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Experimental Investigation on Effect of Spent Wash Usage in Mixing Water on Properties of Concrete

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Abstract: ***The by-product of sugar industry- distillery spent wash, is the unwanted residual liquid waste generated during alcohol production and pollution caused by it is one of the most critical environmental issue because it poses a serious threat to the water quality in several regions around the globe. Despite standards imposed on effluent quality, untreated or partially treated effluent very often finds access to water courses. The ever-increasing generation of distillery spent wash on the one hand and stringent legislative regulations of its disposal on the other has stimulated the need for developing new technologies to process this effluent efficiently and economically. This paper presents an overview on experimental study on usage of spent wash in concrete with various percentages and its alternative use in various sectors. The contribution of distillery waste i.e. spent wash on the mechanical properties of concrete is high compared to conventional concrete. In this study partial replacement of water has been done at 0%, 0.5%, 1%, 1.5% and 2% with Spent wash Compressive as well as acid curing test on concrete made with spent wash has been compared with conventional concrete of grade M40.***

Keywords: Spent Wash, strength, durability, environment, disposal.

I. INTRODUCTION

Industrialization produces lots of waste product are from every manufacturing industry. The main problem is to decompose this waste without disturbing the sustainability of the environment. Spent wash is a distillery waste having high BOD, COD and corrosive content which causes the extreme harm to cropping land and water resources after direct contact with spent wash. Most of water from natural sources get polluted due to wastewater emerging from chemical industries. India being a developing country establishing a large number of industries such as sugar, distillery, steel, paper, textile etc. that play important role in progress of the nation. These industries along with their product produce wastewater, which causes various environmental problems. However, wastewater characteristics are different from industry to industry. One such major chemical industry is distillery. India is a major producer of sugar in the world and this industry offer employment potential and contributes substantially to economic development. There are about 579 sugar mills and 285 distilleries in India. Apart from sugar and alcohol these industries generate many by product and waste material. Molasses, one of the important by product, is the chief source for the production of alcohol in distillery by fermentation method. This molasses contains 7-8 % glucose, which is converted into alcohol by fermentation process. First molasses is diluted by adding water to adjust the total dissolved solids up to 7-8%. Then yeast is added in diluted molasses solution and fermentation process takes place. As process go up glucose is converted into ethyl alcohol and carbon dioxide. This carbon dioxide is removed as a gaseous form, which is collected separately. After sufficient conversion of glucose into ethyl alcohol this solution is now called as a beer solution. This beer solution then passed through distillation column. Based on temperature difference ethyl alcohol is separated from the beer solution and condensed into liquid form. The wastewater from distillery column is called spent wash liquor About 40 billion liters of waste water annually discharged by the distilleries. The distillery spent wash in general practice discharge into local water bodies which cause pollution in water, underground water and soil. It also affects the aquatic life of these water bodies. When this polluted water is used for irrigation purpose it directly or indirectly affect the growth and productivity of plants like pea, wheat, rice, legumes and others. Spent wash contains the toxic parameters High COD, total nitrogen and total phosphate content of the effluent may result in eutrophication of natural water bodies. The demand of better concrete is increasing day by day. Improved quality of concrete will only perform better if concrete improve workability, durability, flow ability & resistance to chemical attack/corrosion and reduce w/c ratio, heat of hydration & segregation mainly. For the fulfillment of above properties waste produced from Sugar industries & other industries are used for effective & efficient strength & durability of concrete in various climatic conditions with addition of spent wash in mixing water of concrete.

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II. LITERATURE REVIEW

Literature review provides the historical review of concrete researchers mixed with spent wash along with the different parameters of different nature. The extensive literature review was carried out by referring standard journals, reference books, IS Code and conference proceeding. The major work carried out by different researchers is summarized below.

G.K.Arunvivek et al [2013] had performed experimental study on properties of fresh and hardened concrete made with distillery spent wash are presented and discussed. Proportions of 0-1.25% of distillery spent wash were added in concrete specimen.They found after elimination of excess reducing sugars and colored colloids from distillery spent wash, the properties of spent wash become similar to the properties of known super plasticizers, such as lingosulfonates or sulfated melamine formaldehyde and[2] naphthalene-formaldehyde resins. Thus, waste material of distillery units are good modifiers of the properties of concrete. Wide use of distillery spent wash in the construction industry saves cement; improves the quality of concrete mixtures; and solves ecological problems, because the wastes from distillery units is dumped to water bodies and fields, which causes pollution of the environment and acidifies the arable soils.

Sugiladevi et al [2019] Studied about the suitable replacements of cement as to reduce problems of global warming and to create sustainable environment. In India, 285 distilleries use sugarcane Spent wash. The initial setting time of cement paste was longest at 0.6% sugar content. Spent wash as a partial replacement of retarders.

They concluded that maximum strength was achieved at a Spent wash (0.5%), Ceramic powder (10%), Ceramic powder (10%) + Spent wash (0.5%) replacement of concrete materials. Replacement of Spent wash (0.5%) concrete cube attained maximum strength of 51.1 N/mm2 at 28 Days. Finally, this experiment concludes when the replacement of percentage of spent wash decreases it reduces the strength and the replacement of ceramic powder increases the strength while increases the replacement of materials. Ceramic powder is good insulating and naturally contains pozzolanas. The spent wash is one kind of superplasticizers and it act like a polymer against the polymerization process to increase the strength. The durability test provided the health enhancement of structure and the replacement is adopted for semi acid & acid region.

C.V.Naik et al [2018] have studied that, spent wash is distillery waste product of sugar industry and harmful if not properly treated and dispersed in water. Their study deals with the study of effect of mixing spent wash in water on index properties of black cotton soil. It can be economical and environmental friendly replacement option to water with improvement in index properties of black cotton soil. They investigated that, Spent wash contaminated water is harmful for aquatic life and human beings as pH, Hardness, Turbidity where highly greater as compared to potable water. The liquid limit for black cotton soil increases with increase in percentage of spent wash. Shrinkage limit decreases for black cotton soil with Increase in percentage of spent wash. Consistency limit increases for black cotton soil with increase in percentage of spent wash. The replacement of water by 5 % spent wash, as per local market rates, becomes economical.

III.MATERIALS USED IN EXPERIMENTAL WORK

A. Cement

Cement is a well known binding material and has occupied an indispensable place in construction works there are a variety of cement available in the market and each type is used under certain condition due to its special properties. The cement commonly used is Ordinary Portland cement in this project we are using 53 Grade cement. Accordingly the relevant test method may be choose from amongst the various test covered as per IS: 4031 (part-3) - 1996.

TABLE 1 PHYSICAL PROPERTIES OF CEMENT

Sr. No	Property	Results
1	Specific Gravity	3.15
2	Initial setting time	160 min
3	Final setting time	240 min
4	Fineness of cement	4%
5	Standard consistency	32%

B. Aggregate

Aggregate properties greatly influence the behaviour of concrete since they occupy 80% of the total volume of concrete. The aggregates are classified as Fine Aggregate & Coarse Aggregate. These aggregate are generally obtained from natural deposits of sand and gravel or from quarries by cutting rocks. Accordingly, the relevant test methods may be chosen from among the various tests covered as per IS: 2386 (Part-3)-1963

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Table 2 Physical Properties Of Coarse Aggregate

Sr. No	Name of test	Result
1	Particle size	20mm
2	Specific gravity	2.5
3	Water absorption	1%

Table 3 Physical Properties Of Coarse Aggregate

Sr. No	Name of test	Result
1	Particle size zone	Zone I
2	Specific gravity	2.6
3	Water absorption	0.5%

C. Spent wash

Production of ethyl alcohol in distilleries based on sugarcane molasses constitutes a major industry in Asia and South America. The world's total annual production of alcohol from sugarcane molasses is more than 13 million m3. The aqueous distillery effluent stream known as spent wash is a dark brown highly organic effluent and is approximately 12-15 times by volume of product alcohol. The disposal of distillery spent wash is of serious concern due to its large volume and high biological oxygen demand (BOD) and chemical oxygen demand (COD). Due to high concentration of organic load, distillery spent wash is a potential source of renewable energy.

TABLE 4 CHEMICAL PROPERTIES OF SPENT WASH

Element	PH	BOD (mg/l)	COD (mg/l)	N (mg/l)	K (mg/l)	Ca (mg/l)	S (mg/l)
Spent Wash	3.9	46,100	104,000	1660	960	2050	492

1) Mix Proportioning

The mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability as economically as possible. By using IS code IS 10262-2019.

2) Mix proportion for 1 m3 concrete

a) Cement = 458kg/m^3
b) Water = 192 kg/m^3
c) Fine aggregate = 662kg/m^3
d) Coarse aggregate = 1022kg/m^3
e) Water cement ratio = 0.42

IV. EXPERIMENTAL WORK

The percentage of spent wash is varied from 0 to 2 % with interval of 0.5%. The spent wash is replaced with quantity of water with specified percentage and it has been used as mixing water for experimental work.

A. Test Conducted on Fresh Concrete

Slump Cone Test-Slump of fresh concrete is done to determine the workability of fresh concrete by Slump cone test IS1199-2018 Part – 2. The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions.

B. Test Conducted on Hardened Concrete

Compressive strength of concrete Compressive test is important test conducted on harden concrete because most of the desired characteristics of concrete are qualitatively related to compressive strength, The main objective of the test is control of quality and to check that the concrete at site has developed required strength. The failure load was noted. For each percentage three cubes were tested and their average value is reported. The compressive strength was calculated as follows-

$$\text{Compressive Strength (MPa)} = \frac{\text{Failure load}}{\text{cross sectional area}}$$

$$F_c = \frac{P}{A}$$

Where,

P = Failure load in compression (N)

A = Loaded area of cube (mm^2)

V. RESULT AND DISCUSSION.

A. Slump Cone Test

The results obtained from slump cone test for various percentage of spent wash in mixing water is shown as below. From the Slump cone test it can be concluded that the concrete has low workability.

TABLE 5 WORKABILITY SLUMP CONE TEST

Sr. No	Mix designation	Percentage of Spent wash	Workability by slump cone test (Slump value in mm)
1	A0	0	10mm
2	A1	0.5	20mm
3	A2	1	20mm
4	A3	1.5	25mm
5	A4	2	35mm

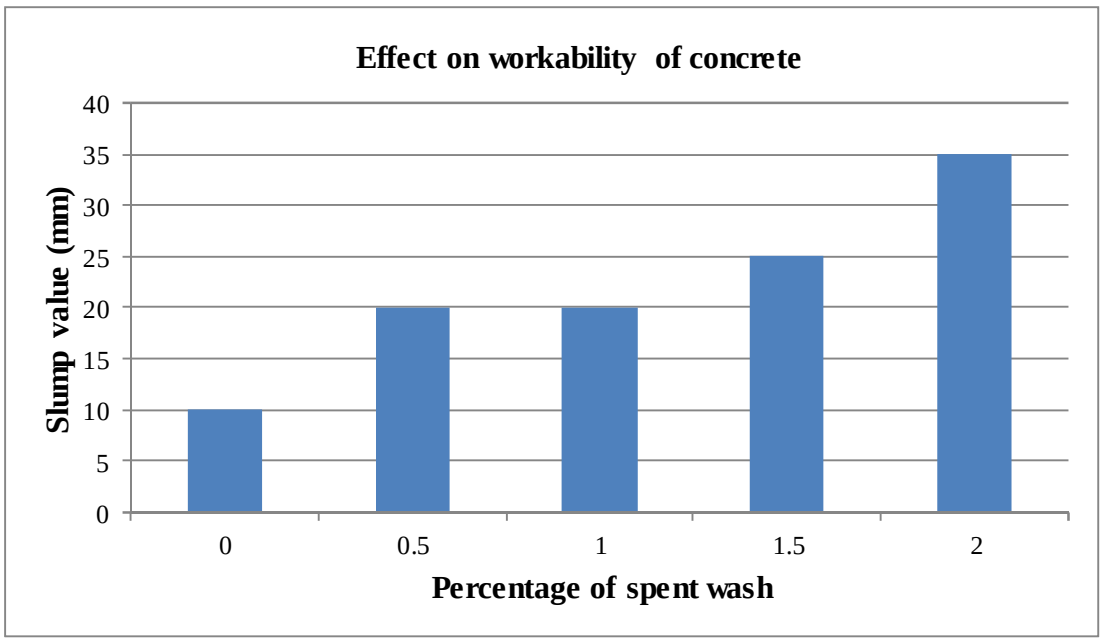


Fig. 1 Percentage of spent wash vs slump value

B. Compressive Strength test on Concrete

The results of compressive strength of spent wash mixing water concrete after 7days and 28 days are presented in following tables. The variation of compressive strength with respect to variation of percentage of spent wash is shown in following table.

Table 6 Compressive Strength Test

Sr. No	Mix designation	Percentage of Spent wash	Average Compressive Strength (MPa) (After 7 days)	Average Compressive Strength (MPa) (After 28 days)
1	A0	0	33.73	53.43
2	A1	0.5	39.68	51.58
3	A2	1	39.25	51.56
4	A3	1.5	38.70	54.33
5	A4	2	37.29	57.58

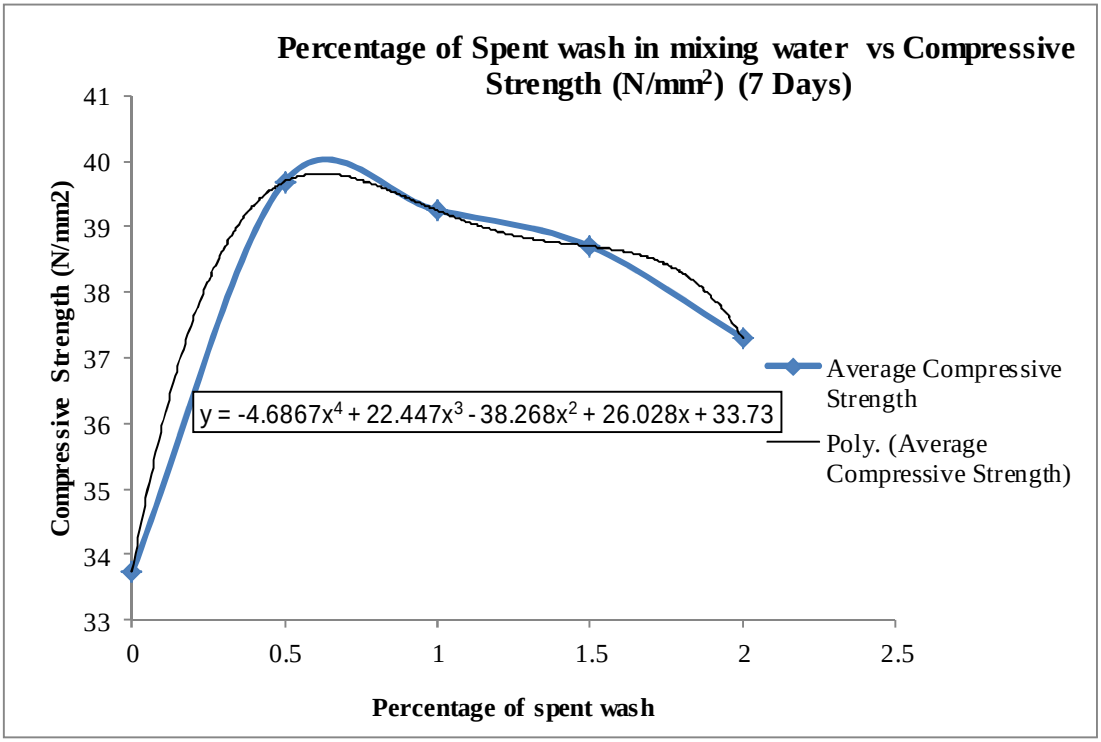


Fig. 2 Percentage of spent wash in mixing water vs. compressive strength of concrete after 7 days

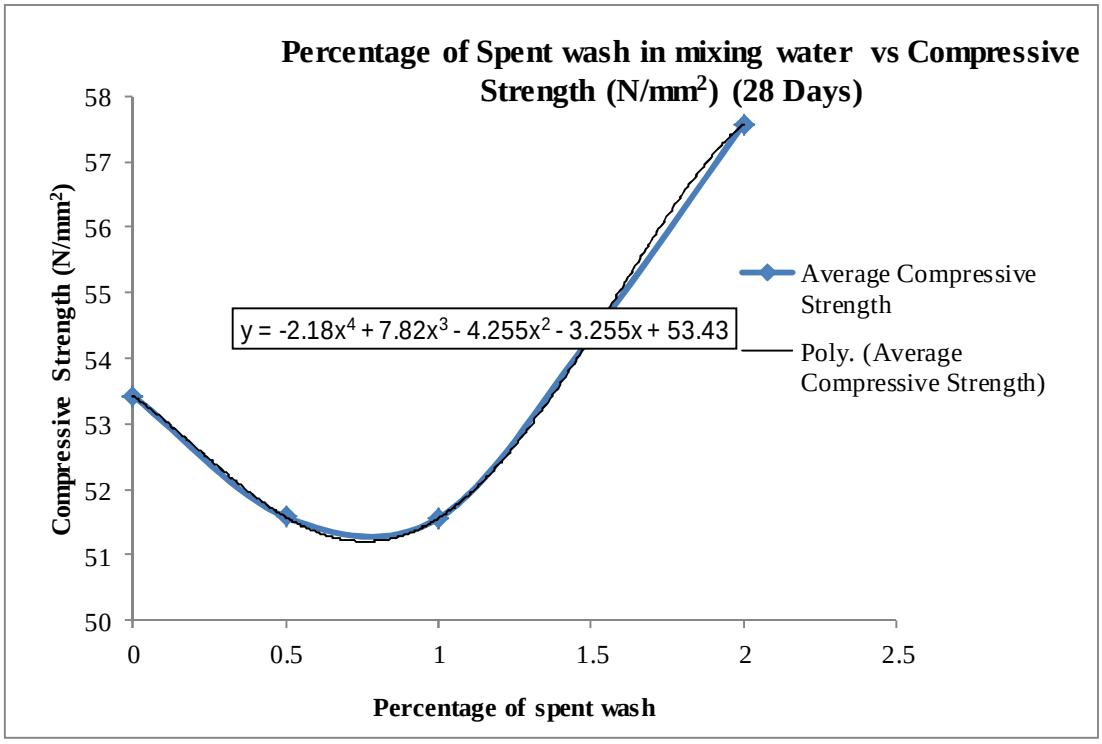


Fig. 3 Percentage of spent wash in mixing water vs. compressive strength of concrete after 28 days

VI. CONCLUSIONS

The present experimental study concludes that increase compressive strength of concrete in comparison to conventional concrete, there is a potential large market for concrete products in which inclusion of spent wash would be feasible which will utilize the spent wash. The following conclusions are drawn based on the results discussed in the previous section.

1) Spent wash is feasible solution for concrete production, economically and environmental. Study provides a solution for disposal of spent wash which can be used as 2% without affecting compressive strength up to certain limit.

2) The slump cone test concludes that, the concrete have workability after 1% and above replacement of spent wash in mixing water.

3) Experimental study concludes that increase in compressive strength of concrete for 1%, 1.5% and 2% of spent wash (28 days curing).

4) Significant changes were not observed in dry density of concrete with replacement of spent wash in mixing water over water.

5) Usage of spent wash for mixing water in concrete saves significant quantity of water. (For $1m^3$ of concrete 3.84 liters of water can saved) so one can utilize the distillery waste disposal and produce a cheaper concrete for construction.

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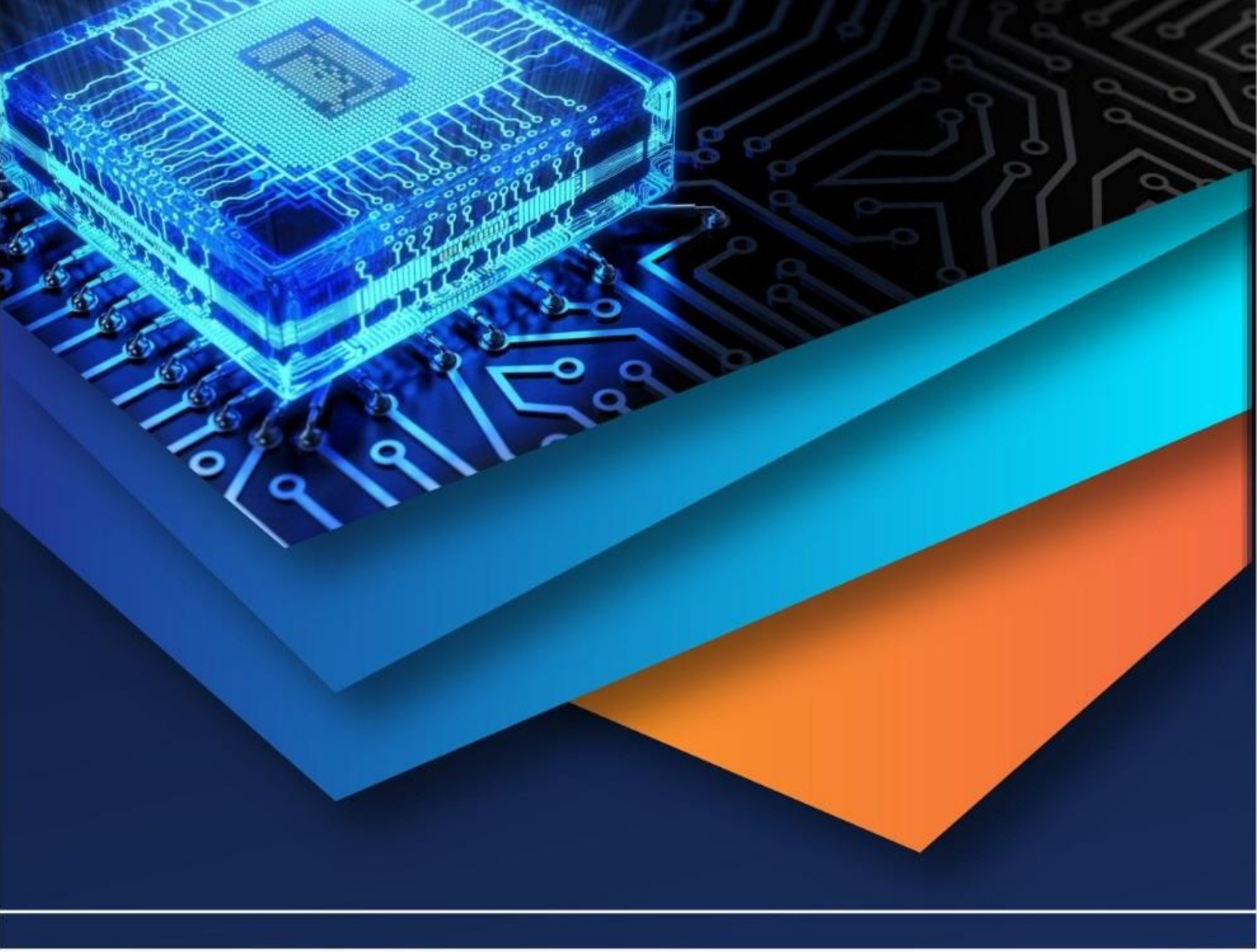
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