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Sustainable and Cost-Effective Development of Pervious Paver Block made with RHA (Rice Husk Ash) and RAP (Recycled Asphalt Pavement)

Satish Katare[1], Manoj Kumar Trivedi[2]
[1]PG Student, Department of Civil Engineering, MITS Gwalior, Madhya Pradesh, India
[2]Professor&head, Department of Civil Engineering, MITS Gwalior, Madhya Pradesh, India

Abstract: The study's goal is to create cost-effective and eco-friendly pervious paver blocks by reusing asphalt pavement at 0%, 50%, and 100% weight ratios. Building permeable paver blocks using RHA (Rice Husk Ash), an industrial waste product with a cementous ratio of 10% to 20% by weight, is a step toward a more eco-friendly and cost-effective future. Both recycled asphalt pavement (RAP) aggregates and newly quarried "fresh aggregates" (FA) were employed in this investigation. Bituminous concrete (BC) pavement that was 2 years old and Stored in dumping yard besides the Rahul ware house in Gwalior, Madhya Pradesh on Srinagar – Kanyakumari Highway yielded RAP with a nominal maximum aggregate size of 13 mm. The production of PCPB has been standardized. This technique is known as the "cement paste encapsulating aggregate blending method." "After adding all of the aggregate and 20–25% of the total calculated water content, the concrete mixer was operated for 15-20 seconds". The RP overseas in Lohgarh (M.P.) provided the rice husk ash that was used in the project. Rice husk ash (RHA) has a high specific gravity of 2.10 and a low bulk density of 0.781 g/cc, making it highly reactive and pozzolanic. RHA is recommended for use in both plain and reinforced concrete by the IS 456-2000 Indian Standard code of practice. The results of the investigation demonstrated that G2 graded mixes had higher porosity than G1 graded mixes. The results showed that CL values were minimal at w-c ratios of 0.35. The cement paste at this water-to-cement ratio is strong enough to bind the aggregate particles together, which explains why this occurs. In comparison to the conventional approach, the optimal replacement level of RHA results in block costs that are reduced by 7.5% for 0 RAP and 10% RHA, 15% for 0 RAP and 20% RHA, 20% for 50% Rap and 10% RHA, 27% for 50% RAP and 20% RHA, 33.2% for 100% RAP and 10% RHA, and 40.62% for 100% RAP and 20% RHA. The conclusion is that RHA-made paver blocks are reliable and cost-effective. The conclusion is that paver blocks made by RHA are durable and affordable.
Keywords: Sustainable, Affordable, Development, Pervious, Paver block. Rice husk ash, Recycled asphalt pavement

I. INTRODUCTION

Recycling road maintenance and rehabilitation garbage is now a global concern. Numerous nations are addressing the issue. In affluent countries, asphalt pavement that has worn out is being recovered and used for other purposes. When asphalt pavement is dug up to replace, resurface, or access underground utilities, RAP is formed. RAP is also made by removing asphalt pavement. RAP is produced when asphalt pavement is removed to access subterranean services. RAP's many uses make it adaptable. RAP is made from well sorted aggregates. These aggregates are bituminized after crushing and screening. Our research found that recycling asphalt pavement is a great technical option that might improve socioeconomic and environmental conditions. The approach unlocks this potential. RAP is a good decision today and in the future, but it will also be necessary to keep firms competitive. RAP is eco-friendly, lowers waste, and saves company's money. Because RAP is a must, not a choice. Even though bitumen and RAP aggregates are non-renewable, most asphalt pavements may be reclaimed and restored to their former consistency. RAP is recycled asphalt pavement. Asphalt recycling allows bitumen to be reused. RAP, recently mined aggregate, bitumen, and mineral filler may achieve this goal. Even though asphalt pavement deteriorates with age, it may be recycled. Any asphalt surface may be recycled. Due to growing building costs and environmental concerns, demand for sustainable and cost-effective construction materials has increased dramatically. Pervious paver blocks manufactured from Rice Husk Ash (RHA) and Recycled Asphalt Pavement (RAP) might solve both of these problems. These novel pavement materials may improve building sustainability and save costs.(1)

The soil is revitalized by the permeation of water via pervious paver stones. It serves as a pollution filter, lessens the impacts of storm water runoff, and cools off metropolitan areas.

The use of RHA and RAP in these paving stones may be beneficial to nature. Rice husk ash, a by-product of rice milling, is typically burnt or thrown away, polluting the environment. Recent study has shown that RHA is pozzolanic, making it a great additional cementation material. RHA partially replaces cement in pervious paver blocks, reducing cement production's environmental effect. This also improves the blocks' mechanical qualities, making them stronger. Recycled Asphalt Pavement is made by rehabilitating and reconstructing asphalt pavements. Crushed asphalt may be used in pervious paver blocks instead of landfills. This method decreases waste, virgin material use, and resource use. By adding RAP to the manufacturing process, pervious paver blocks may be made more affordable for building projects. The study will improve understanding of sustainable, affordable building materials. Promote such creative ideas to create a more sustainable and resilient built environment.(2)(3)

A. Use of Rice Husk Ash (RHA) in Place of Cement

Rice husk is usually dumped or burned, however some is utilized as a low-grade fuel. In India and other nations, RHA is utilized as a pozzolanic in commercial manufacturing. RHA application in civil construction may reduce environmental waste. RHA use in building is not new. Depending on combustion circumstances, researcher found silica-rich ashes (crystalline or glassy). Highly pozzolanic ashes from glassy silica might partially replace Portland cement. According to the American Society for Testing and Materials (ASTM), cementitious compounds are produced by mixing pozzolanic materials with calcium hydroxide at room temperature.

Rice husk (RH)-burned RHA is reactive and pozzolanic. Burning and temperature alter RHA chemical compositions. Burning temperature increases ash silica concentration. Silicon dioxide (90–95%), potassium oxide (1–3%), and carbon (5%) make up the author's respiratory health aid (RHA). In order to determine that RHA included amorphous, highly cellular silica with a surface area of 50-1000 m2/g, scientists used an industrial furnace. Image 1 shows below product after each process. When added to RHA, cement reduces the material's heat evolution, thermal cracking, and plastic shrinkage, making it more workable and stable. “The pozzolanic process improves the strength, permeability, and durability of hydrated cement paste by reinforcing the transition zone, altering the pore-structure, and filling the wide voids”. Through contraction, pore refinement, and the prevention of alkali ion migration to the aggregate surface through the micro porous structure, RHA reduces the alkali-aggregate reaction. Portland cement alone won't do the trick for these requirements.

Between 0% and 20% of Portland cement (OPC) can be replaced by RHA in building projects. OPC grades affect concrete strength when partly replaced by a material processing pozzolanic characteristic. Country code categorization determines OPC grades. BIS classifies three construction-industry OPC grades. India's suggested code of practice for plain and reinforced concrete makes no mention of RHA. RHA as a partial substitute for OPC should be investigated before utilizing these materials. However, the literature analysis found no comparison study on concrete qualities when RHA partly replaced cement of different grades. Thus, this study investigated RHA as a building material utilizing a comprehensive approach. The essential parameters are strength growth, durability, water absorption, and shrinking.(4)

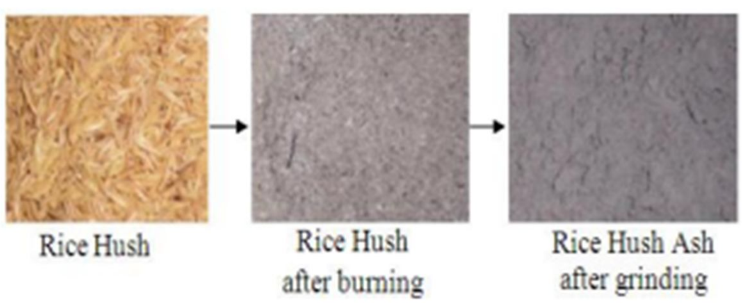

Image A Product after each process

B. Use of Recycled Materials in Roads

The road industry's growth and vehicle numbers need spending all resources to improve delayed administration life roads. Bitumen, crushed, and unbound totals hampered 1980s street growth. Materials production is costly and harmful. Recycled materials and by-products improve road construction as trash production rises. “Plastics, used tires, foundry sand, base and fly ash, oil sand, marble dust, recycled solid totals, recovered black-top asphalt, and steel slag are only some of the often recycled materials”. It's well-studied. Recycling is being researched.

Despite its benefits, promising research, and common sense, environmental concerns and a lack of field knowledge have prevented waste material from replacing crude materials. Repurposed, recycled, and waste-by-products may be useful when exhibited and used with other development resources. Recycled materials are used in road structures. The handling cost, technical attributes, practicality, and long-term street development advantages justify employing repurposed waste material. Understanding reused by-product behaviour and its impact on development material integration is essential to ensure appropriate and acceptable material and dose utilization.(5)

C. Paver Blocks

Paver blocks are dense, flat blocks that may be used not just for constructing pavers but also walls, pillars, and other architectural elements. When it comes to the colors, measurements, and patterns of these blocks, customers have a broad variety of options to pick from. Paver blocks are primarily porous blocks that are created by combining a range of substances, including cement, sand, and tiny stone shards, amongst others, in variable ratios. Paver blocks may be used to create a variety of surfaces, including walkways, patios, and driveways. Because they are perfectly interlocked with one another, they are sturdy and have a lower chance of shattering than other similar structures. As a matter of fact, because to the aesthetic attractiveness, durability, and decreased cost of maintenance that they give, they are the alternative that is most often chosen for use in applications that include outdoor pavement applications.(6)

II. AIM

Sustainable and cost-effective development of pervious paver block made with RHA (Rice husk ash) and RPA (Recycled asphalt pavement)

III. OBJECTIVES

1) "The development of pervious paver blocks using (RAP) recycled asphalt pavement in three weight ratios of 0%, 50%, and 100% that are environmentally friendly as well as financially feasible".
2) Sustainable and affordable development of permeable paver blocks constructed with industrial waste RHA (Rice Husk Ash), which has cementious ratio in 10% and 20% by weight.

IV. REVIEW OF LITERATURE

(Abukhettala, 2016) (7) Traffic increased building material specialization. As natural resources grow scarce and dangerous, road builders are trying new materials. Such elements need multiple auxiliary and tertiary components. Many leftovers and scraps have been assessed and weighed for usage. Recyclable grade affects integration. Recycled materials work better. Despite its benefits, experimental and field data show that such integration requires additional study. A wide variety of materials, including asphalt pavement, recovered concrete aggregates, plastic wastes, scrap tires, mine wastes, recycled broken glass, foundry sand, coal combustion products including fly, bottom, and pond ash, steel slag, oil sand, oil shale sand, and lateritic soil, may be reused. Many believe recycling road building materials conserves primary resources. To solve performance difficulties, academia and industry must work together to educate paving operators. This study determines the best recycled road materials for effective usage.

(Reddy & Mohan, 2016) (8)Recycled materials are used to create roadways. This project uses recycled road construction materials since the road industry and traffic are growing and development resources for highway building are dwindling. Road builders investigated alternate materials due to the scarcity of natural resources and environmental impact. Materials originating from a higher organizational level. In the field, we evaluate the value of garbage and other resources. The quality of recycled asphalt pavement varies. Renewable materials may be used for a very long period. Some examples of recyclable materials include: oil sand, oil shale sand, steel slag, lateritic soil, foundry sand, shattered glass, bottom ash, pond ash, and fly ash from coal combustion, oil sand, and asphalt pavement. This initiative assesses recycled materials. This project promotes road construction using the industry's finest recycled resources.

(Kumar, 2016) (9) When rice is ground in India, the husk is thrown away. In order to generate steam for the cooking process, this husk is burnt in the rice mills. About 75% of a rice husk is made up of organisms that can't be destroyed by fire, and the remaining 25% is what is burnt to create rice husk ash (RHA). Between 85% and 90 % amorphous silica has been found in rice husk ash (RHA). The characteristics of concrete may be enhanced by including rice husk ash into the mix. This research and experiment were conducted to learn more about the benefits of using Rice husk ash in concrete. Researchers looked at how using rice husk ash in concrete would affect the material's workability and found that adding 20% RHA led to better hardened qualities, such as compressive strength, compared to using no RHA at all. At 14, 21, and 28 days post-curing, the material with 20% RHA replacement had better compressive strength than the material with 0% RHA replacement.

(Zareei et al., 2017) (10) The requirement for the cement industry to take action to reduce air pollution likely sparked the early and ongoing interest in using partial replacements or by-products as supplemental pozzolanic components. Milling rice results in a by-product called rise husk, which, although being heated to 200 degrees Celsius, still weights around 40 kilos per ton of rice. In this study, five different mixtures were tested against a reference mixture consisting of 100% Portland cement. The RHA percentages tested were 5, 10, 15, 20, and 25%. Ten percent micro- silica (MS) is also used in the blends. When RHA was used in place of it at a rate of 15%, compressive strengths increased by about 20%. Increases up to 20% often result in enhanced strength and durability; however, increases over this threshold are typically accompanied by a small decrease in strength characteristics of about 4.5 %. Same poor water absorption ratios were discovered. When compared to the initial results (less than a fifth), chloride ion penetration increased by around 25% with each subsequent cement replacement.

(Ghosal & Moulik, 2015) (11) Growth has depleted construction materials. Conventional building materials are costly, slowing global housing deliveries. Alternate building material research was needed. Effective housing technologies save building costs and reinforce structures. Gravel, sand, and cement make concrete. Rice husk as a partly fine aggregate alternative may stimulate house developers. India produces 100 million tons of rice husk. 20 kg rice husk from 100 kg rice.80% organic. Rice husk burning at optimal temperatures creates rice ash. Proper rice husk utilization protects the environment, motivates the government to discover trash disposal options, and educates contractors and developers how to enhance building, product performance, and recycling objectives. Rice husk ash concrete may reduce building self-load and handle large precast components. Thus, fostering low-cost home creation utilizing these "seemingly" trash things is the main purpose. This page discusses rice husk concrete properties.

(Vishal et al., 2018) (12) Most countries employ bituminous mixes. Lack of natural resources and rising bitumen prices. Lime, fly ash, fibres, ceramic waste, silica fumes, slag, plastic, etc. are all examples of easily accessible wastes that may now be studied thanks to this development. Dumping debris like ceramic sludge (CW) and rice husk ash (RHA) might pollute groundwater and contaminate aquatic ecosystems. Bituminous concrete mixes with 2, 5, and 7% ceramic waste and 2, 5, and 4% bitumen content were tested to see how well they performed mechanically as a potential solution to this issue. This lab study designed and evaluated bituminous pavement mixtures using Marshall Stability and indirect tensile strength tests. These two materials' mechanical qualities will be assessed for benefit. In low-to-medium traffic routes, CW and RHA reduce land hazards.

(Radhakrishnan et al., 2022) (13) Bituminous materials are used for the majority of road surfaces across the world. Virgin natural aggregates are required in large quantities for both new road building and routine road maintenance. The cost and the environment are both affected by the depletion of resources used in building the road. Therefore, it is important to cut down on the amount of virgin aggregate used to build bituminous pavements. Sustainable resources like marble rubble and recycled asphalt pavement (RAP) might be used to build hot mix asphalt (HMA) roads toward this goal. The emphasis of this study is on Sustainable Development Goal 12.5: Maximizing resource recovery and reutilization. Unfortunately, I was unable to locate any studies that looked at the combination of RAP and sustainable materials in bituminous paver blocks. The bituminous mixes and a control mixture were put through a battery of strength tests to evaluate how they compared. Laboratory studies of the cast bituminous paver blocks included compression, Cantabro loss, and wheel rut tests, among others. The values obtained from the tests were good, thus these bituminous blocks may be utilized for servicing the pavement constructions. According to the research, combining RAP with sustainable materials in pavement blocks may create a low-impact, low-maintenance system, making it an important strategy for achieving SDG.

(Kene et al., 2020) (14) The study's overarching goal is to locate the sources of environmental pollution, such agricultural and industrial waste, so that they may be eradicated.

This waste product might be used to create cement-concrete paving blocks. Concrete is used extensively in today's building practices. Paver blocks are widely used around the world, particularly in India, because to their low cost and visually beautiful design, which makes them preferable to both flexible and rigid pavements. Paving materials, such as interlocking concrete slabs, are often utilized in outdoor landscaping. They are a unique kind of precast concrete made using a dry mixture. When compared to other options, paver blocks are superior in terms of appearance, convenience of installation, and quality of finish. Parking lots, walkways, traffic circles, container yards, and motorways are just some of the commercial, municipal, and industrial uses for paving stones due to their strength, durability, and visually beautiful surfaces. We will investigate the potential for reducing cement use in paver blocks by integrating recycled materials such as plastic, Fly ash, and rice husk ash. It's useful for better managing trash like plastic, fly ash, and rice husk ash. Materials including plastic, rice husk ash, and fly ash are included into the cement and aggregate of paver bricks.

(Hossiney et al., 2020) (15) India's policymakers have recently come around to the idea that those who choose not to drive themselves should be taken into account while designing cities. As a consequence, there has been a rise in the usage of environmentally damaging products like Portland cement and crushed stone. This research shows how various waste materials may be transformed into useful paver stones for a public plaza. Geopolymer concrete, made from fly ash and recycled asphalt pavement, was used in the production of the paving blocks. Various percentages of recycled asphalt pavement aggregate were substituted for virgin coarse and fine aggregates during laboratory production of paver blocks at 0%, 20%, 40%, 60%, and 80%. In accordance with IS15658:2006, the planned paving blocks were put through a battery of tests for dimensional accuracy, water absorption, compressive strength, and abrasion resistance. Experiments in a lab reveal that high-quality paver blocks may be made by incorporating recycled asphalt pavement particles into a geopolymer matrix. It's a creative answer to the waste that's now piling up in landfills and pushing up paving prices, and it can also be used for pedestrian amenities. As a result, the suggested strategy has the potential to influence policymakers in the paving sector to adopt more environmentally friendly choices regarding recycled asphalt pavement.

V. METHODOLOGY

In the present study, two different types of aggregates (FA and RAP) were used: RAP aggregates and fresh aggregates (FA) that were procured from a nearby quarry. RAP was acquired through the uncontrolled milling of bituminous concrete (BC) pavement that was 2 years old and Stored in dumping yard besides the Rahul ware house in Gwalior, Madhya Pradesh on Srinagar – Kanyakumari Highway yielded RAP with a nominal maximum aggregate size of 13 mm. Large RAP aggregate fragments that clung together due to softened asphalt made up the material. In order to put these materials to use, it was necessary to separate them from their agglomerated state. RAP aggregates were thus evenly baked for 30 to 40 minutes at 80 C in an oven before being shattered into individual aggregates with a wooden hammer.

“This method was continuously used to make appropriate use of RAP aggregates in pervious paver blocks (PPB)”. Additionally, cement of OPC-43 grade was used. “In the current investigation, c/a ratio (0.25) and w/c ratio (0.35) were chosen by weight. Pervious paver blocks were made using two distinct gradations, as shown in Table 1.” “These grades are G1 and G2, respectively. G2 was chosen to have a finer texture than G1, whereas G1 was picked from a prior study by (Chandrappa et al., 2018). (16) Virgin aggregates and RAP were combined in three different ways: 100% FA, 50% FA + 50% RAP, and 100% RAP.” “The weight of the aggregates was used to replace RAP”.

“The mix ratios for the various aggregates and gradations are denoted as G1 0, G1 50, G1 100, and G2 0, G2 50, and G2 100.” RAP usage has been denoted in the mix by the numbers 0, 50, and 100. Table 4 provides information on the mix proportion as well as the fundamental characteristics of FA and RAP.

Specific gravity, density, and Los-Angeles abrasion values of RAP aggregates are reduced when an asphalt binder coating is present on their surface. Material abrasion during milling operations increases water absorption. Additionally, the RAP aggregates are contaminated by fines and dust, which is another factor in the water absorption.

The aggregates were sieved into a range of sizes to make it easier to create an interconnected open pore structure, which would allow us to measure the performance of pervious paver blocks. “According to Table 1 two aggregate gradations were used: 6.3 mm passing 2.36 mm retained and 12.5 mm passing 6.3 mm retained”. ‘’Image 2 and Image 3’’ shows sieve analysis of FA and RAP respectively “No superplasticizer was used when the aggregates were batched in the saturated surface dry state”. The binding substance was Ordinary Portland cement (OPC), often known as OPC43.Table 2 represent the Physical and chemical compositions of cement. In the current investigation, cement aggregate ratio (C/A) 0.25 and water cement ratio (W/C) 0.35 were chosen by weight.

A. *Material*

1) Waste material RAP & RHA used for replacing aggregate and cement respectively making it economical and sustainable.
2) Coarse aggregate FA replaced by RAP (Recycled asphalt pavement) in three percent 0%, 50% and 100% ratio by weight. In two different grades G1&G2. Table 3 represent Basic Properties of Aggregates Used in the Study.
3) Cement OPC 43 replaced by industrial waste RHA (Rice husk ash) which have cementious properties in two percent 10% and 20% ratio by weight.

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Image B sieve analysis of FA

Image C sieve analysis of RAP

Table 1 Details of gradation

	"Aggregate size, mm"	
"Gradation"	12.5 - 6.3	6.3 - 2.36
G1	100	0
G2	50	50

Table 2 Physical and chemical compositions of cement

	"SiO2"	"Al2O3"	"Fe2O3"	"CaO"	"MgO"	"SO3"
Oxides, %	"25.1"	"6"	"3.5"	"43"	"13.2"	"1.82"
"Initial setting time, min"			40			
"Final setting time, min"			150			
"Specific gravity"			"3.15"			

Table 3 Basic properties and abrasion value of FA & RAP

Properties	Bulk Specific Gravity	Water Absorption	% Density, (kg/m3)	Los-Angeles abrasion value %
FA	2.7	0.65	1708.36	18.98
RAP	2.63	0.71	1596.72	11.84

B. RHA (Rice Husk Ash)

In this research, we provide the results of an experiment designed to determine how combining cement with RHA affects the behavior of Paver blocks. RHA's chemical and physical characteristics were studied. Compressive strength, a mechanical property that varies with age, was one of two measures used to determine RHA's impact on concrete's properties while testing fresh properties. The RP overseas in Lohgarh (M.P.) provided the rice husk ash that was used in the project. where we got our used rice husk ash from. When rice husk (RH) is burned, it creates ash (RHA) that is highly reactive and has excellent pozzolanic capacity. It has a bulk density of 0.781 g/cc and a specific gravity of 2.10. Indian Standard Code of Practice for Plain and Reinforced Concrete (IS 456-2000) recommends using RHA in concrete.

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1) "Normal Consistency" = "17%"
2) "Initial and Final Setting time" = "195min. and 265min."
3) "Compressive Strength" = "11 N/mm2"
4) "Specific Gravity" = "2.09"

C. *Mix Design*

Cement aggregate ratio (c/a) = 0.25
Water cement ratio (w/c) = 0.35
Note No fine aggregate and sand is used in concrete mix for pervious paver block.

Table 4 Mix design and its proportions by weight

Sieve size, mm	% composition	cement content	10% RHA		20% RHA		water content	Aggregate Requirement	0% RAP		50% RAP		100% RAP	
		(C/A) 0.25	10% RHA	90% C	20% RHA	80% C	w/c (0.35)		RAP	FA	RAP	FA	RAP	FA
Gradation 1														
12.5 - 6.3	100	433	43.3	389.7	86.6	346.4	152	1730	0	1730	865	865	100	0
6.3 - 2.36	0													
Total	100	433	43.3	389.7	86.6	346.4	152	1730	0	1730	865	865	100	0
Gradation 2														
12.5 - 6.3	50	433	43.3	389.7	86.6	346.4	152	865	0	865	433	433	865	0
6.3 - 2.36	50							865	0	865	433	433	865	0
Total	100	433	43.3	389.7	86.6	346.4	152	1730		1730	865	865	1730	0

Note: All the calculations are in kg/m^3

VI. PREPARATION OF PCPB

The manufacturing process for PCPB was standardized. The term "cement paste encapsulating aggregate blending method" describes this practice. "In this procedure, the concrete mixer was run for 15–20 seconds after the whole amount of aggregate and 20–25 percent of the entire calculated water content had been added". "The necessary amount of cement was then added to the mixture to bind the aggregate". The remaining water was added last, and after roughly 2 minutes of mixing, the resulting substance was put into the molds. A vibrating table was used to condense the PCPB samples. The typical paver brick is prepared in the factory by being vibrated for 15-20 seconds. The prepared samples were let to dry in the mold overnight. After curing in water for 28 days, the dry samples were demolded. It's important to remember that there are four distinct PCPB preparation shapes. Line drawings of the various molds utilized in this research are shown in Figure 1. The area and diameters of the several PCPBs measured in this investigation. Shown in Table 5.

Table 5 Dimensions, area & volume of pcpbs in mm,mm^2&mm^3respectively

Shape	A	B	C	D	E	F	G	H	surface Area	Thickness	Volume
	221	175	86	35	40	24	67.5	127	34409.5	60	2064570

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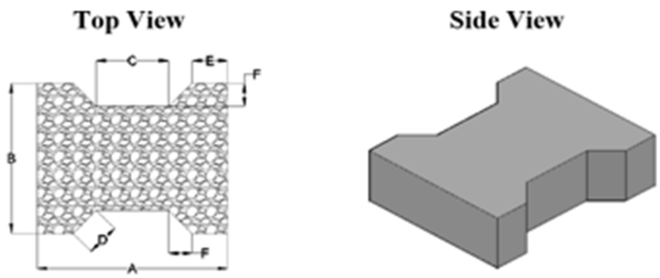


(A)

Figure 1 Line drawing

“The total of **84** specimens **[2 gradient ×{** (2 RHA× 3RAP)+1ideal 0% RHA 0%RAP**}]×6 Replicates.** were fabricated for laboratory evaluation”. The porosity, density, infiltration rate, and Cantabro abrasion were assessed on three of six replicates, while the strength properties were assessed on three of the six duplicates. The averages are included in the published content. All measurements have a coefficient of variation of less than 10%.

Tests

1) Density and Porosity
2) Cantabro abrasion loss (%)
3) Infiltration rate (mm/sec.)
4) Compressive strength
5)

VII. HARDENED DENSITY AND POROSITY

Density and porosity, two important pore properties, best define PCPB's structural and functional activities. “In this investigation, ASTM C1754/C1754M-12, Standard Test Method for Density and Void Content of Hardened Pervious Concrete (Withdrawn 2021) was used to measure the density and porosity of hardened concrete samples that had been water-cured for 28 days “shown in image 4. “The pore parameters were calculated after first establishing the dry weight of each sample”. Then, the measurements were written down so that volume could be determined. “The density of a hardened sample is the same as the ratio of its dry weight to its volume. Submerging samples for 30 minutes allowed researchers to measure porosity”. Air bubbles were tapped out of the PCPB by tapping the samples on the outside. “As soon as the conditioning period ended, the submerged weight was measured, shown in image 5 and the porosity value was calculated using the formula provided in ASTM C1754”.(17)

Image D ppb drying in sun light

image E 28 days cured wet ppb

Image F Dissolved weight of ppb in water

VIII. CANTABRO ABRASION TEST

Durability is one of the crucial characteristics of PPB. The cement paste binds the aggregates together to form a honeycomb-like structure. For this structure's integrity, it is essential that the amount of material lost under abrasive load be kept to a minimum. Cantabro loss (CL) is one of the straightforward methods for evaluating the durability of prepared mixtures. The test procedure involves inserting the prepared PPB samples in an abrasion machine in Los Angeles (LA) without using steel balls. (18) The Cantabro attrition loss is reported as a percentage of the loss in mass of the PPB after 300 revolutions at 30 revolutions per minute.

Mathematically, expression shown by Eq-1 W_1, is the weight of compacted PPB before the test and W2 is the weight of the specimen after abrasion in the LA abrasion machine.

Equation 1 Cantabro loss

$$CantabroLoss = \frac{W_1 - W_2}{W_1} \times 100$$

Image G pcpb after Cantabro abrasion

IX. FAILURE LOAD AND COMPRESSIVE STRENGTH

Every PCPB sample we created was put through a displacement controlled compressive strength test for this research. One millimeter of force was applied per minute. We evaluated the PCPBs' surface areas and made note of the failure loads in order to evaluate their compressive strengths. The precast concrete blocks were evaluated in accordance with the requirements of Indian Standard (IS) 15658:2006, which is known as the CED 5: Flooring, Wall Finishing, and Roofing.(19)

X. INFILTRATION RATE

Each specimen's hardened density and porosity were assessed before it underwent an infiltration rate test. A steel ring with a 50 mm height and a 75 mm inside diameter was used for the test. Plumber putty was placed to the bottom edge of the ring to stop water leakage after it had been secured to the PCPB sample as illustrated in image 8. While 250 milliliters of water were put to the ring, a 15 millimeter head was tried to be maintained as illustrated in image 7. The time between the first water pour and its complete removal from PCPB's surface was then recorded. According to C1701/C1701M-17a, Standard Test Method for Infiltration Rate of In Place Pervious Concrete, the diameter of the ring and the time needed for a certain amount of water to permeate the PCPB were used to calculate the PCPB's infiltration rate. (20)

XI. COMPRESSIVE STRENGTH TEST

A displacement-controlled compressive testing instrument was used to determine the PPB's compressive strength (CS). Gypsum paste was placed to the paver stones' rough edges to create a level loading area. The rate of applying the load was 1 mm/min. Both the failure load and the total surface area of the PPB samples were used to calculate their CS. The measured compressive strength is increased by 1.18 in accordance with IS 15658: 2006 to reflect the distorted aspect ratio of the PPB. (21)

Image I water pouring to ppb ,in ring

Image H plumber putty sealing ring bottom

XII. RESULT

A. Density and porosity

1) Gradation G1

Specimen 1, 0% RAP 10% RHA

Specimen 2, 0% RAP 20% RHA

Specimen 3, 50% RAP 10% RHA

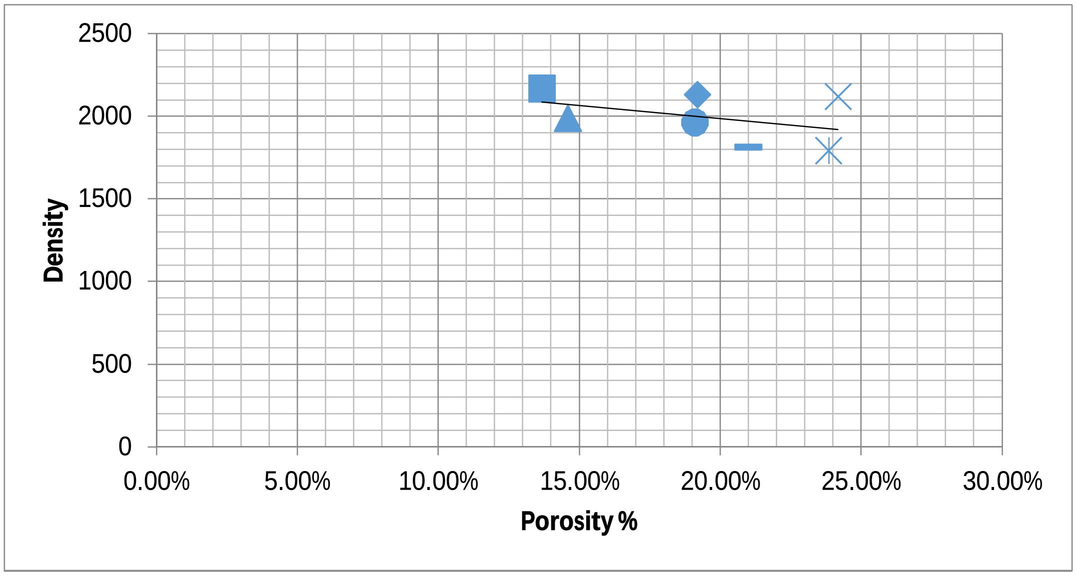
Specimen 4, 50% RAP 20% RHA

Specimen 5, 100% RAP 10% RHA

Specimen 6, 100% RAP 20% RHA

Specimen 7, Ideal (100% Fresh aggregate and 100% cement)

Graph 1 G1 Density kg/mm3and porosity in



2) *Gradation G2*

Specimen 8, 0% RAP 10% RHA

Specimen 9, 0% RAP 20% RHA

Specimen 10, 50% RAP 10% RHA

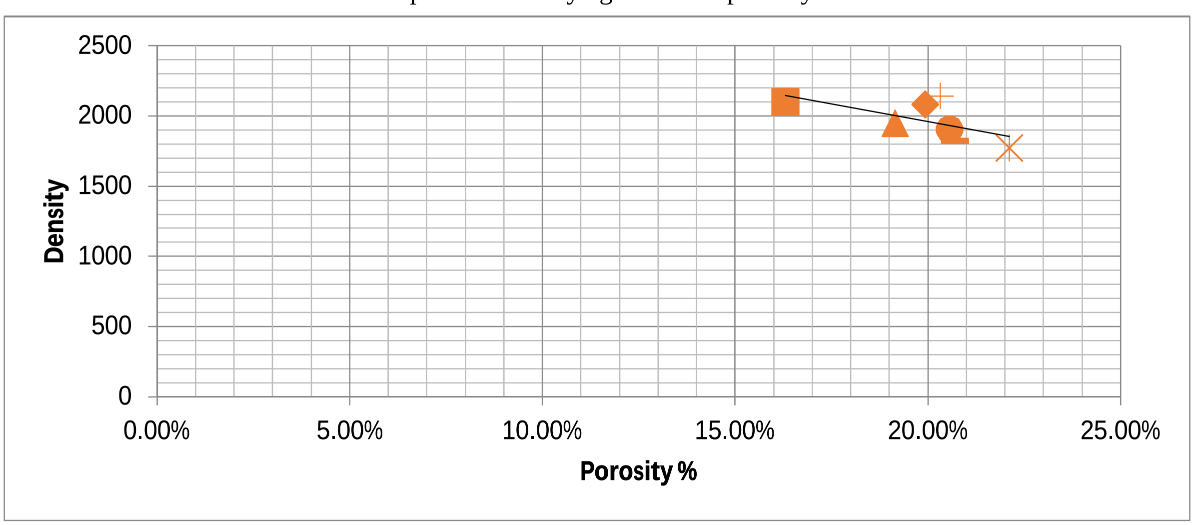
Specimen 11, 50% RAP 20% RHA

Specimen 12, 100% RAP 10% RHA

Specimen 13, 100% RAP 20% RHA

Specimen 14, Ideal (100% Fresh aggregate and 100% cement)

Graph 2 G2 density kg/mm3 and porosity in %

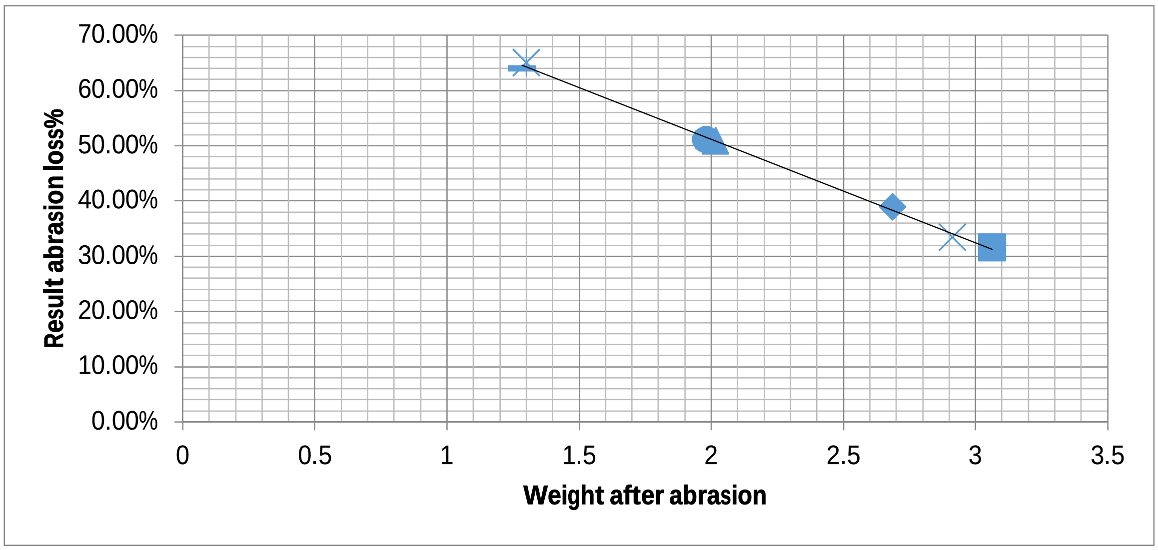


Density and porosity of paver blocks of grade G1 are covered in the table above. Two blocks deviated from the PC definition of porosity by having less than 15% of porosity. However, these blocks showed water percolation, demonstrating the existence of a section of a linked void system, as would be shown by the infiltration rate data. The G2 gradation, which used larger particles than the G1 gradation, had the same results. The density of G2 and G1 graded blocks was found to be almost same for the same combination composition (w/c and c/a). Porosity was also measured and found to be higher in G2 graded mixes compared to G1 graded mixes. In the case of G2 graded mixes, because the blocks with other ratios had blocked bottoms, only the mixture with a c/a ratio of 0.25 and a w/c ratio of 0.35 was addressed. The thinness of the blocks, in comparison to standard PC cylinders with a 200 mm diameter, allowed the cement paste to quickly drain to the bottom when subjected to vibration.

B. Cantabro Abrasion Loss%

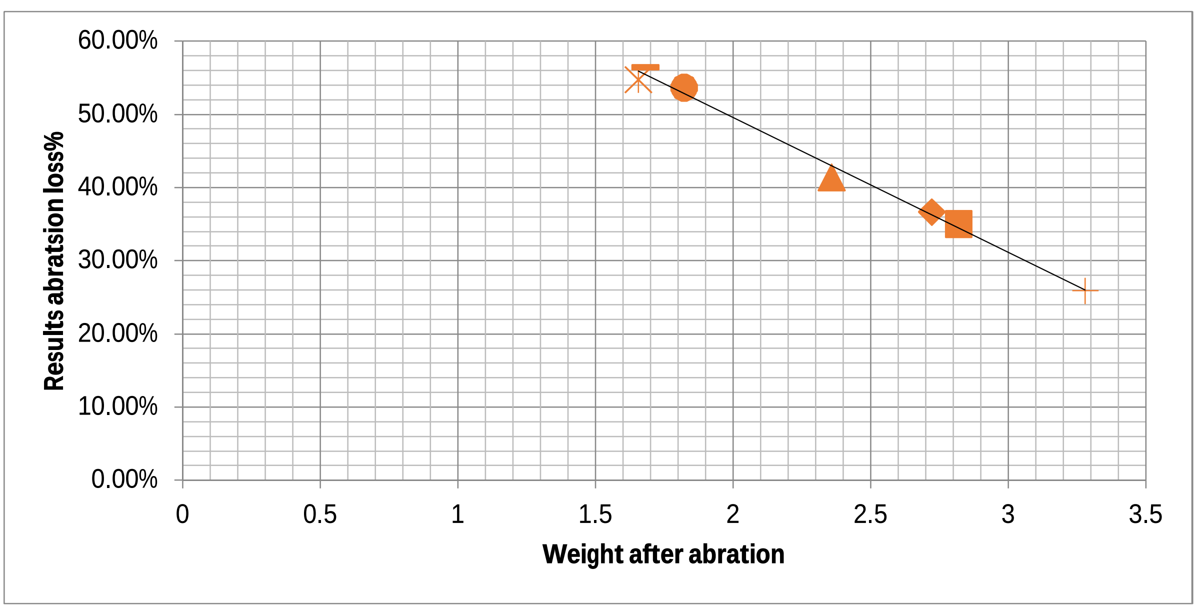
1) Gradation G1

Graph 3 G1 Abrasion loss % and weight after abrasion kg



2) Gradation G2

Graph 4 G2 Abrasion loss % and weight after abrasion in kg



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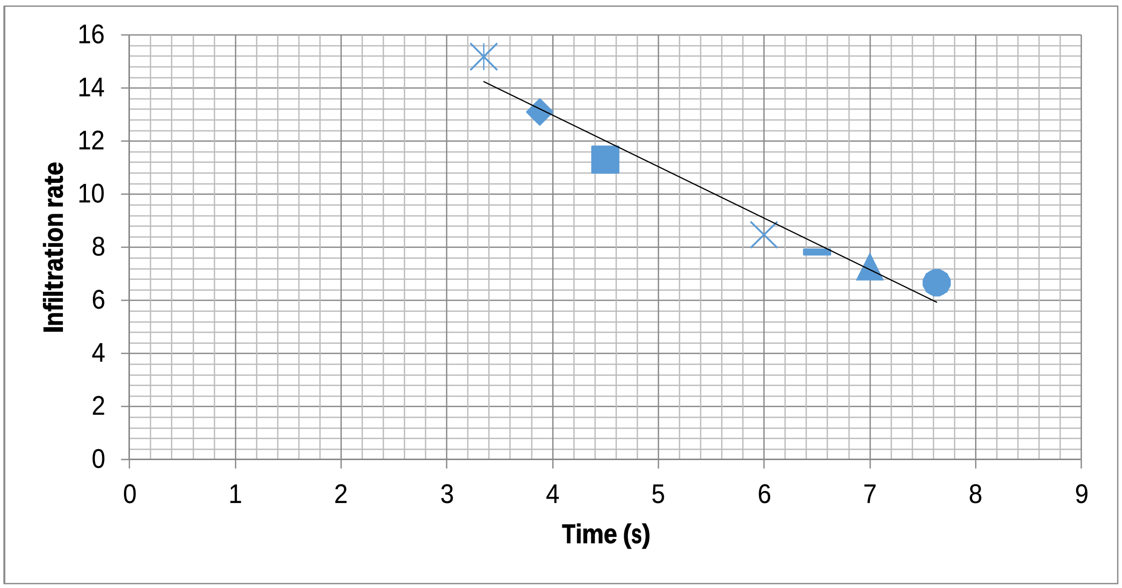
As seen in Fig., the Cantabro abrasion test yields typical PPB. Figure is a stacked area map that demonstrates the impact of different mix parameters on Cantabro loss (CL) values. As can be seen by the central depression, CL values were found to be lowest for w-c ratios of 0.30. Cement paste is strong enough to hold the aggregate particles together at this water-to-cement ratio, which explains the phenomenon. A lower w-c ratio results in a too-dry mixture, whereas a greater number produces a cement paste that is easily spreadable but has poor binding qualities. While G2's 100% VA produced the lowest CL value, G1's 50% RAP performed the best. The PPB density data obtained is supplemented by these findings. 3-inch ring was used to measure the PCPBs' infiltration rate. "While there was less variance in infiltration rate as a function of PCPB form than strength or failure load, there was still a noticeable range in infiltration rate with respect to c/a and w/c".

C. Infiltration Rate

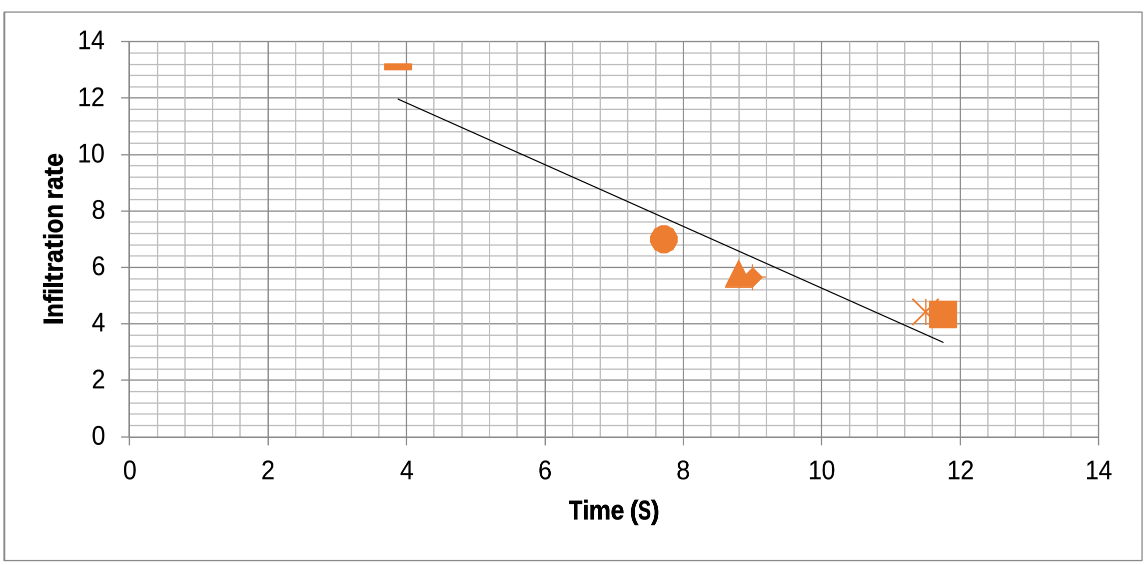
1) Gradation G1

Graph 5 G1 Infiltration rate mm/sec and time in sec



2) Gradation G2

Graph 6 G2 infiltration rate mm/sec and time in sec



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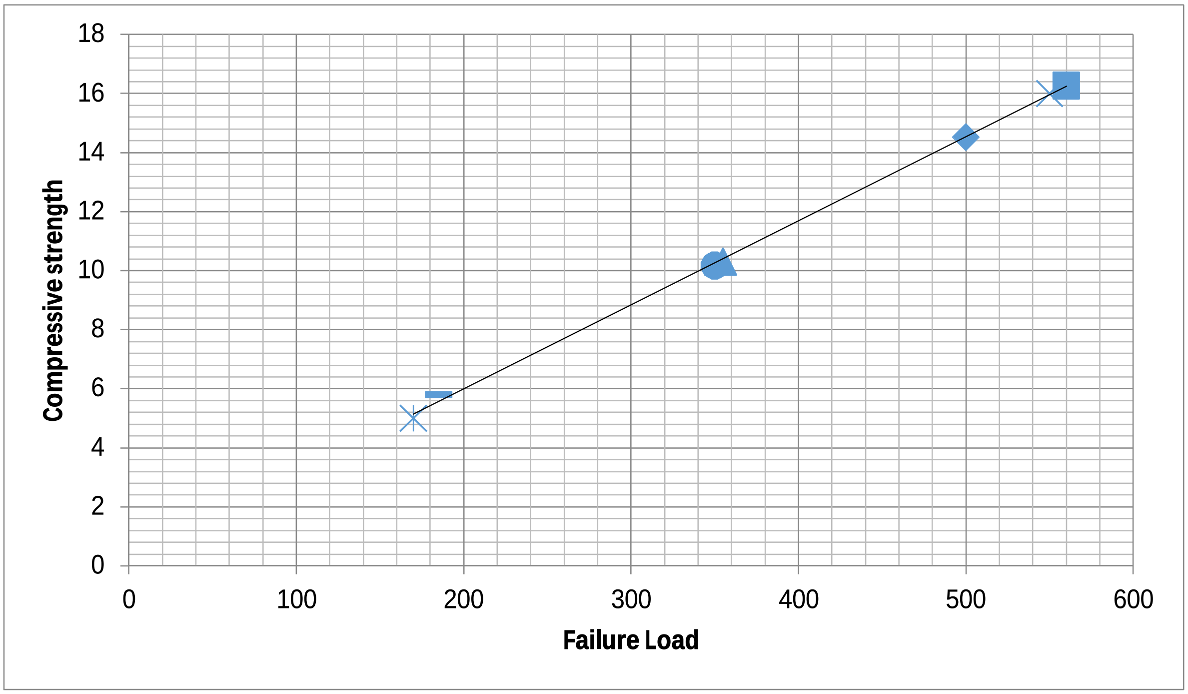
D. Compressive Strength

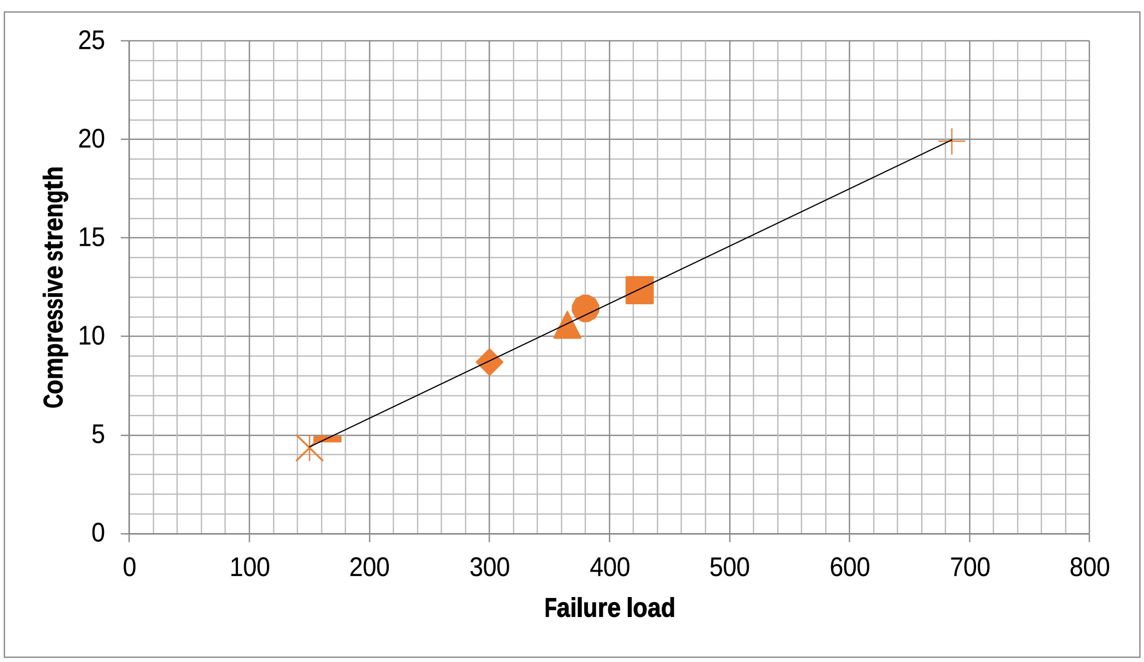
1) Gradation G1

Graph 7 G1 Compressive strength in Mpa and failure load in KN



2) Gradation G2

Graph 8 G2 Compressive strength in Mpa and Failure load in KN



XIII. STATISTICAL ANALYSIS

Table 6 one way anova on infiltration rate

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Density	218091.822	11	19826.529	.804	.074
Porosity	120.481	11	10.953	18.239	.053
Abrasion loss%	1818.841	11	165.349	1.566	.043
Failure Load	227610.714	11	20691.883	.318	.017
Compressive strength	187.758	11	17.069	.310	.021

XIV. CONCLUSION

Variations in precipitation patterns and increased frequency of extreme weather events are consequences of climate change in many parts of the world. Where adequate storm water management methods are not in place, unexpected and abrupt rainfall can cause flooding in metropolitan areas. Unplanned urban areas, especially in developing countries, are more vulnerable to flood damage from storm water. PCPs have the potential to be an effective feature of storm water management strategies. However, in underdeveloped nations, PCPs have not been given significant priority because to a lack of experience in construction and past success. The goal of this research is to investigate the Sustainable and cost-effective development of pervious paver block made with RHA (Rice husk ash) and RPA (Recycled asphalt pavement). The inferences can be drawn from this study based on the laboratory examination and analysis: It was discovered that the porosity of G2 graded mixtures was greater than that of G1 graded mixtures. CL values were found to be lowest for w-c ratios of 0.30. Cement paste is strong enough to hold the aggregate particles together at this water-to-cement ratio, which explains the phenomenon. In comparison to the conventional approach, the optimal replacement level of RHA results in block costs that are reduced by 7.5% for 0 RAP and 10% RHA, 15% for 0 RAP and 20% RHA, 20% for 50% Rap and 10% RHA, 27% for 50% RAP and 20% RHA, 33.2% for 100% RAP and 10% RHA, and 40.62% for 100% RAP and 20% RHA. The conclusion is that RHA-made paver blocks are reliable and cost-effective. Unlike c/a and w/c, the infiltration rate was not significantly impacted by shape, but rather by the quality of mixture or pore configuration.

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Disclosure statement
Conflict of interest Authors report no potential conflict of interest with any person and organization. The required copyright permissions were duly obtained by authors to reproduce Figures and Tables.

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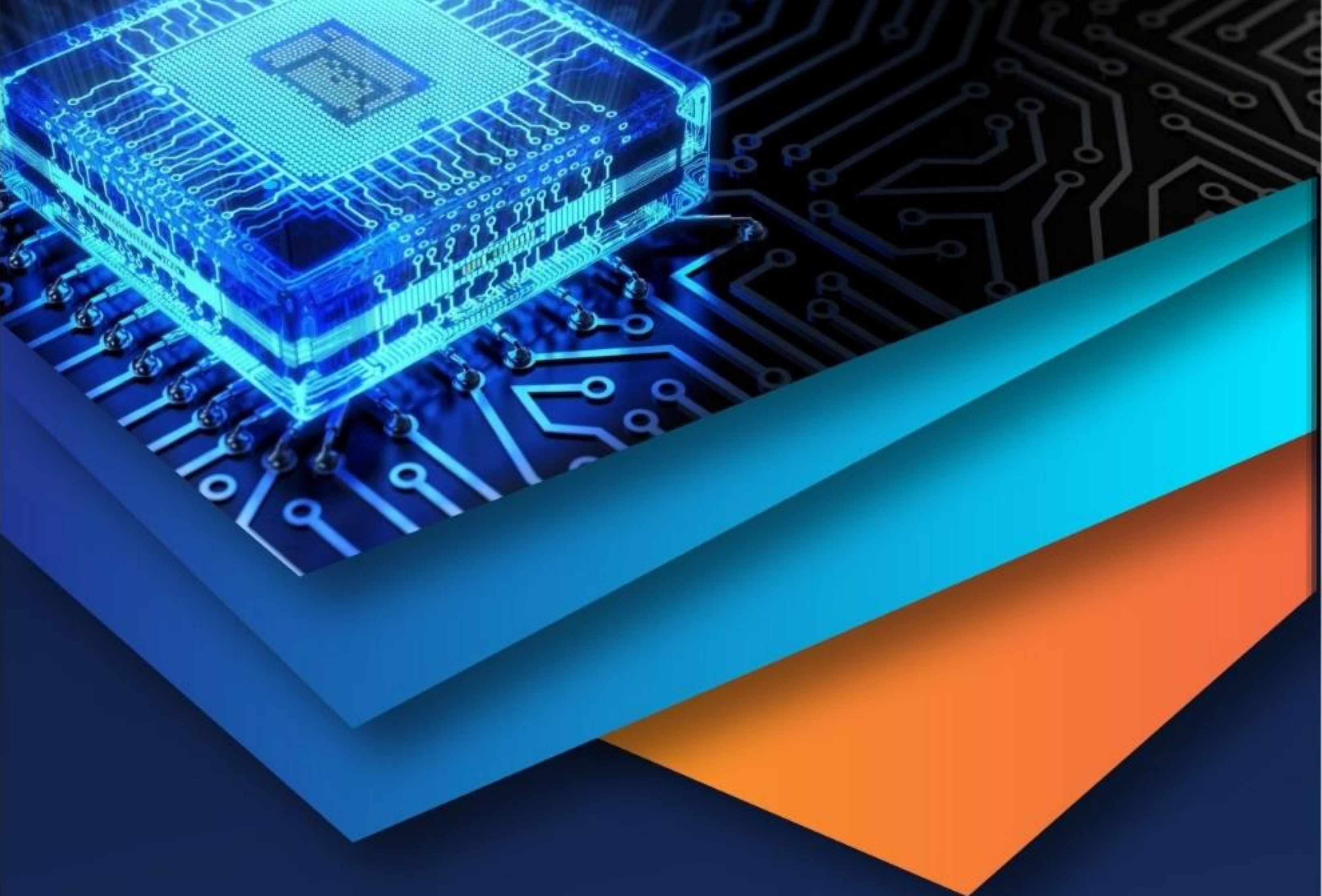

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