2026 Volume: 02 Issue: 09 www.ijrpa.com ISSN 2456-9995 Research Article

International Journal Research Publication Analysis

Page: 01-12

"THERMAL AND CHEMICAL RESISTIVITY OF POLYETHYLENE-BOUND PAVEMENT BLOCKS WITH RICE HUSK ASH ADDITION"

***Engr. Gidado Garba Lawal, Engr. Abdulaziz Dayyabu**

Department of Civil Engineering, Hassan Usman Katsina Polytechnic, Katsina State, Nigeria.

Article Received: 26 July 2026
Article Revised: 15 August 2026
Published on: 04 September 2026

***Corresponding Author: Engr. Gidado Garba Lawal**
Department of Civil Engineering, Hassan Usman Katsina Polytechnic, Katsina State, Nigeria.

DOI: https://doi-doi.org/101555/ijrpa.2146

ABSTRACT

The investigation was based on using rice husk ash as filler(reinforcement) with 0%, 5%, 10%, 15%, 20% and 25% by weight of the LDPE binder with average melting point of 110^{0}C (sachet water nylon). RHA was obtained by burning the Rice husk at 600^{0}C for 2 hours and later grinded after cooling and sieved using 300micron sieve to obtained a very finer material. A mix ratio of 1:4 was adopted in producing the pavement block. The laboratory tests conducted for both the materials and pavement blocks include specific gravity, particle size distribution (sieve analysis), chemical composition of RHA, temperature resistivity test, water absorption and chemical resistivity test. The specific gravity of the fine aggregate and RHA was 2.64 and 2.17 respectively, with the fine aggregate classified under zone II. The sieve analysis confirmed the fine aggregate as well graded and suitable for manufacturing. Key findings include a significant improvement in compressive strength with optimal RHA dossage at 15%, leading to an enhancement of up to 33% compared to conventional blocks. Also, the Temperature resistance analysis indicated that blocks with 15% RHA retained higher compressive strength than controls after 1 and 2 hours at 50°C, though extended exposure led to strength reductions or even collapse. The highest notable water absorption was 4.18% at control, decreases as the content of RHA was increases. The study further revealed that RHA enhances chemical Resistance, with blocks showing increased in compressive strength when exposed to hydrochloric acid and sodium hydroxide, improving by (18N/mm^2 and 19N/mm^2) 20% and 31.6% respectively compared to controls. These findings underscore the potential of RHA as a sustainable additive in pavement block manufacturing, enhancing durability under various environmental conditions.

KEYWORDS: Inter-lock pavement block, Polyethylene, Rice Husk Ash, Temperature resistivity, Water absorption, Chemical resistivity.

1.0 INTRODUCTION

The pursuit of sustainable construction materials has led researchers to explore the use of waste products as potential substitutes for conventional raw materials [11][9]. Among these, rice husk ash (RHA) has emerged as a promising additive due to its high silica content and pozzolanic properties, which can enhance the performance of various construction composites [5]. This study focuses on the integration of RHA into polyethylene-bound pavement blocks and its effects on thermal and chemical resistivity.

Rice husk ash is produced by the controlled combustion of rice husks, an agricultural by-product generated in significant quantities worldwide [6]. The management of rice husk waste poses environmental challenges, making its utilization in construction both economically and ecologically advantageous [10]. Previous studies have demonstrated that incorporating RHA into cementitious materials can improve their mechanical properties, durability, and resistance to chemical attacks [8].

Polyethylene, known for its versatility and chemical resistance, is widely used in various applications, including as a binder in composite materials [3][7]. However, its use in pavement blocks is relatively new. Integrating RHA into polyethylene composites could potentially enhance their performance under adverse environmental conditions [12][13]. Specifically, this study investigates how varying amounts of RHA (0%, 5%, 10%, 15%, 20%, and 25%) affect the thermal resistivity, water absorption and chemical resistivity of pavement blocks at different curing periods (28, and 56 days).

Thermal resistivity is a critical property for materials exposed to varying temperatures, as it determines their ability to withstand thermal stress without significant degradation. The incorporation of RHA is expected to influence the thermal stability of polyethylene composites, enhancing their performance in high-temperature environments [14].

Similarly, chemical resistivity is essential for materials subjected to aggressive chemical environments. RHA's pozzolanic reaction can potentially enhance the composite's resistance to chemical attacks, making it more durable in corrosive conditions [2].

Previous research has shown that incorporating RHA into cement-based materials can significantly reduce water absorption and improve durability. For example, [1] reported that RHA-modified concrete exhibited lower water absorption rates and increased resistance to sulfate attacks. Similarly, [4] found that the addition of RHA improved the impermeability and long-term durability of concrete structures.

This study aims to provide a comprehensive evaluation of the thermal and chemical resistivity of polyethylene-bound pavement blocks with RHA. By analyzing the effects of different RHA contents and curing times, the research seeks to determine the optimal formulation for enhanced performance in diverse environmental conditions. The findings could have significant implications for the development of sustainable, high-performance construction materials.

2.0 MATERIALS

A. The polyethylene (sachet water nylon) was collected from Katsina environs**.** The air in the bag was forced out and manual cutting method was adopted to create a better surface area for washing of the sachet using clean water and sun drier to remove the water content present before being melted at 250^{0}C, since the presence of water delays the process.

B. Aggregates are the highest constituents of Pavement block mixture; their strength plays significant role in the overall pavement strength. Weak aggregates produce pavement of potential cracks and or rutting as form of distress that undermines the integrity of pavements. The specific gravity and size distribution of aggregates in the pavement was evaluated and the result was presented in Figure I and II respectively.

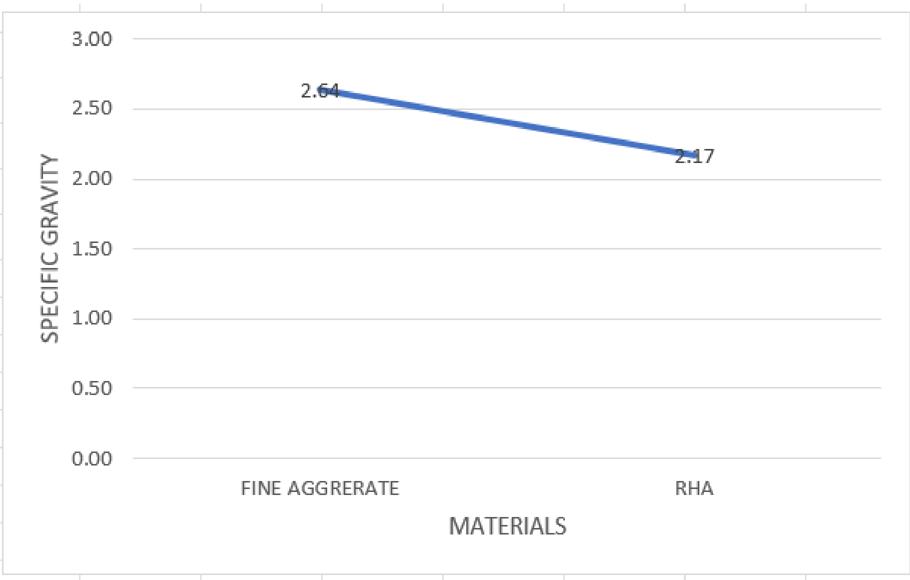


Figure 1: Specific Gravity of Fine Aggregate and RHA.

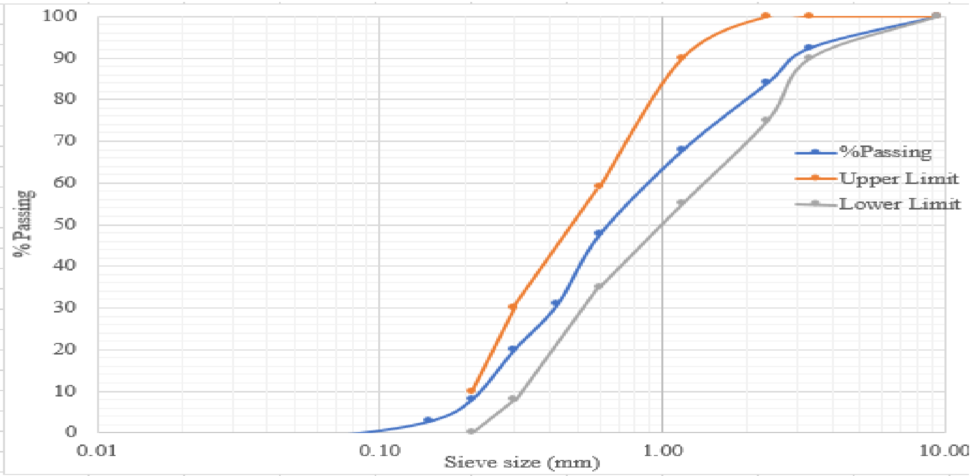


Figure 2: Sieve Analysis Result for Fine Aggregate test.

C. The rice husk was burned in a pot by application of fire to turn the husk in to ash, it was cooled, grinded and sieved using sieve size 300mic. Chemical composition and specific gravity tests were carried out and results were presented in Table I and Figure I respectively.

Table I: Chemical Composition of Rice Husk Ash.

Components (oxides)	Weight (%)
Na_2O	0.155
MgO	3.810
Al_2O_3	2.524
SiO_2	73.049
P_2O_5	11.651
SO_3	0.586
Cl	0.052
K_2O	3.589
CaO	2.023
TiO_2	0.323
Cr_2O_3	0.002
Mn_2O_3	0.341
Fe_2O_3	1.808
ZnO	0.072
SrO	0.014

3.0 METHODS

3.1 Mix Proportion

RHA was dosage at 0%, 5%, 10%, 15%, 20% and 25%. A mix proportion of 1:4 was adopted in producing the pavement block and the content of the rice husk ash in percentage are shown below in table 1:

Table 2: Mixing Proportion.

S/N	Sample	Ratio of polythene	Ratio of Sand	Rice husk ash	Percentage Filler of RHA
1	A	1	4	0	0%
2	B	1	4	0.05	5%
3	C	1	4	0.1	10%
4	D	1	4	0.15	15%
5	E	1	4	0.2	20%
6	F	1	4	0.25	25%

3.2 Compressive Strength Test

Compressive strength is an important property which was determined by loading molded and cured specimens as dictated by the standard. In determining this property, the cubes specimen of 75 x 75 x 75mm was placed with its center perfectly positioned against the platens of the universal testing machine at a Loading Rate of 10mm/min, a Total 72 number of cubes was casted (figure 3b) and crushed to determine the Compressive strength (figure 3d) and density (figure 3c) at 7, 14, 28 and 56 days accordance to ASTM D638

The compressive strength and density were found using the formula:

$$\sigma_{compressive} = \frac{P}{A} \quad (3.1)$$

Where:

$\sigma_{compressive}$ = Compressive strength of the sample (N/mm^2)

P = Crushing Load (kN)

A = Surface area of specimen (length x width) (mm^2)

3.3 Temperature Resistivity Test

This was conducted to determine the effect of temperature on the compressive strength of the pavement block.

The test specimen with high compressive strength (i.e at 15% rice husk ash content) was used, the samples were subjected to temperature of 50°C for 1, 2, and 3 hours respectively and the compressive strength was determined based on ASTM D638.

3.4 Water Absorption Test

The test specimens with the highest compressive strength which fallen on 15% rice husk ash additive where completely immersed in water for 24 hours, the specimens where then removed from the water and visible water on the specimens was removed with damp cloth, the specimens where immediately weighed and the weight for each specimen was noted According to ASTM D638.

The water absorption rate was calculated using the following Formula:

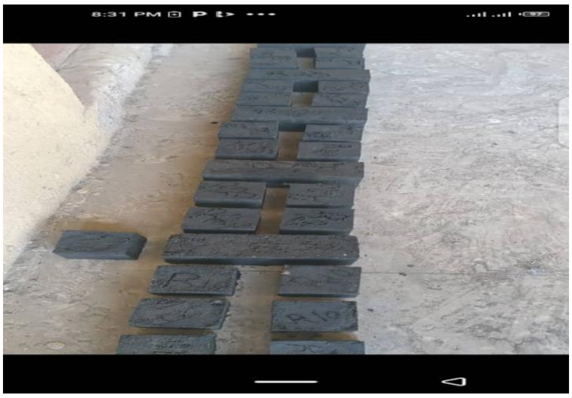
Water absorption rate = $\frac{(\text{weight wet} - \text{weight dry})}{\text{weight dry}}$ ×100%.................... (1)

3.5 Chemical resistivity

The test specimens with the highest compressive strength which fallen on 15% rice husk ash additive where completely immersed in Acid/water solution for 24 hours, the specimens where then removed from the solution and visible solution on the specimens was removed with damp cloth, the specimens where immediately weight for each specimen and the crushing load then determined and noted According to ASTM D638.

RHA produce

(a)



Inter-lock samples (cubes and beams)

(b)

Weight of sample taken

(c)

Sample under crushing

(d)

Figure 3: RHA produced, Casted Specimen and crushing of samples.

4.0 RESULTS AND DISCUSSION

4.1 Compressive Strength Test Results

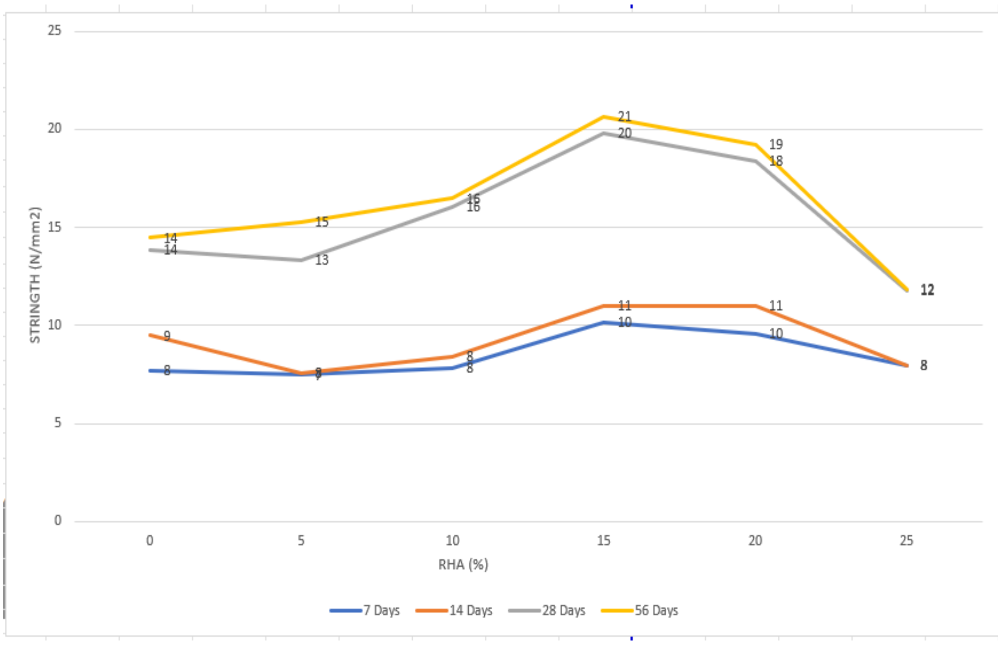


Figure 4: Compressive strength results of the pavement block.

From the graph shown in Figure 4, results indicated that, there was notable improvement in compressive strength with increase of aging and RHA content resp., peaking at 15% RHA as the optimal dossage level where the strength decreases.

At 28 days of aging, the compressive strength increased from 14 N/mm² to 20 N/mm² and 21 N/mm^2 at 15% and 20% RHA content, this enhancement represents a significant improvement of 30% and 33% respectively compared to the control samples, suggesting that RHA effectively enhances the structural integrity of pavement blocks.

4.2 Temperature Resistivity

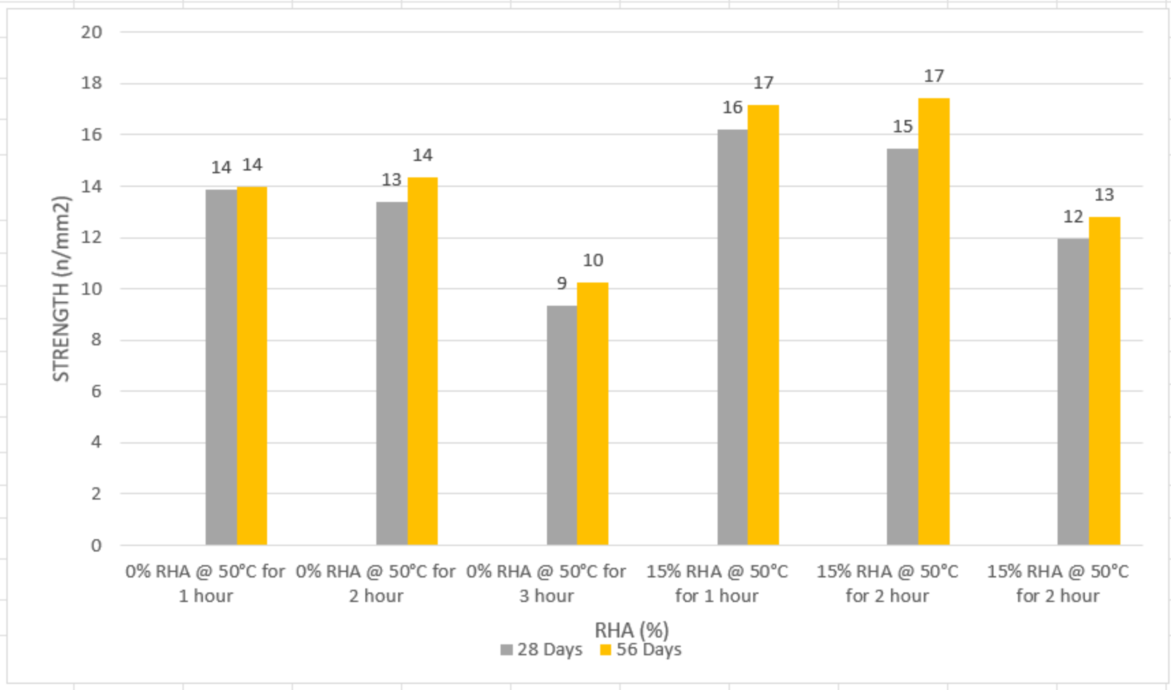


Figure 5: Temperature Test Results.

Figure 3 above the results revealed that both the control (0% RHA) and the pavement blocks with 15% RHA experienced a decrease in compressive strength as the duration of exposure to elevated temperatures increased. Specifically, the compressive strength decreased from 14 N/mm² to 9 N/mm² for the control blocks and from 16 N/mm² to 12 N/mm² for blocks with 15% RHA when exposed to 50^{0} C for varying durations.

Furthermore, the compressive strength showed an increase with the age of the pavement blocks, which was consistent with the general behavior observed in earlier stages of the research. Notably, the compressive strength of blocks with 15% RHA was higher than that of the control blocks after 1 and 2 hours of exposure to 50^{0} C, indicating a potential beneficial effect of RHA in enhancing temperature resistivity within these time frames. However, after 3 hours of exposure, the compressive strength of blocks with 15% RHA was slightly lower than that of the control blocks.

4.3 Water Absorption Test Result

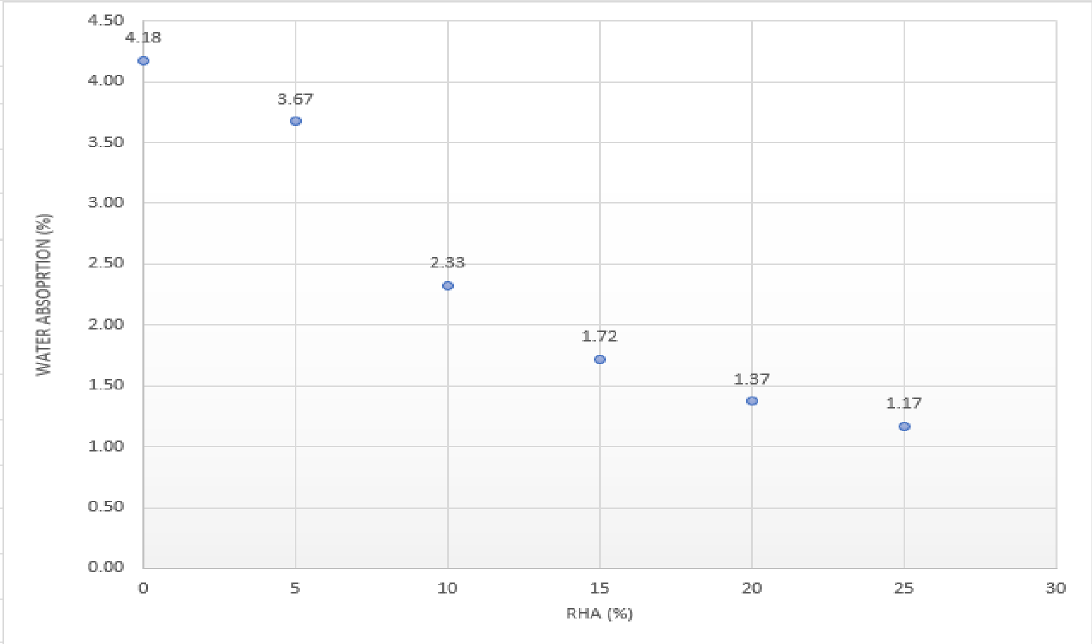


Figure 6: Water Absorption Test.

The results indicated a significant influence of RHA content on the water absorption characteristics of the pavement blocks. The highest water absorption rate, observed at 0% RHA (control), was recorded at 4.18%. As the percentage of RHA increased, there was a noticeable decrease in water absorption. Notably, at 15% RHA content, the pavement blocks exhibited a remarkably low water absorption rate, which was 58.8% lower than that of the control blocks.

4.4 Chemical Resistivity Test Result

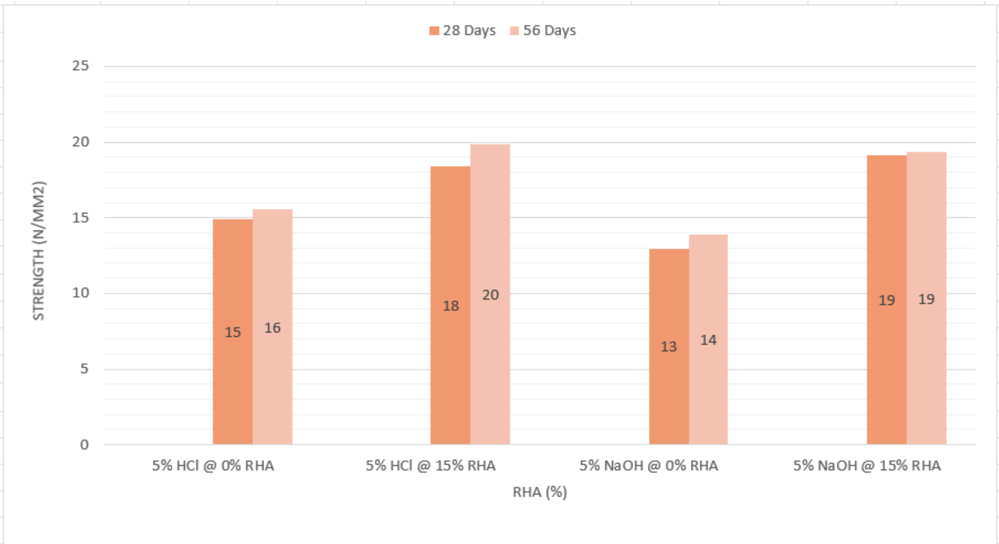


Figure 7: Chemical Resistivity test.

Figure 7 above revealed that pavement blocks incorporating 15% RHA exhibited higher compressive strength compared to the control blocks when subjected to chemical exposure. Specifically, after 28 days of curing:

Hydrochloric Acid (HCl): The compressive strength increased by 20% (from 15 N/mm² to 18 N/mm²) for blocks with 15% RHA compared to the control.

Sodium Hydroxide (NaOH): The compressive strength increased by 31.6% (from 13 N/mm² to 19 N/mm²) for blocks with 15% RHA compared to the control.

These findings indicate that incorporating RHA in pavement blocks enhances their resistance to chemical deterioration caused by both acids and alkalis. The improvement in compressive strength with age further supports the durability of RHA-enhanced blocks under chemical exposure conditions.

5.0 CONCLUTION AND RECOMMENDATION

5.1 Conclusion

Based on the result obtained from the various test undertaken, it shows that;

1. The material characterization confirmed that both the fine aggregate (Specific Gravity = 2.64, Zone II classification, well-graded) and the RHA (Specific Gravity = 2.17, sieved through 300μm) possess the physical and structural properties required for quality pavement block production.
2. RHA as a filler significantly improves the mechanical properties of the pavement blocks. The optimal dossage level was found to be 15% RHA by weight. At the peak 15% RHA dossage, the blocks achieved a remarkable 30% increase in compressive strength
3. The variation in temperature resistivity for 0% and 15% RHA at 1, 2 and 3 hours are 12.5%, 13% and 25% respectively, while the water absorption at 0% and 25% RHA are 4.18% and 1.17% rate and the variation in chemical resistivity for 0% and 15% RHA of HCl and NaOH are 16.7% and 31.5% respectively.

5.2 Recommendation

1. Further optimize the percentage of RHA to achieve the best balance between material cost and performance in pavement block production.
2. Conduct more durability tests (such as freeze-thaw resistance, abrasion resistance) to evaluate the long-term performance of pavement blocks incorporating RHA.
3. Conduct field trials to validate the laboratory findings under real-world conditions and assess the practical feasibility of implementing RHA-enhanced pavement blocks.

4. Conduct a comprehensive cost-benefit analysis to evaluate the economic feasibility of using RHA in pavement block production, considering material cost, performance improvements, and potential savings in maintenance.
5. Investigate the specific mechanisms by which RHA influences temperature resistivity in pavement blocks, focusing on thermal conductivity and heat dissipation properties.

REFERENCES

1. Alam, M. S., Haque, M. A., & Islam, M. T. (2022). Performance of Rice Husk Ash Concrete under Aggressive Environmental Conditions. *Journal of Sustainable Cement-Based Materials*, 11(6), 403-419.
2. Bui, D. D., & Satoh, T. (2023). Pozzolanic Activity of Rice Husk Ash: A Review. *Journal of Cement and Concrete Research*, 48(3), 567-581.
3. Chen, J., Li, Y., & Zhang, W. (2022). Polyethylene as a Binder for Pavement Blocks: Challenges and Opportunities. *Journal of Polymer Engineering*, 32(4), 299-312.
4. Gupta, R., Kumar, A., & Tiwari, A. (2022). Evaluation of Durability Properties of Concrete Containing Rice Husk Ash. *Journal of Advanced Concrete Technology*, 20(4), 334-347.
5. Kumar, S., Patel, R., & Mehta, P. (2022). Rice Husk Ash: A Green Supplementary Cementitious Material. *International Journal of Environmental Engineering*, 10(1), 55-67.
6. Lee, S., & Kim, H. (2023). Innovative Use of Rice Husk Ash in Polymer-Modified Concrete. *Journal of Cleaner Production*, 368, 133-145.
7. Li, Q., & Gao, H. (2023). Enhancing Pavement Block Performance with Polyethylene-Rice Husk Ash Composites. *Journal of Materials in Civil Engineering*, 35(5), 540-552.
8. Patel, A., & Shah, N. (2023). Enhancing the Durability of Concrete with Rice Husk Ash: A Review. *Journal of Advanced Civil Engineering*, 22(3), 134-145.
9. Sharma, P., Kumar, R., & Singh, R. (2023). Utilization of Rice Husk Ash in Sustainable Construction: A Review. *Journal of Sustainable Building Materials*, 15(2), 123-138.
10. Singh, A., Gupta, V., & Chandra, S. (2023). Enhancing Concrete Properties with Rice Husk Ash: A Comprehensive Review. *Materials Science and Engineering*, 45(3), 456-471.
11. Tiwari, A., & Sharma, R. (2023). Advancements in the Utilization of Rice Husk Ash in Construction Materials. *Journal of Construction and Building Materials*, 65(2), 890-905.

12. Wang, F., & Liu, Y. (2023). Evaluation of Rice Husk Ash as a Sustainable Supplementary Material in Construction. *Journal of Sustainable Engineering*, 18(4), 657-670.
13. Zhang, L., Zhou, X., & Wang, Y. (2023). Mechanical Performance of Polyethylene Composites with Mineral Additives. *Journal of Composite Materials*, 57(2), 234-247.
14. Zhao, Y., & Hu, J. (2023). Polyethylene and Rice Husk Ash Blends for Pavement Applications. *Journal of Transportation Engineering*, 149(4), 04023036.