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Development of Pervious Paver Block by Using Rap and Rice Husk Ash

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***Abstract:** This specific kind of concrete is characterized by its interconnected pore structure and substantial void content or porosity, often ranging from 15 to 35% in terms of volume. Pervious concrete has the potential to mitigate the risk of floods, decrease storm-water runoff, attenuate noise generated by vehicle tires, and prevent glare and skidding in wet conditions by facilitating the infiltration of water via its porous structure, therefore replenishing the groundwater table. In light of the current state of the adjacent road networks, a conscientious endeavour is undertaken to develop a concrete paver with minimal permeability. Compression strength, void ratio, and infiltration experiments were conducted to evaluate the desired Mix proportions. In the current study, pervious paver blocks with a thickness of 60mm were manufactured using different percentages of RAP aggregate and rice husk ash. These blocks were specifically designed for medium traffic conditions. Consequently, the compressive strength is enhanced. Recycled asphalt pavement (RAP) aggregates provide a viable alternative to natural and synthetic aggregates for use into construction endeavours. The thesis provides an analysis of the potential use of rice husk ash residue. The compressive strength, density test, porosity, permeability, and durability of the paver block were assessed by several research investigations.*
***Keywords**: Pervious Paver Blocks, Rice Husk Ash, Reclaimed Asphalt Pavement (RAP), Sustainable Construction, Mechanical Properties, Water Infiltration, Waste Utilization.*

I. INTRODUCTION

The rapid urbanization and growth in infrastructure development have led to an escalating demand for construction materials, often resulting in the depletion of natural resources. Additionally, the construction industry is one of the significant contributors to landfill waste, which aggregates environmental concerns [5,17]. Thus, there is an increasing need for sustainable alternatives in construction materials that are both economically viable and environmentally friendly. The study aims to address two significant issues: waste management and sustainable construction By utilizing Rice husk ash, a byproduct of the boiler industry, and RAP aggregates, waste from road renovation or construction, the study aims to reduce landfill waste [4,5,9,10,14,16,18]. Secondly, by developing pervious paver blocks, the study aspires to contribute to the sustainability of urban infrastructure by allowing better water management and utilizing waste materials that are usually considered non-recyclable.

Due to its interconnected pore structure, pervious concrete is a high-performance concrete that has a comparatively high-water permeability compared to standard concrete [15,19,20]. Porous concrete and permeable concrete are other names for pervious concrete. It may be made using the standard components for building concrete, such as cement, cement additives, various kinds of coarse and fine aggregates, and water. Fine aggregate without the finest component, binder ingredients, and water are used to make pervious mortar[1,12].

Figure 1 : Pervious concrete

In order to reduce runoff from a site and enable groundwater recharge, pervious concrete is a specific kind of concrete with a high porosity that is used for concrete flatwork applications. Pervious concrete enables water from precipitation and other sources to flow through directly[1,12]. The terms porous concrete, permeable concrete, no fines concrete, and porous pavement are also used to describe it. Large aggregates, with little or no small particles, are used to make pervious concrete. Additionally, roads, footpaths, and pathways with modest loading intensities are excellent places to use pervious concrete. The Environmental Protection Agency (EPA) regards pervious concrete as a means of providing stormwater management, pollution reduction, and appropriate development [17]. It is a composite material made by combining crushed stone, inert sand and gravel, and cement. Because of its light colour and open-cell structure, this concrete does not absorb heat from the sun and does not reflect heat back into the atmosphere, which lowers environmental heating. Installing pervious concrete is inexpensive. Furthermore, it filters storm water, lowering the amount of contaminants that reach rivers and ponds. Additionally, pervious concrete promotes tree growth.

Our project's primary goal is to enhance pervious concrete's strength properties. However, it should be observed that the permeability of pervious concrete will decrease as strength increases. Therefore, because the permeability quality serves a function, the development of strength shouldn't have an impact on it [3].

It has been discovered that pervious concrete, also referred to as no-fines, porous, gap-graded, and permeable concrete, and enhance porosity concrete, is a dependable storm water management strategy. Gravel or granite stone, cement, water, and little to no sand (fine aggregate) are the main components of pervious concrete, according to definition. Storm water may seep through pervious concrete pavements and into the soil's underneath thanks to the open cell architecture. In other words, pervious concrete contributes to the preservation of the environment and the pavement's surface.

II. DESIGN OF PAVER BLOCK

Unusual uses of waste materials reduce the burden on the environment and available resources. The manufacture of paver blocks may easily make use of a variety of wastes thanks to the repolymerization process, which can lead to the preservation of high-quality resources. Savings and sustainable practices will also result from this. Numerous studies have examined the properties of cement concrete with RAP aggregates; however, in this research, we are mixing two types of waste materials with RAP aggregates and sugarcane bag ash in various proportions.

A. Dimension of the Paver Blocks

First, the dimensions for paver block manufacture are chosen in accordance with the producer, as shown beneath:
Shape: I section
Length: 200 mm
Width: 160 mm
Thickness = 80 mm
Aspect ratio (L/T) = 200/80 = 2.5 < 4.0 as in step with IS 15658: 2021
Area shall be calculated by as per IS 15658: 2021 their method and regard is given under.

Table 1: Design shape of paver block mould

Shape	Zigzag	I- shape
Thickness (mm)	80	80
Plane Area (m2)	0.0281	0.0289
Length (mm)	225	200
Width (mm)	112.5	163

B. Plan Area (A_{sp}) (Method 1)

The test sample has to be completely submerged in water and weighed while suspended on a metal wire. The weight is precise to within 0.01N (Wa) and must be given in N. They must be removed from the water and let to drain for one minute on a wire mesh with a diameter of 10 mm or more. Any water that is visible on the specimen may be wiped off using a wet cloth. Each specimen has to be weighed right away, and the load needs to be recorded N times to the next 0.The example's volume will be determined using the formula below: 01N (W_W):

$$\text{Volume} = (Ww - Wa)\ 10^{-3}\ m^3$$

The volume has to be divided using thickness to achieve an arrangement in mm^2.

For I-Section
Ww = 4.690 kg
Wa = 2.440 kg
Volume = 0.002250 m^3
Thickness = 0.08 m
Area= 0.028125 m^2 = 28125 mm^2

For Zig-Zag Section
Ww = 4.902 kg
Wa = 2.590 kg
Volume = 0.002285 m^3
Thickness = 0.08 m
Area= 0.028900 m^2 = 28900

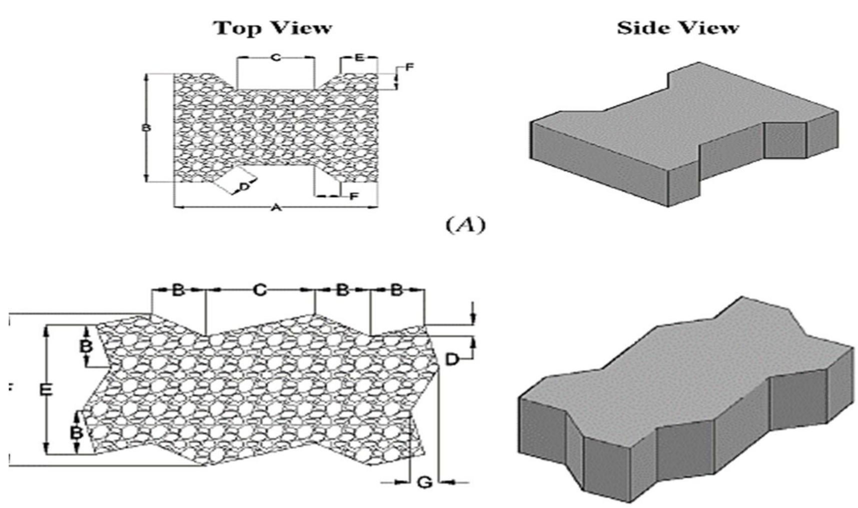
C. Plan Area (Asp) (Method 2)

The specimen must be positioned on cardboard with the sport side facing up, and the perimeter must be drawn in pencil. The form must be accurately shortened using the scissors, weighed to the closest 0.0001N, and the result entered as mass (msp). The formula must be used to calculate the block's plan area, and a comparable cardboard rectangle measuring 200 mm by 100 mm must also be weighted to the nearest 0.0001 N, and result recorded as mass (mstd):

$$A_{sp} = \frac{20000 m_{sp}}{m_{std}} mm^2$$

For I-section
Msp= 0.3091 N
Mstd= 0.220 N
Area (Asp) = 28100 mm^2

For Zig-Zag section
Msp= 0.3179 N
Mstd= 0.220 N
Area (Asp) = 28900 mm^2



(B)
Figure 1: Paver Block Area calculation

Table 2: Dimensions and area of different blocks

Shape	A	B	C	D	E	F	G	Surface Area mm2
Dumble	200	163	76	35.4	37	25		28100
Zigzag	225	37.5	75	10	112.5	132.5	20	28900

III. METHODOLOGY

This section shows detailed methodology adopted for this project. In this chapter how paver block is manufactured for experimental work is defined. 60 mm thick Paver block of M-30 grade is stable for the experimental work. For manufacturing of paver blocks sure Steps is accompanied that is given below.

A. Mixing of Materials

1) Concrete Mix Design (M30)

Mix design A mix design has been used for this investigation. Precast concrete paver blocks are typically produced using dry, low slump mixtures. A control mix of concrete of the M30 grade was created using the IS code 10262: 2009 and the requirements from the IS code 15658: 2021.

a) Properties of Materials

- Grade designation : M 30
- Type of cement : OPC 43 confirming to IS 1489 Part (I):1991
- Maximum nominal size of Aggregate: 10 mm
- Minimum cement content: 400 kg/m3
- Workability required: Medium
- Slump needed : 20- 80 mm
- Exposure condition: Severe
- Maximum water cement ratio: 0.40
- Type of aggregate: Crushed angular

b) Target Strength for MIX PROPortioning

F’ck = fck + t x sd
Standard deviations – 4 N/mm2
Assuming t = 1.65
Target strength = 30 + 1.65 x 5 = 38.25 N/mm2

c) Selection of Water- cement ratio

Maximum water cement ratio = 0.40

d) Selection of Water Content

From IS – 10262:2009,

Table 3: Mixing proportion of materials

S.no	Natural Aggregates	RAP Aggregates	Cement	Rice husk Ash	Sample Remarks
1	100%		100%		S0
2		100%	100%		S1
3	50%	50%	100%		S2
4	100%		90%	10%	S3
5	100%		80%	20%	S4
6		100%	90%	10%	S5
7		100%	80%	20%	S6
8	50%	50%	90%	10%	S7
9	50%	50%	80%	20%	S8

M30 concrete mix design -Steps|IS-10262:2009 |IS-456:2000

2) For Mix proportions

The specific mix proportion was chosen to examine the performance and applicability of pervious concrete paver blocks (PCPB).

3) Materials Used

a) Aggregates

- Natural Aggregates (NA)
- Recycled Asphalt Pavement Aggregates (RAP)

b) Supplementary Material

- Rice Husk Ash

c) Binder

- Cement

d) Mix Proportions

- The aggregates were mixed in three different proportions: NA-RAP (0-100), NA-RAP (50-50), and NA-RAP (100-0).
- RHA-Cement mixture ratios were: RHA-Cement (0-100), RHA-Cement (10-90), and RHA-Cement (20-80).

e) Aggregates Gradation

- Aggregate gradation used was G1 with a range of 9.75mm to 6.3mm.

4) Preparation of Mould

Prepare the mould: Ensure that the mould is clean and free of debris. Apply a release agent to the mould to help the finished product release from the mould.

a) Mix the concrete: Mix the concrete as directed by the manufacturer, making sure there are no clumps and that the material is well-combined.

b) Stuff the mold: Pour the concrete mixture into the mold, making sure it fills the mold completely.

c) Consolidate the concrete: To eliminate any air pockets and guarantee that the concrete is dispersed uniformly, use a vibrating table or other consolidating device.

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d) Use a trowel or other tool to smooth the concrete's surface, making sure it is level and free of any ridges or lumps.
e) Cure the concrete: Give the concrete the necessary amount of time, usually between 24 and 48 hours, to cure within the mold.
f) Release the final product: Carefully remove the completed paver block from the mold when the concrete has dried.

Figure 2: Preparation of paver block mould

5) Design of Moulds

Moulds design using I block mould and zigzag block mould

Table 4: Designed mould samples quantity

Moulds	No. of samples
I block Pervious Paver block Mould	108
Zigzag Pervious Paver block Mould	108

We have designed 4 replica sample for one mix and there are 9 mixes selected for designing the paver block. The testing was done at 7, 14 & 28 days. So finally, We have designed 108 total samples for zigzag and 108 total samples for I section. The average values are reported in the manuscript.

For I- section
Cement : 1.16 kg
Aggregates : 3.44 kg
Water : 0.160 ltr
Volume of I section = 0.002255 m^3

For Zigzag Section
Cement : 1.25 kg
Aggregates : 3.48 kg
Water : 0.160 ltr
Volume of Zigzag Section = 0.0022850 m^3

Water Content as per IS code 10262 : 2009

Figure 3: aggregate test

IV. RESULTS AND DISCUSSION

Pervious paving systems are increasingly recognized as an eco-conscious choice for tackling stormwater management issues. In our research, we focused on creating a permeable paver block formulated with rice husk ash and reclaimed asphalt pavement (RAP) aggregates, evaluating its viability based on various performance metrics.

Incorporating rice husk ash, an often-discarded byproduct of rice milling, presents multiple advantages. For one, rice husk ash serves as a sustainable alternative to conventional cementing agents, helping to divert waste from landfills. Furthermore, the use of RAP aggregates in the mixture contributes to conservation efforts by diminishing the need for new, virgin aggregates. This also results in a reduction of the environmental costs tied to mining and transporting these raw materials. Beyond material recycling, the engineered block exhibits significant stormwater management potential. Its permeable structure allows rainwater to percolate into the soil, thereby decreasing surface runoff and mitigating risks associated with flooding and soil erosion. While the preliminary findings are encouraging, more comprehensive studies are necessary to gauge the material's durability and long-term efficacy under real-world conditions. A financial analysis to assess the economic viability of this innovative material for broader applications is also recommended.

A. *Workability of Concrete*

The result of the slump cone test for each grade of concrete has been tabulated in table 5 for each grade of concrete.

Table 5: Workability of Concrete Material mix for paver block

RAP Aggregates	Natural Aggregates	Cement	Rice husk ash	Workability of material mix (mm)
	100%	100%		88
100%		100%		85
50%	50%	100%		83
	100%	90%	10%	81
	100%	80%	20%	77
100%		90%	10%	73
100%		80%	20%	70
50%	50%	90%	10%	66
50%	50%	80%	20%	62

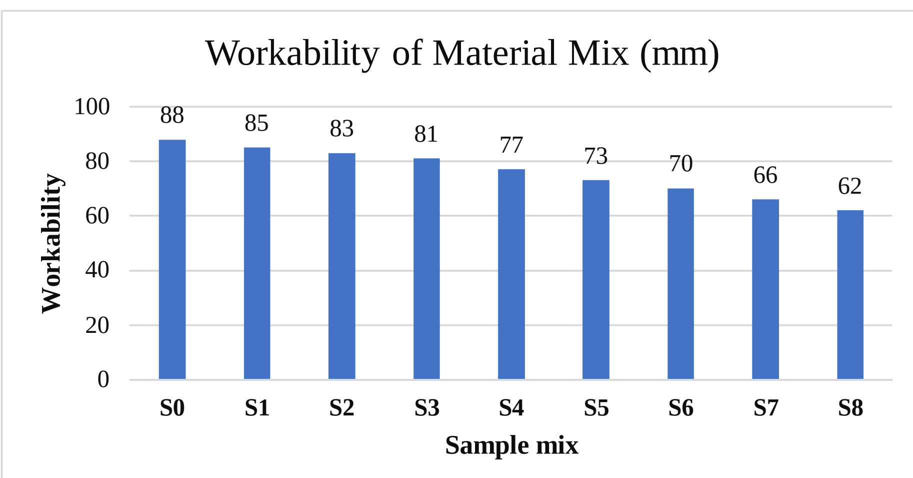

Figure 4: Workability variation at different mixing for samples

Based on the table data, it can be seen that as the amount of Rice husk and recycled aggregate increases, the workability of the material mix decreases. The control mix (S0) had the highest workability with a value of 88 mm, while S8 had the lowest workability with a value of 62 mm. This suggests that higher amounts of these materials in the mix make it more difficult to work with and may require additional efforts to achieve the desired consistency for the paver block. However, it is important to note that other factors such as the water-cement ratio and the use of admixtures can also affect the workability of the concrete material mix.

B. Density of Concrete

The test was conducted to study the variation of density of paver blocks for each grade of concrete. The results have been tabulated in Table 6.

Table 6: Density variation of concrete for paver block

Samples	RAP Aggregates	Natural Aggregates	Cement	Rice husk Ash	Density for I section (kg/m^3)	Density for Zigzag (kg/m^3)
S0 (control)		100%	100%		2111	2131
S1	100%		100%		2007	1999
S2	50%	50%	100%		1988	1991
S3		100%	90%	10%	2039	2068
S4		100%	80%	20%	2014	2020
S5	100%		90%	10%	1904	1908
S6	100%		80%	20%	1885	1899
S7	50%	50%	90%	10%	1981	1986
S8	50%	50%	80%	20%	1975	1984

The density variation for the I section paver block represents that which was made using Rice husk ash. The control mix (S0) had a density of 2111 kg/m3. The other samples (S1-S8) had varying densities ranging from 2007 kg/m3 to 1975 kg/m3. The control sample, presumably made of conventional materials, shows the highest density for both I-section (2111 kg/m³) and Zigzag-section (2131 kg/m³). This may indicate the benchmark against which modified samples can be evaluated. The density varies across the samples from a low of 1885 kg/m³ (S6, I-section) to a high of 2131 kg/m³ (S0, Zigzag). This suggests that the choice of materials has a significant impact on the density of the final product. The density figures for I-section and Zigzag-section are generally quite close for each sample, which suggests that the shape of the paver block does not significantly influence its density. Samples S5 and S6 have notably lower densities, possibly indicating that they are made from lighter materials or have a higher void content, which could be an advantage in certain applications but may compromise strength. S3, S4, and S1 show moderate densities in both I-section and Zigzag-section. These might offer a balanced set of properties like strength and permeability.

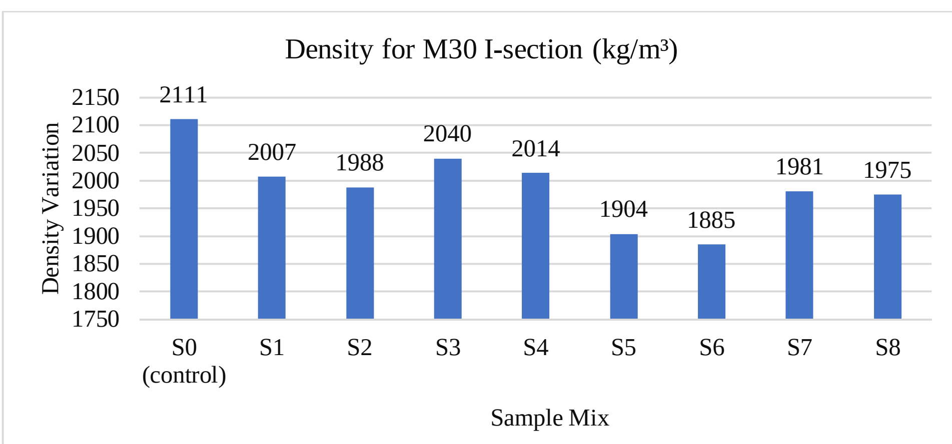

Figure 5: Density variation of paver block concrete

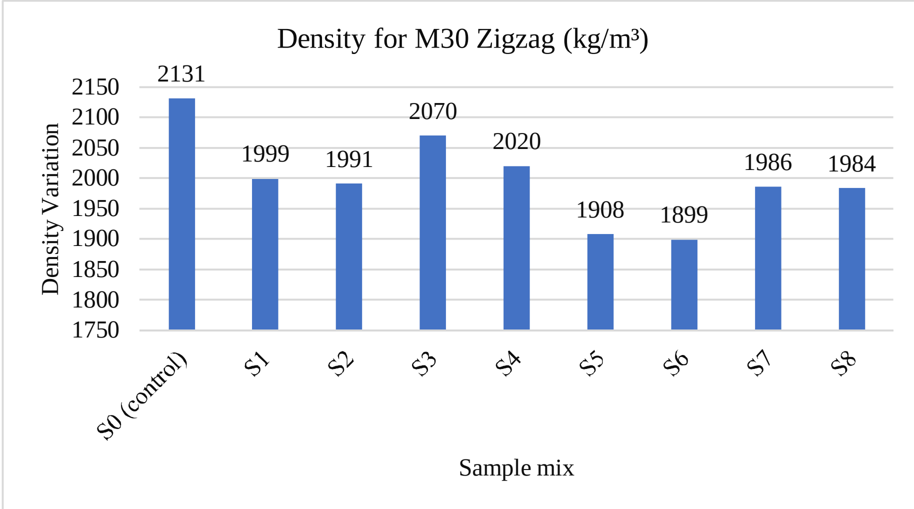

Figure 6: Density variation of paver block concrete

C. Water Absorption

The results of the water absorption test are listed in Table 7. In accordance with Table 7, the water absorption of paver blocks of all shapes rises up to a replacement rate of 5% before declining once again at a replacement rate of 10% for cement. But a 10% cement replacement results in the greatest decrease in water absorption. For 5% cement substitution, all paver block shapes absorb more water than the control mix. At 5% replacement, which is less than the 6% maximum limit specified in IS 15658-2021, the largest water absorption occurs..

% Water Absorption = [(WW – DW) / DW] x 100

Where, WW = Wet Weight of paver block, DW = Dry Weight of paver block

Table 7: Water Absorption test

Water absorption test		
Samples	I section	Zigzag
S0 (Control mix)	2.1	2.2
S1	2	2.1
S2	2.4	2.35
S3	1.7	1.5
S4	2	2.1
S5	1.8	1.8
S6	2.1	1.9
S7	1.9	2.2
S8	1.8	1.9

The table shows the results of water absorption tests for paver blocks made with sugar cane bag ash. Two types of water absorption tests were conducted: the I section test and the zigzag test. The results indicate the percentage of water absorbed by each sample after being submerged in water for a specified period.

Based on the table data, the following interpretations can be made:

1) The water absorption rate varies across the different samples (S1 to S8), suggesting that the modifications in the mix have an impact on the water absorption characteristics. For instance, S2 has the highest absorption rates for both I-section (2.4%) and Zigzag-section (2.35%), while S3 has the lowest for both types (1.7% and 1.5%).
2) Consistency Between I section and Zigzag section , the water absorption rate is fairly consistent between the I-section and the Zigzag-section. This suggests that the shape of the paver block might not significantly impact the water absorption property, and it is more likely a function of the material composition.

3) Generally, water absorption rates seem to range from 1.5% to 2.4%. This range isn't extremely wide, but it is enough to make a difference in applications where water drainage or resistance is a factor.

Overall, the results suggest that the use of Rice husk ash in paver block production may have some impact on water absorption rates, but the variations are relatively small. Additional tests and analysis may be necessary to fully understand the effects of sugar cane bag ash on the water absorption properties of paver blocks.

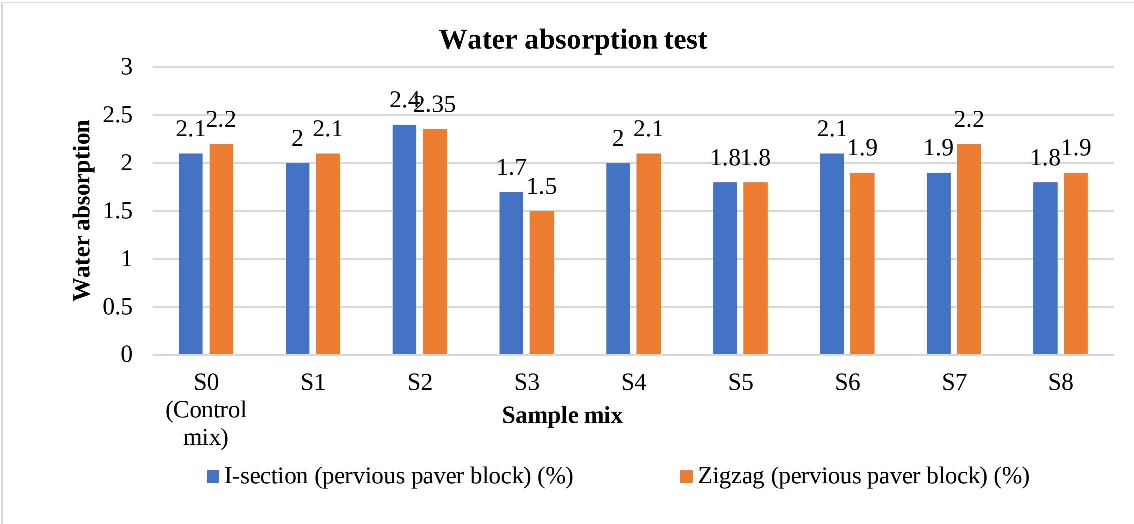

Figure 7: water absorption test for paver blocks.

D. *Strength Test Analysis for Paver Block*

We tested all designed paver block samples at the compression test machine. We apply KN load on the machine to check the compressive strength of the designed paver block with I section and Zigzag section.

Table 8: Compressive strength for I section pervious paver block

Strength For I section pervious paver block			
Sample Remark	7 Days	14 Days	28 Days
S0 (Control mix)	23.63	30.89	36.34
S1	19.41	25.38	29.86
S2	21.91	28.65	33.72
S3	19.88	26	30.59
S4	18.58	24.3	28.58
S5	18.24	23.86	28.07
S6	17.36	22.7	26.7
S7	18.48	24.17	28.44
S8	17.74	23.18	27.28

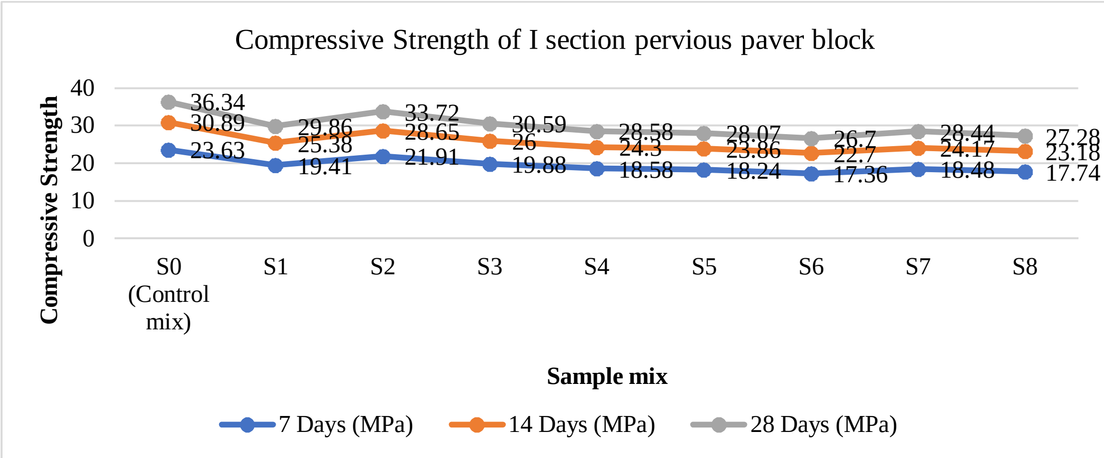

Figure 8: Compressive strength for I section pervious paver block at 7, 14, and 28 days

The table provides a comprehensive look at the compressive strength of I-section pervious paver blocks made from various mixes, measured at 7, 14, and 28 days of curing. Overall, the control sample (S0) serves as a high-performance benchmark, showcasing the greatest strength across all time intervals and reaching 36.34 MPa after a 28-day curing period. All the alternative mixes show an upward trend in strength as the curing time increases, which aligns with the typical behavior of concrete materials. However, these mixes also show a trade-off in compressive strength compared to the control, with reductions ranging from minor to significant. For instance, Sample S2 emerges as a relatively strong performer, reaching a 28-day strength of 33.72 MPa, thus presenting itself as a potential alternative for certain applications. Conversely, samples like S6 lag behind, with a 28-day strength of just 26.7 MPa, making them more suited for low-load-bearing applications. The consistency in the increase in strength over time for all samples suggests that the curing conditions were uniform, adding credibility to the data. Overall, the table indicates that while the control mix remains the gold standard in terms of compressive strength, some alternative mixes offer promising, albeit lower, performance levels and could be considered for specific, less demanding applications. In summary, while the control mix offers the highest compressive strength, certain alternative mixes also exhibit promising results, especially after 28 days of curing. However, the reduced strength in most alternative mixes indicates that careful consideration is needed to determine their suitability for specific applications. From a practical standpoint, S0 remains the most desirable mix for long-term strength. The choice between other mixes would depend on specific strength requirements and the timeframe in which those strengths are needed.

E. Compressive Strength of Zigzag section

Table 9: Compressive strength for **Zigzag** section pervious paver block

Strength For Zigzag section pervious paver block (MPa)			
Sample Remark	7 Days	14 Days	28 Days
S0 (Control mix)	20.83	32.61	38.37
S1	20.48	26.8	31.52
S2	22.65	29.62	34.85
S3	20.98	27.44	32.28
S4	19.49	25.48	29.98
S5	18.56	24.28	28.56
S6	18.3	23.93	28.15
S7	20.04	26.21	30.84
S8	17.87	23.37	27.5

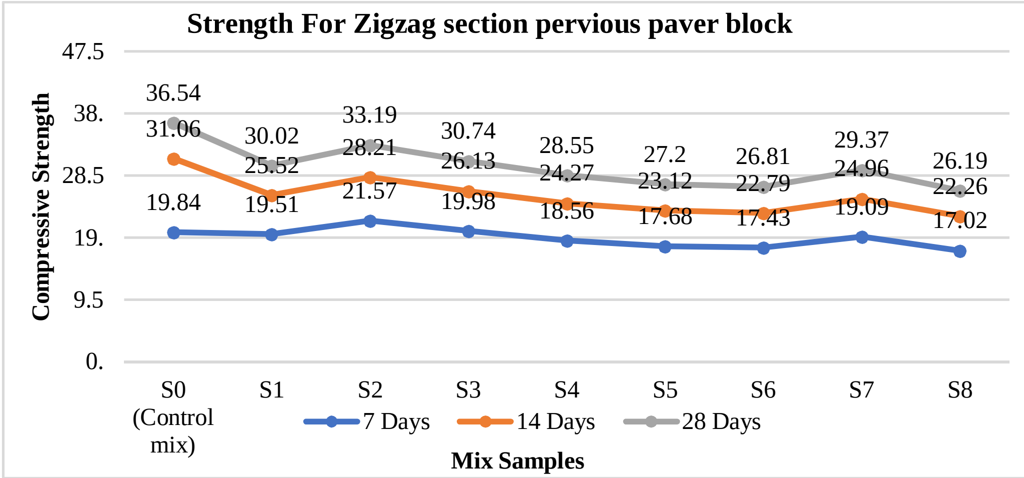

Figure 9: Compressive strength for Zigzag section pervious paver block at 7, 14, and 28 days

The table you provided shows the strength values of different mixes of pervious paver blocks at three different time intervals: 7 days, 14 days, and 28 days. This type of testing is often done to see how the strength of a mix matures over time. Here's an interpretation of the data:

The table presents the compressive strength of Zigzag section pervious paver blocks at different curing periods: 7, 14, and 28 days. The control sample (S0) serves as a benchmark with a compressive strength of 20.83 MPa, 32.61 MPa, and 38.37 MPa at 7, 14, and 28 days respectively.

The data indicates that sample S2 outperforms the control mix at all curing stages, reaching a compressive strength of 22.65 MPa at 7 days, 29.62 MPa at 14 days, and 34.85 MPa at 28 days. S3, S1, and S7 also show competitive results but are generally lower in compressive strength compared to the control mix, especially at the 28-day mark.

On the other hand, samples S4, S5, S6, and S8 exhibit relatively lower compressive strengths throughout the curing period. Particularly, S8 lags considerably with a 28-day strength of just 27.5 MPa, indicating that its mix composition may not be as effective for achieving high strength. The table provides valuable insights into the effectiveness of different mix compositions in achieving desired compressive strengths. This information can be crucial for selecting the appropriate mix for specific applications of pervious paver blocks. From an application perspective, the choice of mix would depend on the required final strength and the time within which the strength is desired. For instance, if one needs a strong mix quickly, S2 may be suitable. However, for long-term strength, the control mix (S0) might be the preferred choice.

F. Porosity Test for Paver Block

The porosity test was carried out in accordance with IS-15658-2021.

Table 10: Porosity test for paver block

Sample of Mix	Porosity Ratio (%) for 'I section'	Porosity Ratio (%) for Zigzag
S0 (Control mix)	19.5	18.4
S1	17	16.9
S2	18.6	17.8
S3	21.7	21.3
S4	23.8	23
S5	16	17.5
S6	20.3	19.4
S7	18.5	19
S8	19	20

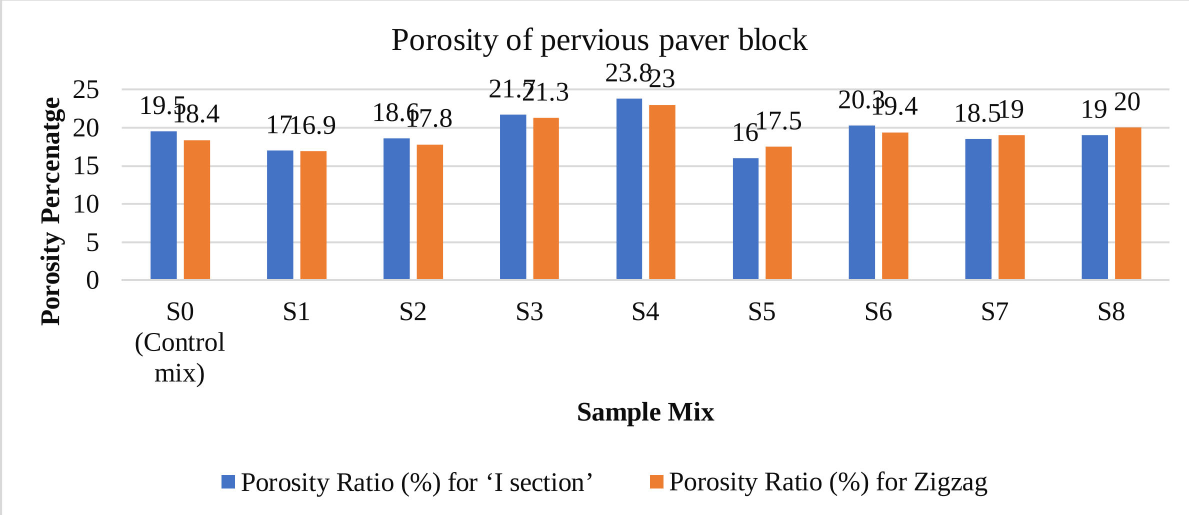

Figure 10: Porosity percentage variations for paver block

The control mix (S0) has porosity ratios of 19.5% for the 'I section' and 18.4% for the Zigzag section. This serves as the baseline for comparing other mixes. S1, with a 17% porosity for 'I section' and 16.9% for Zigzag, exhibits lower porosity compared to the control mix. This could suggest higher material density or fewer voids, possibly leading to less water permeability. S2 and S7 are closer to the control in terms of porosity, which could indicate a more balanced mix of constituents that retain similar permeability characteristics to the control. S3 and S4 show elevated porosity levels, with S4 reaching the highest porosity of 23.8% for 'I section' and 23% for Zigzag. These high ratios likely point to enhanced water permeability but could indicate lower structural strength. On the contrary, S5 has the lowest porosity at 16% and 17.5% for 'I section' and Zigzag, respectively. This could mean a denser, stronger material but at the cost of reduced water permeability. S6 offers a porosity ratio that is slightly higher than the control for both block types, suggesting it might offer a balance between permeability and strength. Finally, S8 has a comparable porosity ratio to the control mix but leans towards higher porosity in the Zigzag configuration.

G. Infiltration Test

The infiltration test is a method used to determine the rate at which water can infiltrate, or penetrate, into the soil or other porous media. It is a crucial parameter for various engineering applications, especially in hydrology, agriculture, and civil engineering, where understanding water movement is critical.

Table 11: Infiltration Test for I section and Zigzag section

Sample Remark	Zigzag section, Infiltration Rate (mm/hr)	I section, Infiltration Rate (mm/hr)
S0 (Control mix)	148	150
S1	163	158
S2	153	153
S3	161	156
S4	168	161
S5	173	165
S6	178	166
S7	170	160
S8	180	168

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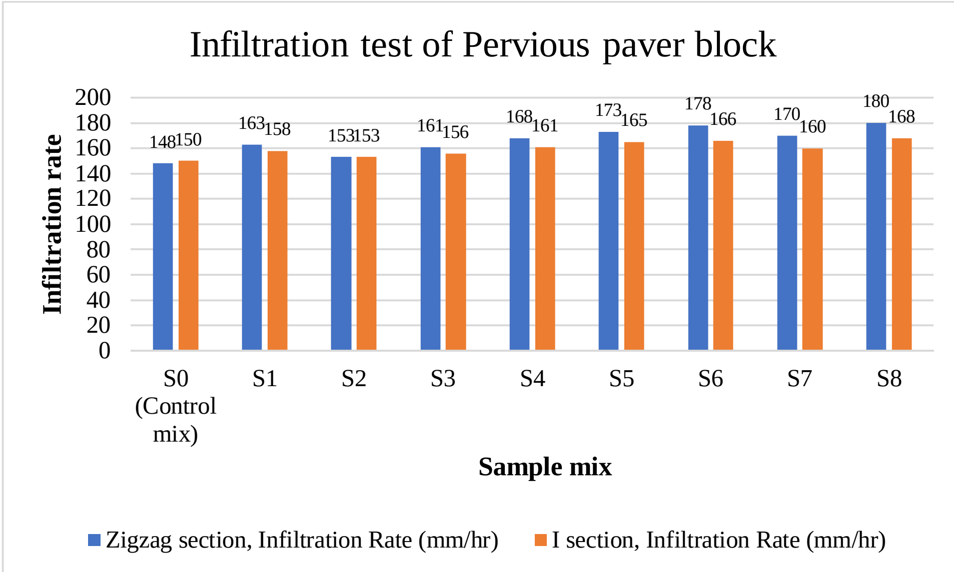

Figure 11: Infiltration test for pervious paver block

V. CONCLUSIONS

The study likely discussed the experimental investigation of different mix designs of pervious paver blocks containing Rice husk ash and RAP aggregates, along with conventional materials such as cement and sand. The methodology may include the preparation of different mixes, testing of their physical properties, and measuring their performance in terms of permeability and compressive strength.

Based on the findings, the conclusion may suggest that the use of Rice husk ash and RAP aggregates can enhance the permeability of the pervious paver blocks, as well as provide satisfactory compressive strength. The thesis may also suggest that the use of these sustainable materials can contribute to reducing waste and promoting sustainable construction practices.

A. Strength Analysis of Paver block for Zigzag shape

1) *Benchmark Strength:* The control sample (S0) provided a robust benchmark with compressive strengths of 20.83 MPa, 32.61 MPa, and 38.37 MPa at 7, 14, and 28 days, respectively.
2) *Strength Improvements:* The alternative sample S2 performed remarkably well, with compressive strengths exceeding that of the control sample at each measurement period (7, 14, and 28 days). This indicates that specific alternative mixes have the potential to yield higher compressive strengths than the control.
3) *Long-Term Viability:* Like with the I-section, the 28-day strength data for most samples were promising. S2, S1, and S3 show 28-day strengths greater than 30 MPa, which is an indicator of their long-term durability and usability in construction applications.
4) *Weaker Performers:* Samples such as S8 and S6 performed relatively poorly compared to the control, especially at the 28-day mark. This suggests that not all alternative mixes are equally viable for high-strength requirements.
5) *Consistent Growth:* A general trend of increasing strength from 7 days to 28 days was observed across most samples, indicating the material's suitability for long-term applications.

In summary, while the control sample gives a strong baseline of performance, certain alternative mixes like S2 show that it's feasible to achieve higher compressive strength. These findings offer a path for further optimizing the material composition for achieving a balance of high strength and permeability, which can be critical in certain construction applications.

B. Strength Analysis of Paver block for I shape

1) *Control Strength:* The control sample (S0) sets the standard with compressive strengths of 23.63 MPa, 30.89 MPa, and 36.34 MPa at 7, 14, and 28 days, respectively. This sample serves as the baseline for assessing the performance of alternative mixes.
2) *Alternative Mixes:* Notably, the alternative mix S2 outperforms the control in compressive strength at all observed time intervals (7, 14, and 28 days), indicating that certain alternative mixes can be formulated to yield greater compressive strengths.

3) *Long-Term Strength:* The 28-day strengths for most samples were generally promising. Samples S2, S1, and S3, for instance, demonstrated strengths close to or exceeding 30 MPa, highlighting their potential for long-term durability.
4) *Weaker Mixes:* Some mixes like S6 and S8 lag behind the control sample and other stronger mixes, particularly at the 28-day mark. These compositions might not be suitable for applications requiring high compressive strength.
5) *Consistency:* The compressive strength generally increased consistently from 7 days to 28 days across all samples, which is a good indicator of the material's long-term reliability.

In conclusion, while the control sample offers a solid benchmark, alternative mixes such as S2 provide compelling advantages in compressive strength. This suggests that with the right mix formulation, it's possible to develop I-section pervious paver blocks that meet or even exceed standard performance metrics. Further research could focus on optimizing these mixes for a balanced performance in terms of both strength and permeability.

a) *Porosity:* Generally, the I-section tends to have slightly higher porosity percentages than the Zigzag section across most sample mixes. Higher porosity would typically lead to better water infiltration and could be advantageous for groundwater recharge. However, this may also indicate a potential compromise in mechanical strength, which needs to be further investigated.
b) *Infiltration Rate:* The infiltration rates for both configurations show that changing the mix composition has a significant impact on water infiltration capability. While both sections exhibit variable rates depending on the sample mix, the I-section generally appears to have comparable or slightly lower infiltration rates than the Zigzag section.

In summary, both I-section and Zigzag section pervious paver blocks have their merits and demerits. The optimal choice would depend on the specific requirements of the project, taking into account factors like porosity, infiltration rates, mechanical strength, and cost.

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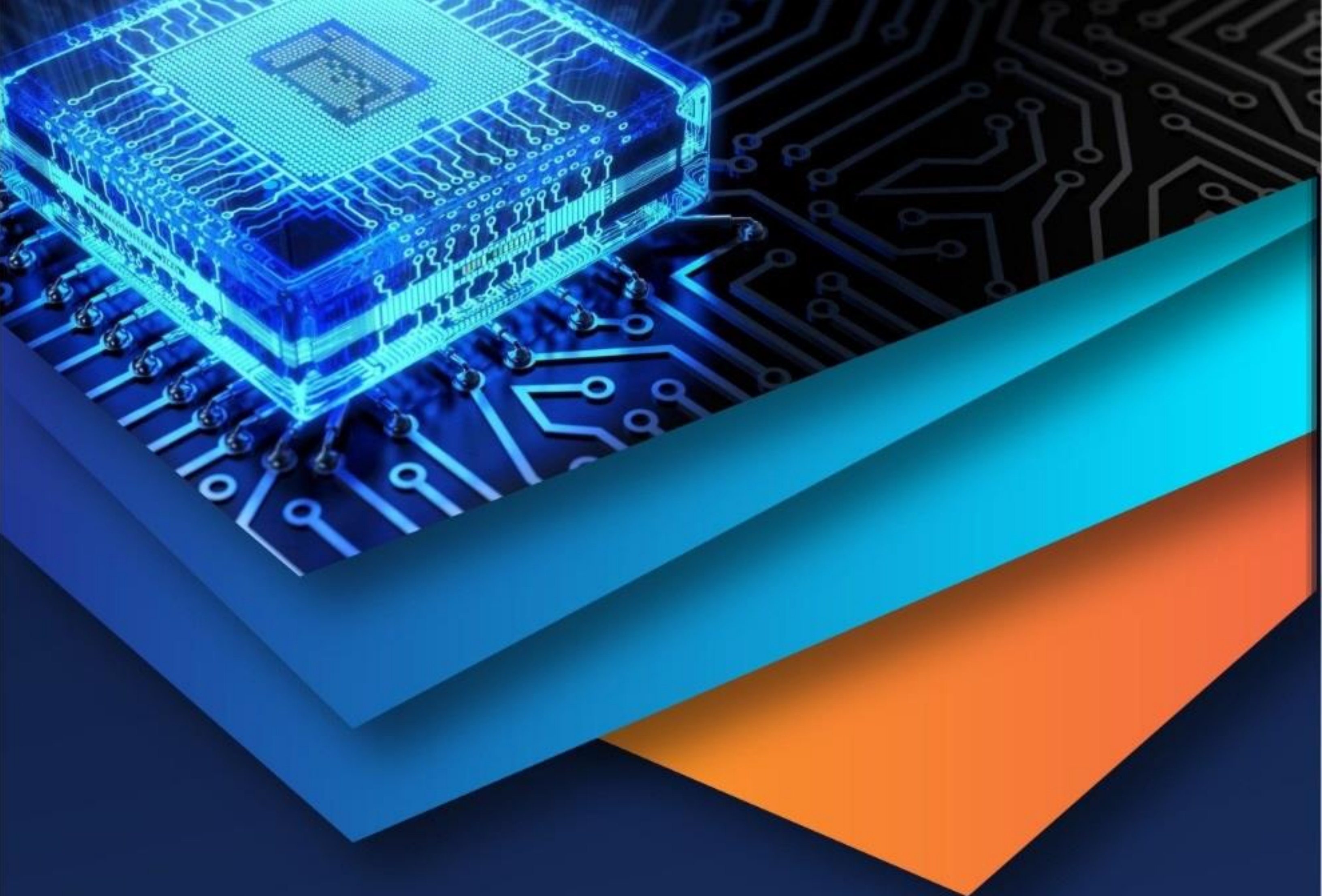

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