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Experimental Study on Bricks Using Water Treatment Sludge

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Abstract: ***Sludge resulting from water treatment plants creates problems of disposal. The sludge generated in most of the treatment systems around the world is discharged into the nearest watercourse, which leads to accumulative rise of aluminium concentrations in water and human bodies. The reuse of sludge as brick material is a long-term approach to sludge disposal for economic and environmental sustainability. The water treatment plant sludge is extremely close to brick clay in chemical composition. So, the sludge could be a potential substitute for brick clay. The objective of this study is to identify the possibilities of using the sludge obtained from water treatment plant. The properties such as crushing strength, water absorption and weight loss on ignition were carried out for various proportions. The results were compared with the standard limits.***
Keywords: Brick, Crushing Strength, Sludge, Water Absorption, weight loss on ignition.

I. INTRODUCTION

Improving drinking water quality has been a priority in India for many years. Chennai metro water board has five water treatment plants. High doses of coagulants and other chemicals are now used in water treatment to improve the drinking water quality. A typical water treatment plant (WTP) produces about 200,000 m^3 of sludge per day. This amount is expected to increase. Open landfills are normally used for sludge disposal. Chennai has the following water treatment plants

270 MLD WTP at Kilpauk,
300 MLD WTP at Puzhal,
180 MLD WTP at Vadakuthu,
530 MLD WTP at Chembarambakkam,
100 MLD Plant at Kattupalli, Minjur.

We collect the sludge from chembarambakkam treatment plant. There is a strong demand for environmentally safe reuse and effective disposal methods for sludge due to the increasing amount of sludge generated by the water treatment plants .While open land dumping are commonly used for disposal in chennai, rapid urbanization has made it increasingly difficult to find suitable dumping sites. Use of sludge as construction and building material converts the waste into useful products that can alleviate the disposal problems. In this project we partially replace the Water treatment plant sludge instead of clay. Widespread use of clay is mainly due to the availability of clay in most countries. Its durability and aesthetic appeal also contribute to its extensive application in both load bearing and non-load bearing structures. The properties of clay units depend on the mineralogical compositions of the clays used to manufacture the unit, the manufacturing process and the firing temperature. So we make the brick both in laboratory & also in brick chamber.

II. MATERIAL

A. CLAY

In brick-making terms, clay covers a range of naturally occurring raw materials which are used to make a product. The clays vary considerably in physical properties, colour, hardness etc, and mineralogical content. They do, however, have certain properties in common. They have the ability to be crushed and mixed with water to form a plastic material which can be moulded into various shapes. This can then be fired to a high temperature during which process it attains a hard, weather resistant characteristic. The key, in geological terms, is the mineral content of the raw material. This is common to all clay types. Pure clay mineral is formed from the erosion and weathering of primary igneous rocks. The clay mineral is transported away by the action of water, wind, ice etc., and re-deposited elsewhere. In the process it picks up a number of impurities, Quartz, mica, Calcium Carbonate (lime), Iron Oxide etc. The subsequent deposit becomes a sedimentary rock.

Due to variances in the age of the deposit, the conditions of its deposition and the impurities involved there will be variations between different clay types and even on occasions within the same deposit. These variations may affect the brick making process

and the properties of the finished product.

1) Chemical Composition & Its Functions

Chemical composition of brick clay is as follows

Silica	- 55%
Alumina	- 30%
Iron oxide	- 08%
Magnesia	-05%
Lime	-01%
Alkali and organic matter	-01%

a) Silica: Silica is present in brick clay as the chemical composition of alumina and forming silicate of alumina. Sometimes silica is present in pure form termed as flint. Silica prevents shrinking, cracking and warping of brick clay. High amount cause uniform texture. Too much presence of silica cause brick to be brittle.

b) Alumina: Alumina imparts plasticity to brick clay which is very important in moulding. It also imparts density. Excess alumina cause brick to crack

c) Iron: The presence of iron oxide increases impermeability and durability of brick. The colour of brick depend upon iron oxide and colour changes from light yellow to orange and red as iron oxide goes up to 8%.

d) Magnesia: Presence of small quantity of magnesia decreases shrinkage.

e) Lime: Lime melts silica in burning and binds the particles of brick together. It also reduces the shrinkage of brick during drying. Excess of lime cause the brick to fuse and shape will be lost.

B. Sludge

The sludge used in the study was the coagulant sludge withdrawn from the clariflocculation tanks of the Chembarambakkam Water Treatment Plant in which aluminium sulphate was used in the coagulation process. The alum sludge is composed of about 1 % of suspended solids and 99 % of water, which is difficult to dewater. The chemical composition of sludge was identified by using the X-ray fluorescence (XRF) spectrometer according to ASTM C114-00. The complete chemical composition of alum sludge is summarized in Table.1.

Ingredient	Ratio by weight (%)
SiO_2	43.12
Fe_2O_3	5.26
Al_2O_3	15.97
MgO	0.85
CaO	5.56
SO_3	1.49
Na_2O	0.52
K_2O	0.26
Cl	0.012
L.O.I	26.79

TABLE 1: chemical composition of alum sludge

It is obvious that is the major chemical compositions of the sludge were silicon, aluminium, and iron oxides, which are extremely similar to the major chemical compositions of the brick clay, but with higher alumina content...

The following three general criteria apply to any water treatment sludge:

1) The sludge must not be a hazardous waste;

2) The use of the sludge must not cause violations of applicable Department ground water or surface water standards and criteria; and

3) The sludge must not cause fugitive dust emissions or objectionable odours, or create a public nuisance. `

Fig.1 Sludge at Disposal Point in Wet State

Fig.2 Sludge at Open Dumped Area in Dry State

III. TESTING

The effect of moisture on the plastic behaviour of the pulverized materials is evaluated by the Atterberg limits test. Normally, non plastic soil has a plastic index (PI) value ranging from 0 to 5 and 15 to 30 for a low-plasticity soil. If the PI value is greater than 35, it is classified as having high plasticity. As per IS 1077-1992 the soil which is making to brick should have a plastic index value between 15 to 25.so we have to test the plastic index value of sludge & clay mixes for various ratios.

TABLE 2: Initial test results analysis

Ash proportion (%)		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX
CLAY	SLUDGE			
100	0	40.21	21.12	19.09
90	10	41.23	23.52	17.71
80	20	43.21	25.72	17.49
70	30	44.89	27.98	16.91
60	40	46.21	29.98	16.23
50	50	47.01	31.48	15.53
40	60	47.92	33.35	14.57

A. The results of Atterberg's tests of sludge-clay mixtures indicate that the value of PI is inversely proportional to the amount of sludge in the brick.

B. A PI value of 20.01 for clay alone shows the clay can be classified as a low-plasticity material.

C. The PI values shown in Table indicate that up to 50% of ash can be applied to brick making without losing the plastic behaviour.

D. So the sludge is replaced up to 50% instead of clay.

IV. BRICKS PREPARATION

A. A level surface is first prepared by using sand.

B. Thermo plastic sheet is placed over the level surface.

C. The required quantity of materials are taken and mixed by using trowel.

D. Required quantity of water is added to the dry mix of sludge & clay.

E. Mix properly till stiff form.

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F. The inner surface of plastic mould (220x110x70 mm) is immersed in the water properly.
G. The sludge & clay mix are placed in the mould & level it.
H. Then the brick should be dried in sunlight for 7 days.
I. Now place the brick in hot air for 12 hours at 1200^{o}C.
J. The brick is placed in open air for 2 days before testing.




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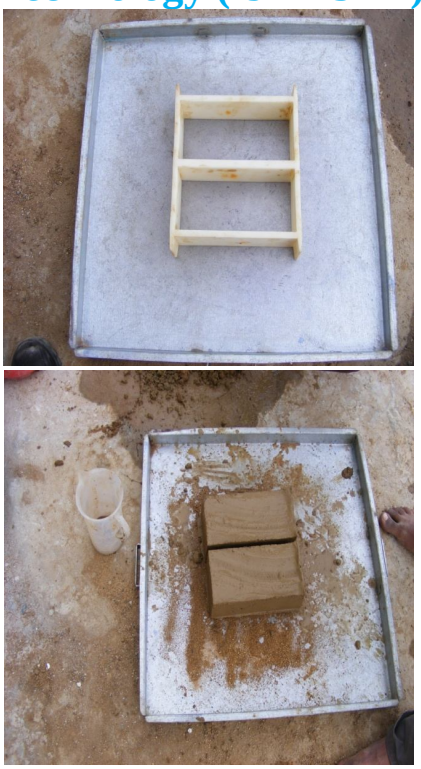

Fig.3 Brick Making Process in Laboratory

V. RESULTS AND DISCUSSIONS

A. *Compressive Strength Of Bricks*

SIZE OF THE BRICK = 220mm X 110mm X 70 mm AREA = 220mm X 110 mm

PROPORTIONS (%)		LOAD(kN)	COMPRESSIVE STRENGT (N/mm^2)	AVG. COMPRESSIVE STRENGTH (N/mm^2)
CLAY	SLUDGE			
100	0	291.12	12.03	12
		290.25	11.99	
		291.02	12.03	
90	10	225.16	9.03	9.06
		218.05	9.01	
		221.20	9.14	
80	20	201.10	8.31	8.08
		192.86	7.96	
		193.23	7.98	
70	30	175.65	7.28	7.24
		178.36	7.37	
		171.26	7.07	
60	40	146.56	6.06	5.71
		135.46	5.60	
		132.25	5.46	
50	50	112.32	4.64	4.50
		105.36	4.35	
		109.25	4.51	

TABLE 3: Compressive strength for bricks in various proportions

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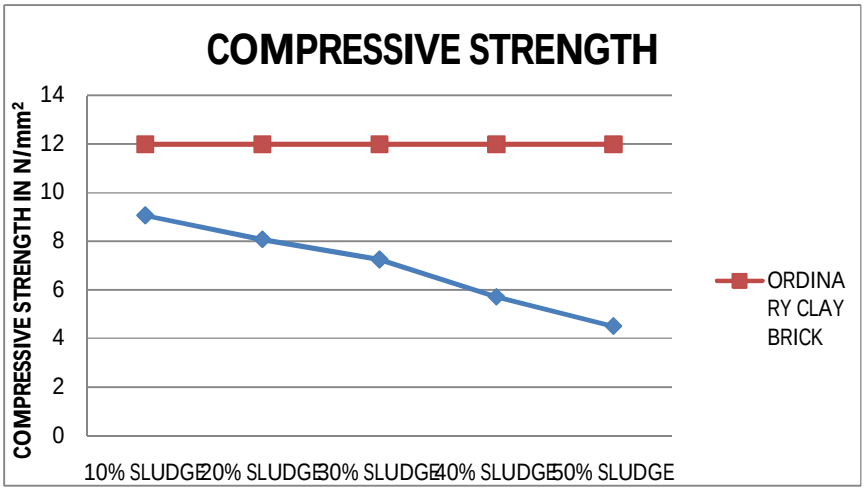

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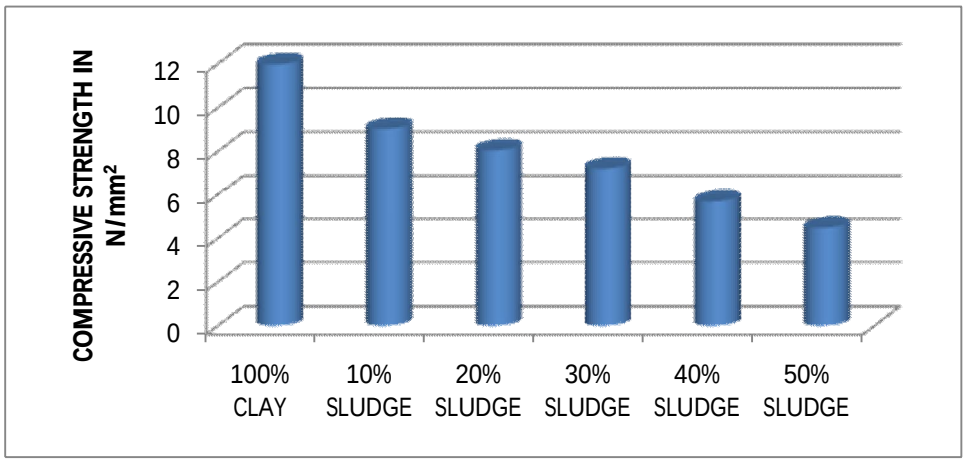

Fig.4 Variations of compressive strength of sludge clay brick with ordinary clay brick

As per Is 1077-1992 the minimum strength of brick should be 3.5 N/mm^2 & grade "A" brick should be 7-14 N/mm^2 & grade "AA" should be more than 14 N/mm^2. From this work, Grade "A" bricks has obtained up to 30% replacement of sludge. So it is recommended that these bricks can be allowed for construction purpose.

B. Water Absorption Test For Bricks

PROPORTIONS (%)		DRY WEIGHT OF BRICK (kg)	WEIGHT OF BRICK AFTER 24 HOURS IMMERSION (kg)	WATER ABSORBTIO (%)	AVG. WATER ABSORBTIO (%)
CLAY	SLUDGE				
100	0	3.02	3.23	7	7.20
		3.03	3.25	7.26	
		3.00	3.22	7.33	
90	10	2.93	3.18	8.53	8.53
		2.90	3.14	8.28	
		2.85	3.10	8.77	
80	20	2.75	3.01	9.45	9.48
		2.71	2.96	9.22	

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		2.76	3.03	9.78	
70	30	2.64	2.94	11.36	11.64
		2.66	2.98	12.03	
		2.60	2.90	11.54	
60	40	2.51	2.90	15.54	15.28
		2.49	2.86	14.86	
		2.46	2.84	15.45	
50	50	2.23	2.65	18.83	19.08
		2.25	2.68	19.11	
		2.28	2.72	19.29	

TABLE 4: Water absorption for bricks in various proportions

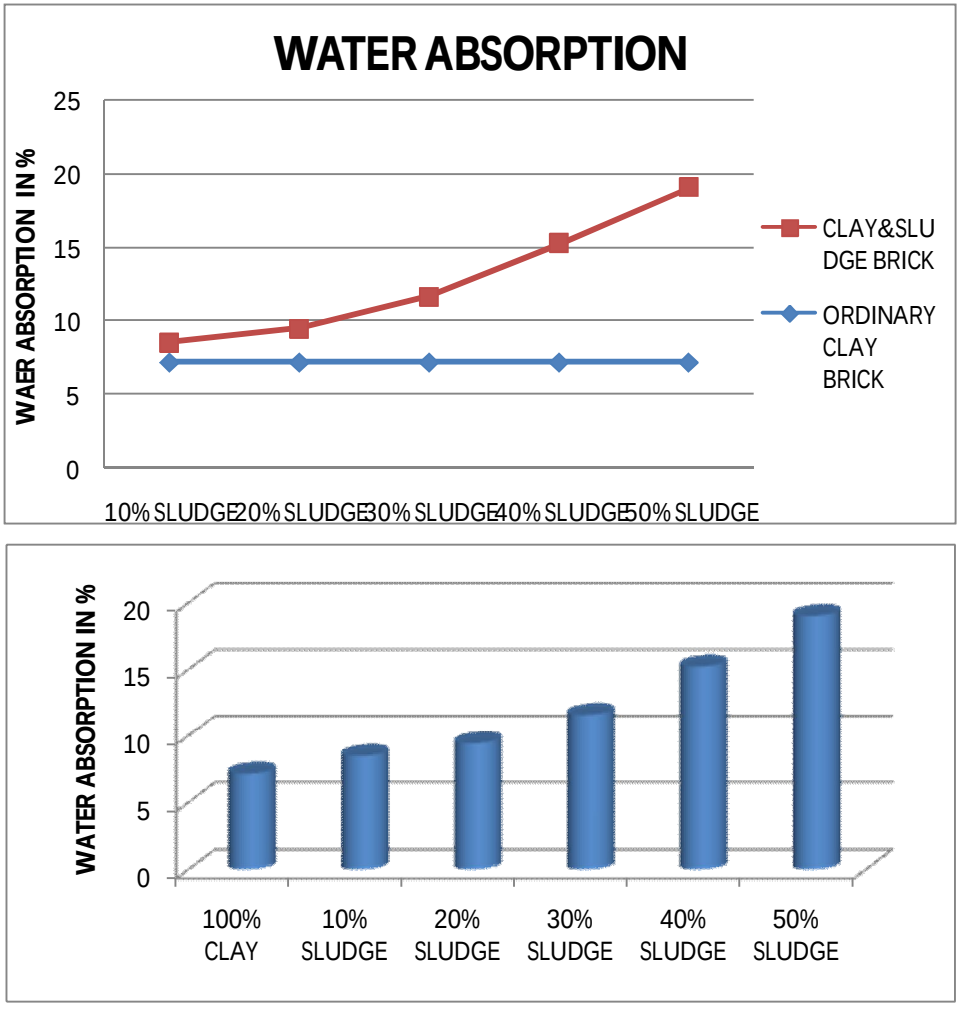


Fig 5: Variations of Water absorption of sludge clay brick with ordinary clay brick

Water absorption is a key factor affecting the durability of brick. The less water infiltrates into brick, the more durability of the brick and resistance to the natural environment are expected. Thus, the internal structure of the brick must be intensive enough to avoid the intrusion of water. The water absorption was determined by using the procedures described in IS1077-1992.

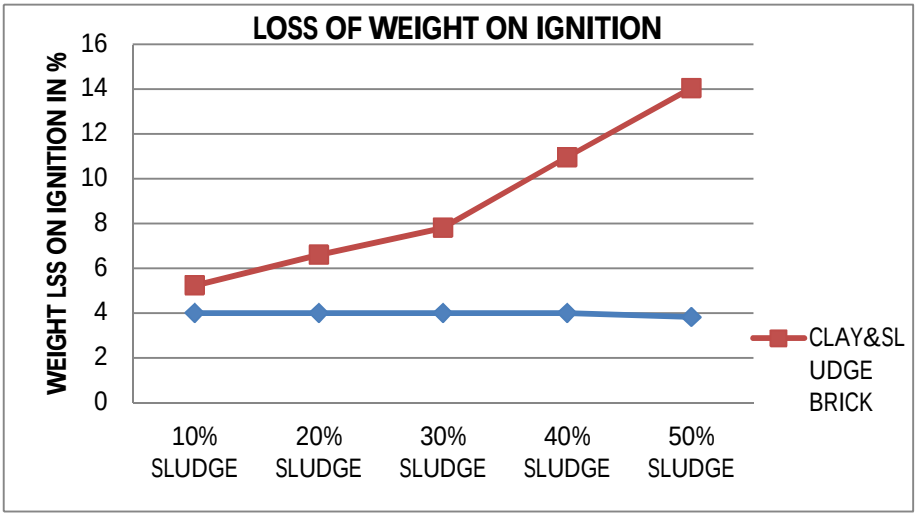
Fig.5 shows the results of the water absorption tests for various Sludge-clay mixtures. From the Fig.5 the value of water absorption is directly proportional to the quantity of Sludge added. The bonding ability of the mixture is apparently related to the amount of sludge added to the mixture. The previously reported PI values have revealed that the addition of Sludge could lower the plastic

nature of the mixture, thereby decreasing its bonding ability. If the mixture contains a rather high percentage of Sludge, the adhesivity of the mixture decreases, but the internal pore of the brick increases. As a result, the quantity of absorbed water increases. However As per IS1077-1992 the maximum water absorption of brick should be 20%.In this work; all the samples are within this limit. So these bricks are recommended for construction purpose.

C. Brick Weight Loss On Ignition

PROPORTIONS (%)		WEIGHT OF BRICK BEFORE IGNITION (kg)	WEIGHT OF BRICK AFTER IGNITION (kg)	(%) OF WEIGHT LOSS	AVG. (%) OF WEIGHT LOSS
CLAY	SLUDGE				
100	0	3.14	3.02	3.82	4
		3.16	3.03	4.29	
		3.12	3.00	4.00	
90	10	3.10	2.93	5.48	5.24
		3.05	2.90	4.91	
		3.01	2.85	5.32	
80	20	2.95	2.75	6.78	6.61
		2.90	2.71	6.55	
		2.93	2.76	6.50	
70	30	2.86	2.64	7.69	7.82
		2.88	2.66	7.63	
		2.83	2.60	8.13	
60	40	2.80	2.51	10.35	10.97
		2.80	2.49	11.07	
		2.78	2.46	11.51	
50	50	2.60	2.23	14.23	14.23
		2.63	2.25	14.45	
		2.65	2.28	13.96	

TABLE 5 Weight loss on ignition for bricks in various proportions



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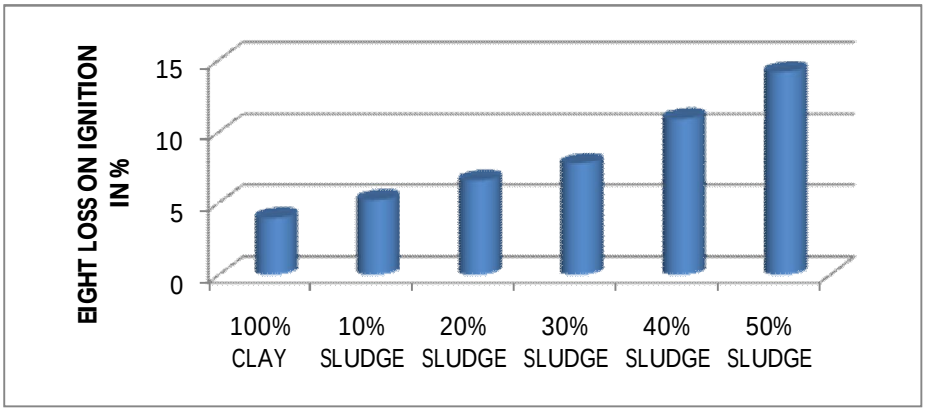

Fig.6 Variations of weight loss on ignition of sludge clay brick with ordinary clay brick

Fig.6 shows that the linear relationship between the ratio of clay & sludge and the weight loss on ignition. Organic matter content in each of the clay-sludge mixtures is predicted by extrapolation from the linear relationships between the weight loss and the sludge ratio. The maximum limit for weight loss on ignition As per IS1077-1992 is 15%.So these bricks are within the permissible limit & it is suitable for the construction purpose.

VI. CONCLUSION

Based on the experimental process executed in this research, and limited on both the tested materials and the testing procedures employed, the following conclusions had been reached:

A. Brick can be successfully produced from water treatment plant sludge incorporated with clay materials; which contain high silica content; under the conditions, mixing proportions, firing temperatures, and manufacturing methods used in this study.

B. The water treatment plant sludge almost resembled the brick clay in its chemical composition.

C. The test results of the research brick types were superior to both the research control clay brick types and commercial clay brick types available in the Indian market.

D. From this project we recommend, that these bricks will be used for the construction.

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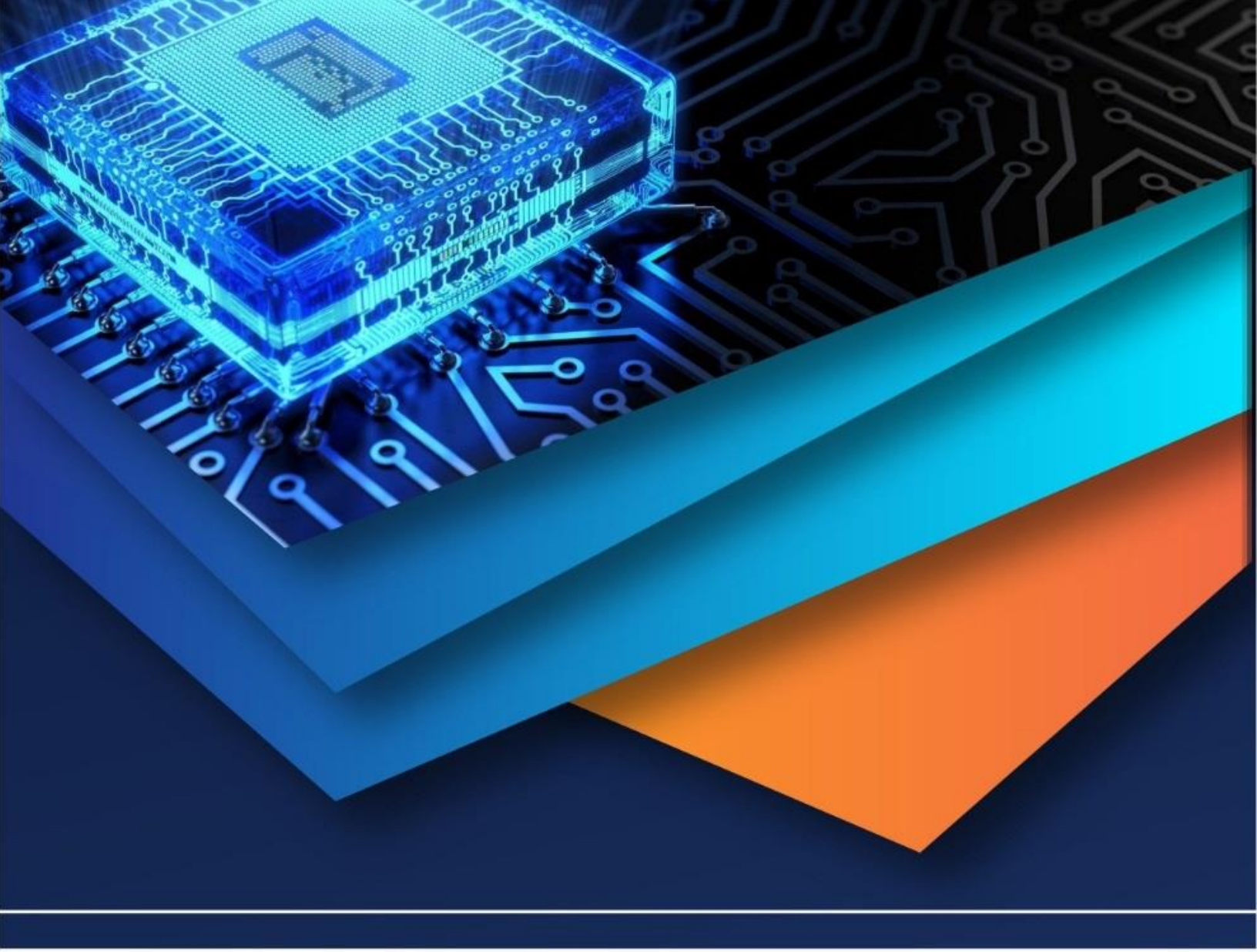

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