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Unconventional Concrete Mix –Improvement in Evaluation, Study and Suitability: Usefulness of Variation in Composition of Concrete Mix and its Association with Strength Findings of Various Moulding Shapes

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Abstract: Background: The study was done on various concrete Cubes, Beams and cylinders that were made by using different compositions of unconventional materials. The strength measurements were done at different intervals. A strong correlation between strength parameters of concrete with respect to its composition, age and economy was found. Aim: To study economical and strength characteristics of different mould shapes of concrete made by using various compositions of unconventional materials like marble powder , fly ash etc. The characteristics were than compared with regular conventional concrete. Methods: We performed a prospective study for a total period of 3 months on a total of 72 moulds of concrete. These 72 moulds of concrete were moulded in 3 different shapes (24 moulds in cube shape, 24 moulds in beam shape, and 24 moulds in cylindrical shape). A particular concrete mix was used for a set of three shapes of concrete moulds (3 cube shaped, 3 beam shaped, and 3 cylindrical shaped). 8 such sets were made using 8 different compositions of concrete mix. These 8 compositions were achieved by either partially of fully replacing coarse aggregate or sand or cement. A) By replacing coarse aggregate: 75% fresh aggregate +25 % recycled aggregate[1], 100% recycled aggregate[2].B) By replacing cement: 95% cement +3% marble powder +2% flyash[3] , 85% cement +10% marble powder +5% flyash[4], 75% cement +15% marble powder +10% flyash[5] . C) By replacing sand : 75% sand +25% brick dust[6] , 50% sand +50% brick dust[7] . The 8th composition was regular concrete mix and was used for reference purposes. Note: M_{20} grade of concrete having ratio 1:1.5:3 (1 cement: 1 fine aggregate: 1 coarse aggregate) was considered for this research. Compressive strength of concrete cubes was tested after 7 days, 21 days and 28 days of moulding. Flexural strength of beams and split tensile strength of concrete cylinders were also calculated. Results: Economy and strength properties of a concrete mix are a function of its components and their respective percentage. It is inferred that concrete mix constituents could be partially replaced by less expensive or waste materials, thus providing less expensive mortar. Although the resultant mix has degraded strength characteristics, it can still be used at places where strength requirements of concrete are fulfilled at less value. Conclusion: Calculated partial replacement of constituents of concrete mixes by unconventional; less expensive and waste materials can be a useful method for reducing the cost of mortar. It can be possible for a concrete mix to meet strength requirements and be less expensive by using unconventional materials. It can also be possible to reflect certain properties of unconventional materials into the concrete. This is only possible after extensive research.
Keywords: Concrete mould, recycled aggregate, fly ash, marble powder, compressive strength, flexural strength, split tensile strength, brick dust, M_{20}

I. INTRODUCTION

Economy and strength of concrete structures are the two important aspects during a construction project . For any concrete structure it is essential that the structure should be durable (has high strength) and is economical. Concrete used in construction is one of the main factors that determine economy and durability of a concrete structure. Reliability on concrete for its strength is a function of its components and their percentage by weight. Evolution of components of concrete is a history of extensive and continuous experiments and researches. There are different types and grades of cement, ranging from low strength to high strength, different setting times, fire resisting properties etc. Interestingly the properties of cement are reflected by concrete. Different types of cements are used for different purposes. Economy of concrete, to a large extent, depends on availability of cement, sand and coarse aggregates. Preference is always given to conventional materials for making concrete. Sometimes, due to unavailability of conventional materials on or near project site, the cost of project increases. This increase in cost is due to increase in transportation costs, taxes etc. Cost of a project can even increase to such an extent that the project may be halted.

Production of cement emits large quantities of carbon dioxide. Emission of carbon dioxide is a matter of environmental concern. This environmental issue could be addressed by reducing the production of cement which is only possible if there is an alternate binding material available which can partially or fully replace cement in a concrete mix.

Aggregates are used as inert materials in a concrete mix. The scope of using unconventional materials is not only reducing the cost of concrete but also imparting properties of these materials in the concrete.

II. STUDY OF MATERIALS AND COMPOSITION OF CONCRETE MIXES

The materials used in concrete mix were available nearby. Recycled aggregate was available from a nearby road reconstruction project site for free of cost. Marble powder, fly ash and brick dust were available from local firms for free of cost. Cement, sand and fresh coarse aggregate was also available from local shops. Potable water was used for mixing of materials.

A. Properties of Materials Used

Materials used in concrete mix were checked for various properties. The properties for which these materials were checked are as follows:

1) Sieve Analysis
2) Fineness Modulus
3) Specific Gravity
4) Water Absorption
5) Moisture Content

The properties of materials used are represented in the tabular forms as follows:

TABLE I

SIEVE ANALYSIS OF AGGREGATES

Sieve Size(mm)	Sieve analysis of 10mm aggregate	
	Cumulative percentage retained	Cumulative percentage passing
20	0	0
10	15.33	84.67
4.75	79.92	20.08
2.36	93.23	6.77

TABLE II

SIEVE ANALYSIS OF AGGREGATES

Sieve Size(mm)	Sieve analysis of 20mm aggregate	
	Cumulative percentage retained	Cumulative percentage passing
40	0	0
20	1.02	98.98
16	14.87	85.13
12.5	79.57	20.43
10	97.16	2.84
4.75	99.55	0.45
2.36	99.59	0.41

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TABLE III
PROPERTIES OF CONCRETE CONSTITUENTS

S. NO	Properties	Material Under Consideration			
		Fresh Aggregate	Recycled Aggregate	Cement	Sand
1	Fineness Modulus	4.9176	5	-	2.8848
2	Specific Gravity	2.6	2.6	3.37	1.03
3	Water Absorption	0.59%	0.63%	-	-
4	Moisture Content	6gm	5 gm	0	0

B. Types Of Concrete Mixes And Their Compositions

A total of 8 different types of concrete mixes were used in this research. These different concrete mixes were achieved by three different ways. These are:

1) Preparation of concrete using fresh aggregate and by replacing fresh aggregate partially or fully with recycled aggregate

TABLE IV

MIX. NO	Material Used		Size
	Fresh Aggregate	Recycled Aggregate	
1	100%	0%	10mm and 20mm
2	75%	25%	
3	0%	100%	

2) Preparation of concrete by partially replacing cement with marble powder/fly ash

TABLE V

MIX. NO	Material Used		
	Cement	Fly Ash	Marble Powder
4	95%	3%	2%
5	85%	10%	5%
6	75%	15%	10%

3) Preparation of concrete by replacing sand partially or fully with brick dust

TABLE VI

MIX. NO	Material Used	
	Sand	Brick Dust
7	75%	25%
8	0%	100%

It is important to note here that while replacing a particular constituent partially or fully with unconventional materials , the other constituents used were conventional materials. This was done to study the effect of variation in a particular constituent on the specimen.

III.RESULTS

A total number of 8 different concrete mix ratios were made and subjected to various tests. All the concrete mixes were tested for their workability. Tests on workability included slump cone test and compaction factor test.

After hardening of concrete moulds , they were tested for their strength properties. It is important to note here that different shapes of concrete moulds were subjected to different strength tests. Concrete cubes were evaluated for compressive strength, concrete beams for flexural strength and concrete cylinders for split tensile strength.

A. Workability

1) For conventional concrete made by using fresh aggregate, cement and sand:

TABLE VII

S. NO	Workability tested by		
	Mix	Slump Value (mm)	Compaction Factor
1	Conventional	20	0.65

2) Concrete made by partially or fully replacing fresh aggregate with recycled aggregate:

TABLE VIII

S. NO	**Workability tested by**	**75% fresh aggregate+ 25% recycled aggregate**	**100% recycled aggregate**
1	Slump value (mm)	25	27
2	Compaction Factor	0.79	0.78

3) Concrete made by partially replacing cement with marble powder and fly ash:

TABLE IX

S. NO	Workability tested by	95% cement + 3% fly ash + 2% marble powder	85% cement + 10% fly ash + 5% marble powder	75% cement + 15% fly ash + 10% marble powder
1	Slump Value (mm)	22	23.5	25
2	Compaction Factor	0.69	0.73	0.79

4) Concrete made by partially or fully replacing sand with brick dust:

TABLE X

S. NO	Workability tested by	75% sand + 25% brick dust	100% brick dust
1	Slump Value (mm)	23	0.71
2	Compaction Factor	24.5	0.68

B. Evaluation of strength properties

1) *Compressive Strength of Concrete Cubes*: Compressive strength of concrete is the most important parameter for which concrete is checked. It is the most common test conducted on concrete to check its strength. Compressive strength of cubes (150mm × 150mm × 150mm) was tested using a calibrated compression testing machine of 2000 kN as per IS 516-1959. The specimens are loaded and failure load is noted. The results were noted in a tabular form as follows:-

TABLE XI

Mould	MIX. NO	Mix	Compressive Strength (N/mm^2)		
			After 7 days	After 21 days	After 28 days
Cube	1	100% FA	21.55	28.89	29.74
	2	75% FA + 25% RA	19.91	24.00	27.42
	3	100% RA	14.97	22.22	24.23
	4	95% Cement + 3% MP +2% fly ash	16.67	22.22	23.25
	5	85% Cement + 10% MP +5% fly ash	15.55	18.44	18.88
	6	75% Cement + 15% MP +10% fly ash	14.67	16.89	20.00
	7	75% Sand + 25% Brick dust	15.56	15.11	16.66
	8	50% Sand + 50% Brick Dust	11.11	13.33	13.33

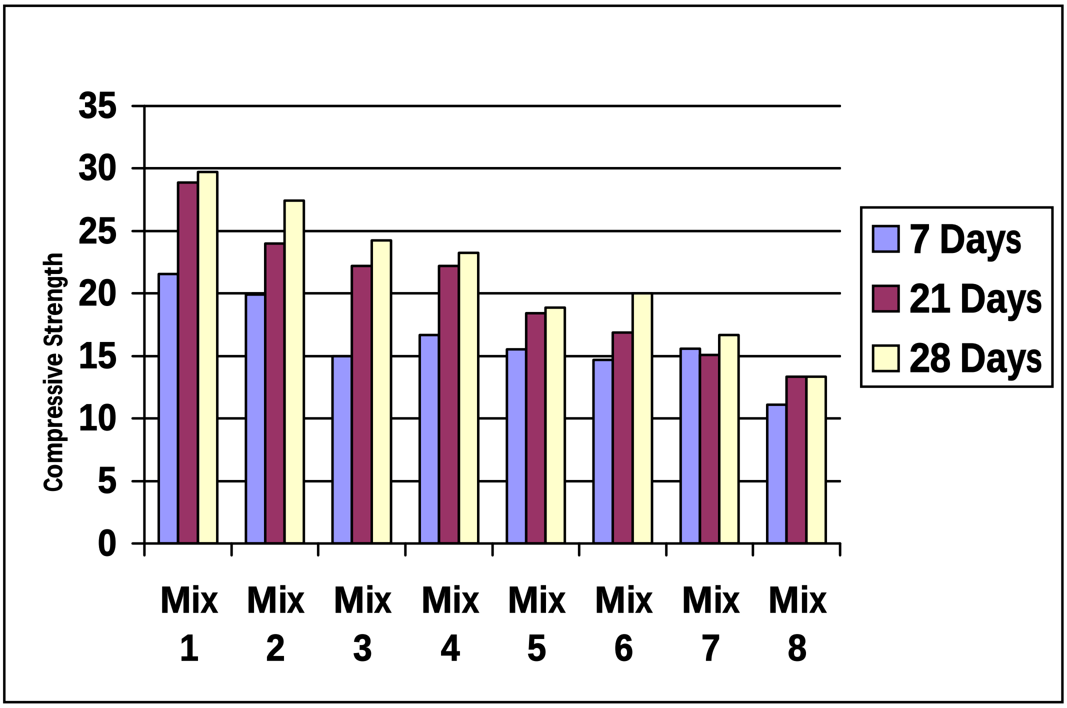

Figure 1: Comparison of Compressive Strength (N/mm^2)

2) *Flexural Strength of Beams:* Flexural strength of beams is a measure of strength to resist failure in bending, measured by loading concrete beams without reinforcement. It is a measure of tensile strength of concrete. The dimensions of beam mould are 150mm × 150mm × 750mm. The results were noted in tabular form as follows

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TABLE XII

Mould	MIX. NO	Mix	Flexural Strength (N/mm^2)		
			After 7 days	After 21 days	After 28 days
Beam	1	100% FA	21.55	28.89	2.75
	2	75% FA + 25% RA	19.91	24.00	2.03
	3	100% RA	14.97	22.22	2.09
	4	95% Cement + 3% MP +2% fly ash	16.67	22.22	1.80
	5	85% Cement + 10% MP +5% fly ash	15.55	18.44	1.34
	6	75% Cement + 15% MP +10% fly ash	14.67	16.89	1.08
	7	75% Sand + 25% Brick dust	15.56	15.11	0.86
	8	50% Sand + 50% Brick Dust	11.11	13.33	0.69

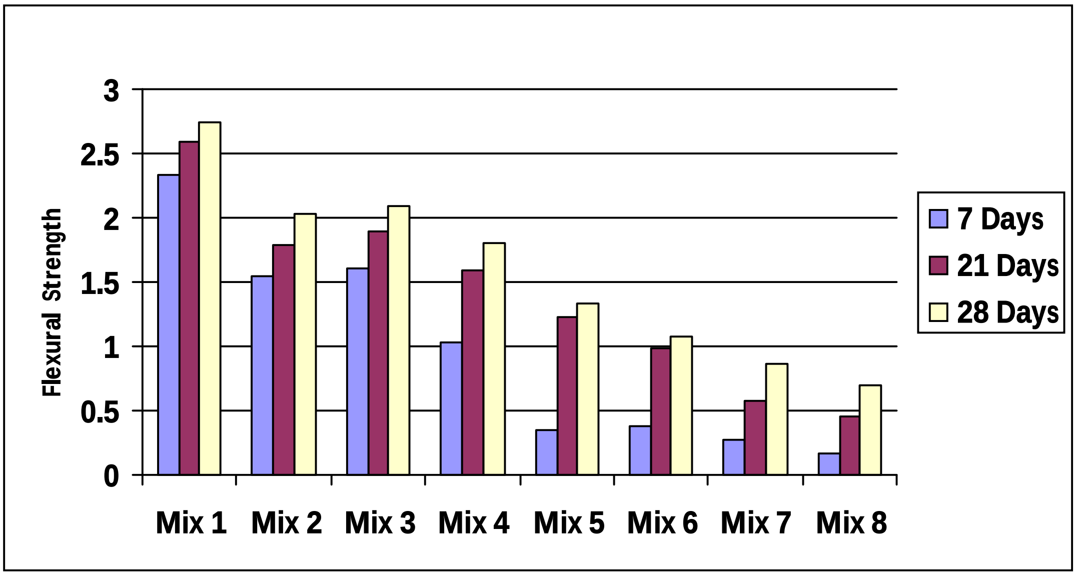

Figure 2: Comparison of Flexural Strength (N/mm^2)

3) *Split Tensile Strength of Concrete Cylinders:* It is also a measure of tensile strength of concrete. The concrete moulds are loaded by a calibrated compression machine of 2000kN. The concrete cylinder splits across the vertical diameter. It is an indirect method of measurement of tensile strength of concrete. Dc

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TABLE XIII

Mould	MIX. NO	Mix	Split Tensile Strength (N/mm^2)		
			After 7 days	After 21 days	After 28 days
Cylinder	1	100% FA	21.55	28.89	2.40
	2	75% FA + 25% RA	19.91	24.00	1.76
	3	100% RA	14.97	22.22	1.76
	4	95% Cement + 3% MP +2% fly ash	16.67	22.22	1.60
	5	85% Cement + 10% MP +5% fly ash	15.55	18.44	1.50
	6	75% Cement + 15% MP +10% fly ash	14.67	16.89	1.42
	7	75% Sand + 25% Brick dust	15.56	15.11	1.36
	8	50% Sand + 50% Brick Dust	11.11	13.33	1.20

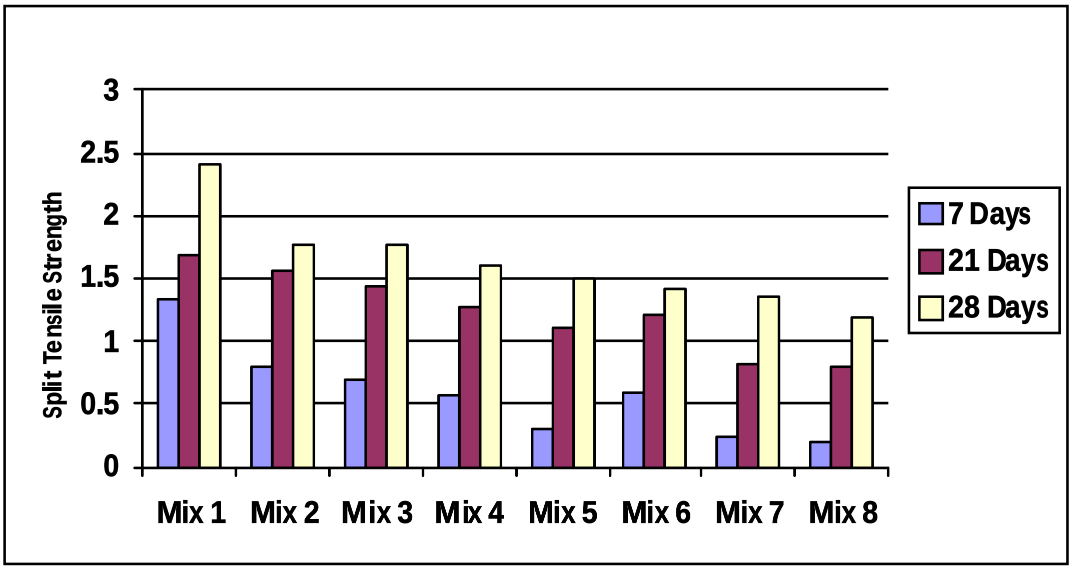

Figure 3: Comparison of Split Tensile Strength (N/mm^2)

C. Cost Analysis

Most of the unconventional materials that were used, were available at free of cost. This was due to the reason that these materials are often regarded as waste materials. However, after proper research on the cost of these materials it can be easily assessed that the cost of concrete still decreases if these waste and unconventional materials were bought from market at their actual price. For comparison, the cost of three different mix compositions of concrete is shown as follows:

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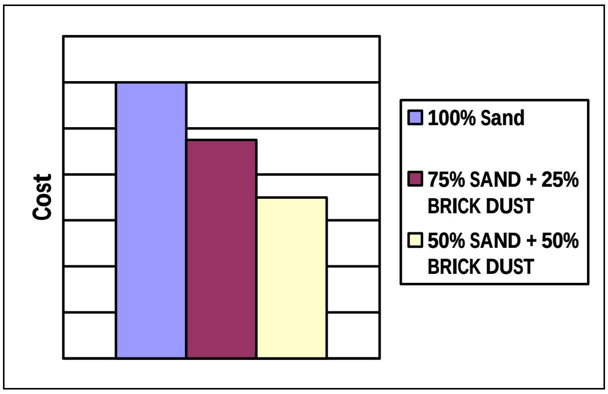

Figure 4: Cost Analysis

Figure 5: a) brick dust b) fly ash c) marble powder

IV.CONCLUSIONS

Replacement of conventional constituents of concrete with locally available unconventional and waste materials can help with reduction in cost of concrete. Feasibility and suitability of replacing conventional materials depends on the workability and strength requirements of concrete mix. On the basis of data available after extensive experimentation, following conclusions can be made:

A. Workability

It is observed from the test results that both the parameters of workability (compaction factor and slump value) showed variations with replacement of different constituents of concrete by unconventional materials. These variations were positive as well as negative with respect to conventional concrete.

B. Strength

Test results show that replacement of conventional concrete mix constituents with unconventional materials cause a decrease in its strength. However, some of the mix compositions were promising and showed least variation in strength.

It can be noted from the test results that increase in replacement of cement with marble powder does not cause a reduction in strength of concrete keeping in mind that fly ash was also added .

It can thus be assessed that there is a possibility of replacing conventional concrete materials with some waste and unconventional materials, which can prove to be cost efficient without compromising strength requirements.

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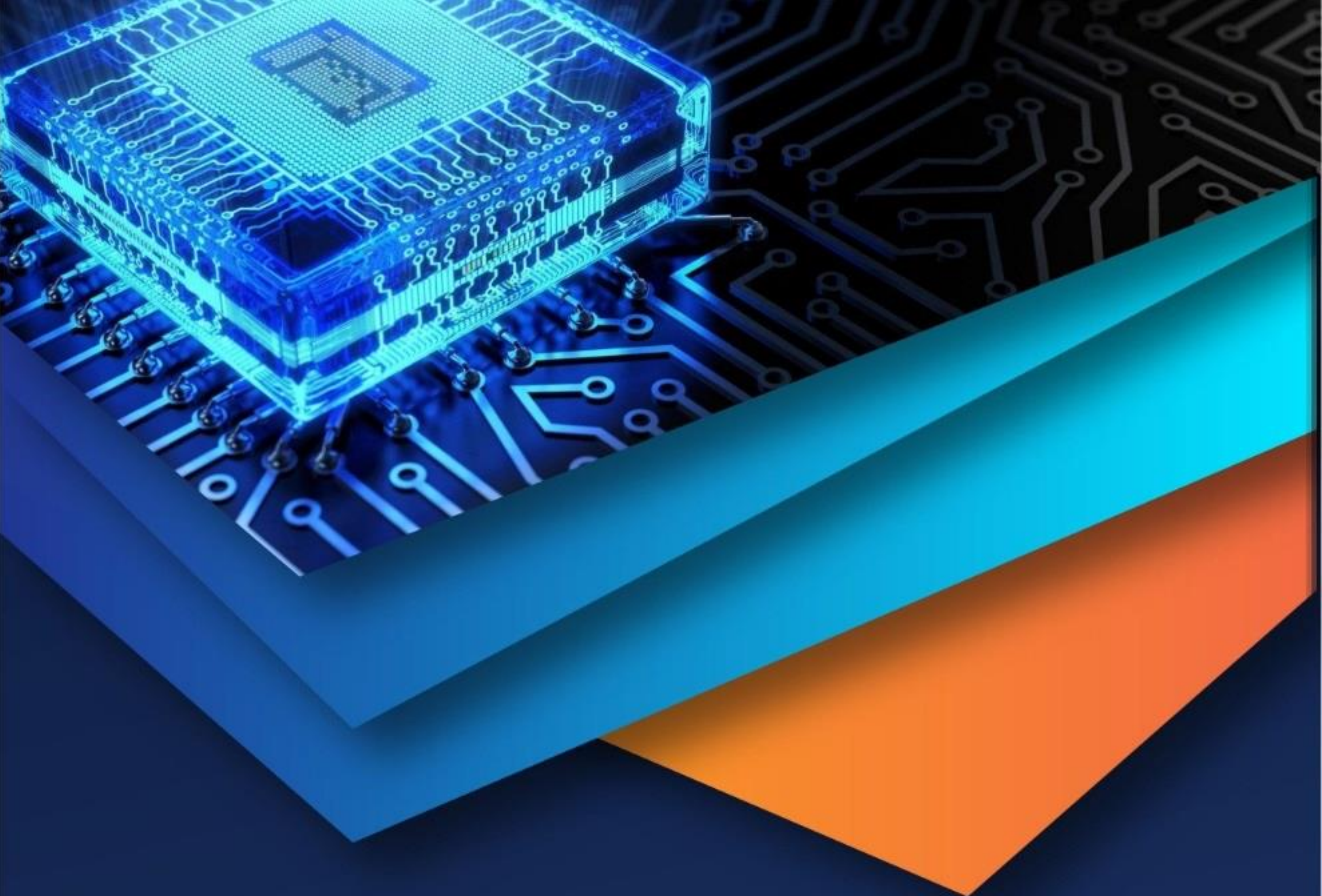

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