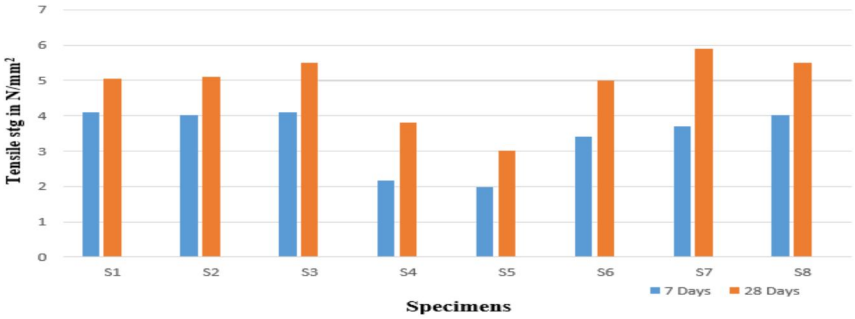
Table 6 shows the compressive stg results with the samples

Sl No.	Samples	Compressive Stg in N/mm^2		
		7 D	14D	28D
1	Conventional mix	41	53.61	63.21
2	30% GGBS	42	52	65
3	2% NS	46	57.10	69.23
4	4%NS	40	51.82	60.2
5	6%NS	39	48.24	59.12
6	2%NS+2%NCl	44	59.10	71.29
7	2%NS+4%NCl	47	60.36	75.63
8	2%NS+6%NCl	45	61.20	74.28

As S3, S4 & S5 is the nanomaterial sample and it is the addition of the 2%, 4% & 6% respectively of the addition of Nano silica. Here which don't known the dosage so in addition of increasing the NS % mix was done and the 2% NS is the more as compare to other two mix samples.

B. *Split Tensile Test*

The below shows the graphical representation of the tensile strength of the work carried out.

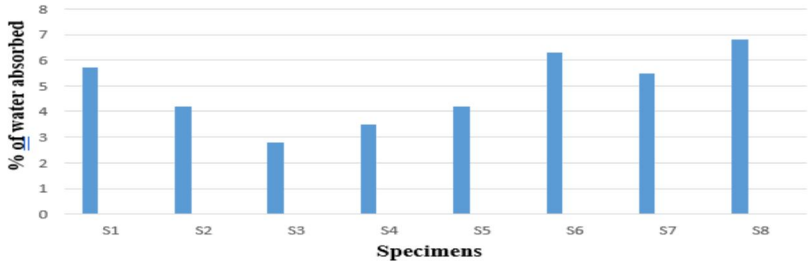


Graph 1 Tensile stg with 7 & 28 Days

The 2% nanosilica gives the more strength as compared to other mix due to the increasing the nano silica the also decreases so the 2% nano silica gives the satisfactory results in tensile test too. As the 2% NS is as the constant the 2, 4 & 6 OMMT NCl gives the desired strength and the 4% OMMT NCl with 2% NS gives the higher strength rather than the other two sample mix with OMMT NCl with NS of 2%.

C. *Water Absorption*

The below shows the graphical representation of water absorbed percentages for the 28 days of curing.

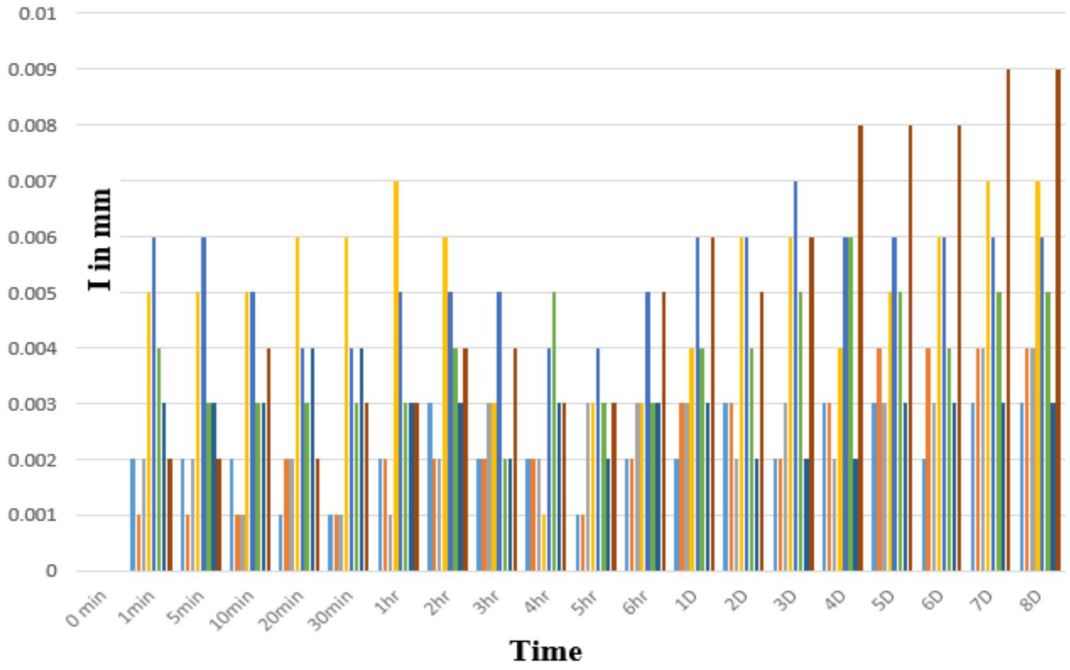


Graph 2 Water absorption test

The test results representation is shown above and from that the mix of 2% nano silica has the less water absorption as compared to other and in the hybrid mix the 2% nano silca and 4% NCl has the less absorption as other two mix has the more due to the excesses of nanomaterials in use also the durable decreases.

D. Sorptivity

The below graph shows the representation of graphical of the test results with satisfactory results as per the code with the density of water in the codeal provision.



Graph 3 Sorptivity test with samples

From this test it shows the initial time the water absorption goes with fluctuation in rising and falling up to till 6hr duration of time after the 2 days there is the rising and the days goes on there is difference in the reading of the results as the increasing.

E. RCPT

The obtained results of RCPT are tabulate below,

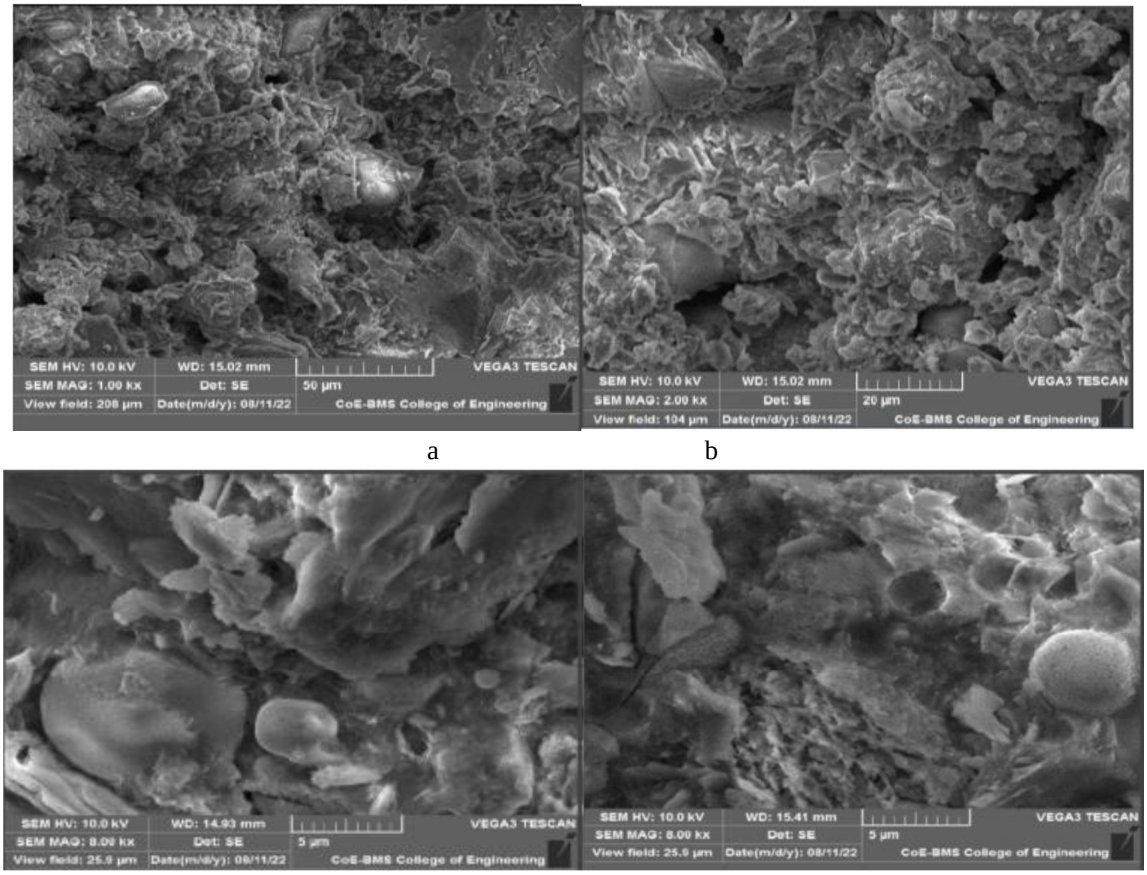
Table 7: RCPT with coulombs

Samples	Total Ain amps	Charge Passed in coulombs	Remarks
S1	0.61	2320	Moderate
S2	0.58	2130	Moderate
S3	0.50	1870	Low
S4	0.59	2130	Moderate
S5	0.64	2290	Moderate
S6	0.68	2448	Moderate
S7	0.56	1970	Low
S8	1.04	3774	Moderate

As the test results are tabulated and the charges passed in columbs are tabulated and the remarks are also given and tabulated in the above table with respect to code book observations. The 2% NS and the hybrid mix of the 4% NCl are the low penetrated chloride ions in the test and the other are moderately ions are penetrated but the concrete is in good conditions of cement are used in the experimental study.

F. SEM

The microstructure analysis SEM and EDX is carried out for the samples and the below images and discussions are carried out in the below with compositions with weights and atomic. This below sem image is shown for the 2% Nano silica with 6% OMMT NCl sample concrete with compositions of additional of GGBS which shows the scale of 10 nm with magnification of 3.50 and the this sem image high voltage accelerating electron scanning with secondary detect of the electrons with wide range sacle of 15.78 mm with the field view with respect to the sem high voltage of 10kilo volts with the field of 59.3 nm.



a b

c d

Fig 10 a) SEM image of conventional concrete b) SEM image of 30% GGBS c) SEM image of 2% NS d) SEM image of 2% NS + 4%NCl.

G. EDX Analysis

After the SEM analysis the EDX analysis is done to show or to know the element compositions mixed or additional with the atomic weight percentages. This analysis are done for the specimens of all samples with 28 days curing period.

V. CONCLUSIONS

1) In the testing the S1 & S2 gives the strength as the control mix the those two has to give the satisfactory results with increasing from curing period of strength with respectively.

2) The use of nanomaterials gives the strength more than the control mix in the use of addition of nano silica the 2% nano silica is has the more strength as compared to other two mixes. Here in the compressive test the 2% nano silica sample S3 is optimum.

3) This S3 and S7 are sample specimen of 2% Nano silica and the hybrid mix with 2% Nanosilica with 4% OMMT nanoclay.

4) The RCP test is one of the most durability test it shows the chloride attack on the sample specimen with charges of coulombs passed and this shows the passing remarks on the concrete conditions.

5) This images show the minute particle in the samples with CSH gel is also shown and the nanomaterials structure is also shown. In this images the 30% mix,GGBS is also shown and the determined for the presenting in the sample.

6) This EDX images shows not only the peaks but also with the elements presents in it with the detectors weather primary or secondary transmissions with magnifications of kiloelectrovolts (keV).

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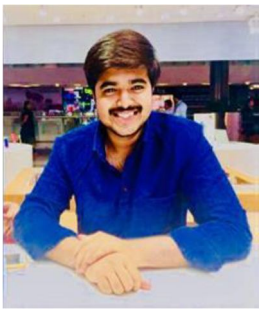

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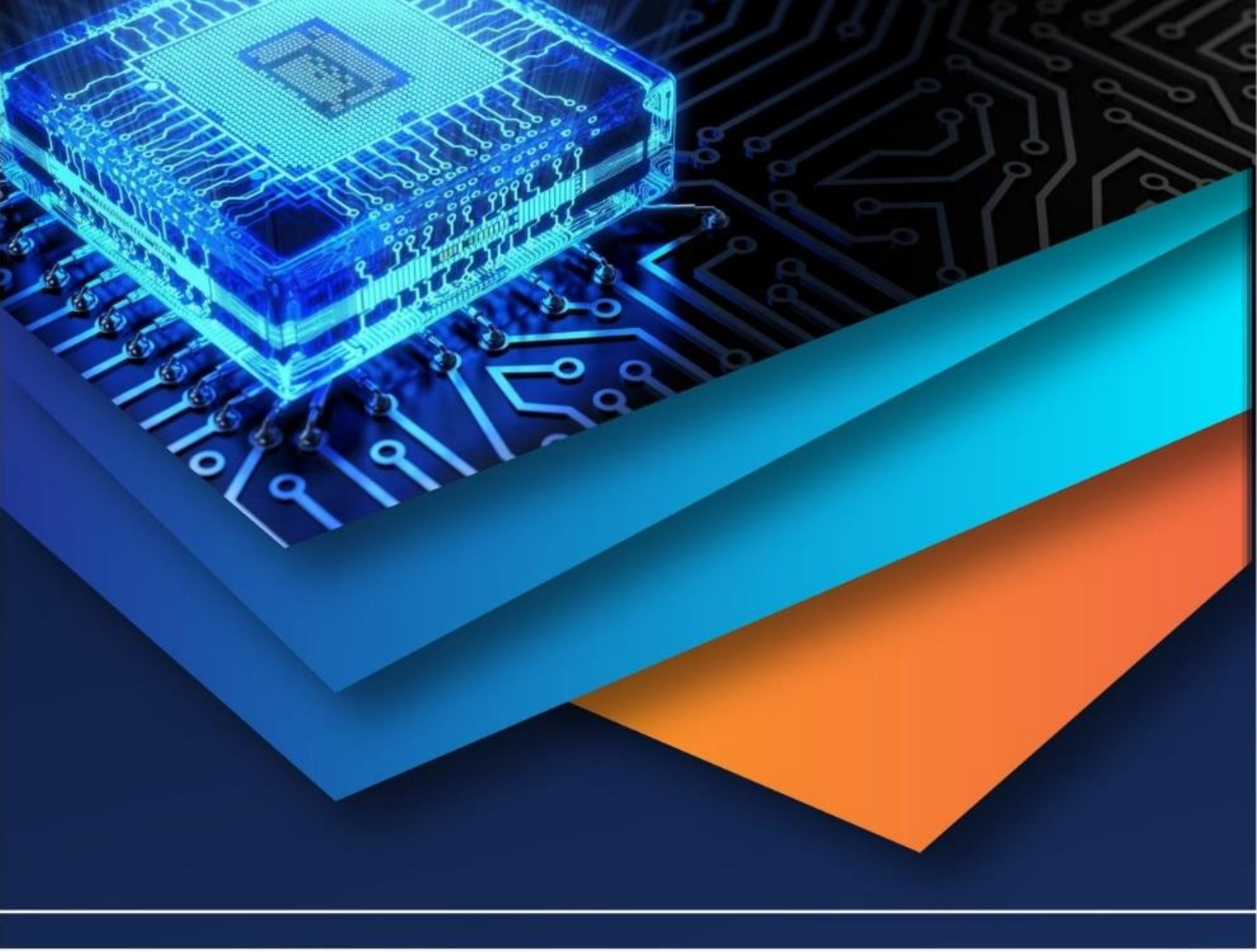

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