American Journal of Applied Sciences and Engineering | *ISSN 2766-7596*
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12011 WestBrae Pkwy, Houston, TX 77031, United States
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Research Article

Comparative Analysis of Thermal Insulation Properties of Bricks Made from Local and Industrial By-Products

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Abstract

As global energy efficiency demands grow, the need for affordable and sustainable insulating building materials becomes more critical. This study explores the thermal insulation performance of bricks made using locally available materials and industrial by-products. The aim of this research is to assess and compare the thermal insulation properties of bricks produced from laterite, clay, and industrial by-products such as fly ash and rice husk ash (RHA). The methodology involved producing four types of bricks: conventional clay bricks, laterite-based bricks, fly ash-based bricks, and RHA-blended bricks. Each type was cured, dried, and tested under standardized conditions for thermal conductivity using the guarded hot plate method, in accordance with ASTM C177. Thermal conductivity values obtained were: conventional clay bricks (0.82 W/mK), laterite bricks (0.67 W/mK), fly ash bricks (0.54 W/mK), and RHA bricks (0.49 W/mK). Results show that RHA and fly ash bricks outperform conventional bricks in thermal insulation, with the RHA-based bricks demonstrating the lowest thermal conductivity. These findings highlight the potential of industrial by-products in producing eco-friendly, energy-efficient building materials. This research supports the application of these alternative bricks in sustainable construction, particularly in hot climates where thermal insulation can significantly reduce energy demand for cooling.

Keywords	*Thermal Insulation Properties; Industrial By-Products; Sustainable Insulating Building Materials; Thermal Conductivity*
Citation	Okiye, S. E., Emekwisia, C. C., Igwe, E. S., Omofaye, V. I., Agbelusi, A. J., Ajibode, H. J., Dada, A. O., & Agbahiwe, O. K. (2025). Comparative Analysis of Thermal Insulation Properties of Bricks Made from Local and Industrial By-Products. *American Journal of Applied Sciences and Engineering 6(3) 11-16.* https://doi.org/10.5281/zenodo.16229391

Introduction

The growing global emphasis on sustainable construction has intensified research into alternative building materials that minimize environmental impact and promote energy efficiency. Traditional building materials such as fired clay bricks and concrete blocks, while effective structurally, often perform poorly in terms of thermal insulation, contributing to increased energy demands for heating and cooling (Neville, 2011). This has led to increasing interest in incorporating both local materials and industrial waste products into brick production to enhance thermal properties and reduce ecological footprints (Adesanya & Raheem, 2009). Bricks made from locally available materials like laterite and clay have been used for centuries in tropical regions due to their accessibility and moderate thermal mass (Olarewaju & Adewale, 2015). However, recent innovations in materials science have identified a range of industrial by-products—such as fly ash, rice husk ash (RHA), and bottom ash—as viable raw materials for brick production (Singh & Garg, 1991). These materials not only help divert industrial waste from landfills but can also improve the physical and thermal properties of bricks (Oyetola & Abdullahi, 2006). Fly ash, a by-product of coal combustion in power plants, has been recognized for its pozzolanic characteristics, which enhance the strength and durability of bricks while reducing their density (Muntohar & Rahman, 2010). Similarly, RHA, which results from the controlled burning of rice husks, is rich in amorphous silica and has been found to significantly improve thermal insulation in masonry products (Ganesan et al., 2008). The incorporation of these by-products can alter the microstructure and pore distribution in bricks, thereby reducing thermal conductivity (Zhang & Malhotra, 1996). This is particularly advantageous in tropical and subtropical regions where high ambient temperatures necessitate efficient building envelopes to reduce reliance on mechanical cooling systems (Raheem & Ogunleye, 2013). Despite the promising potential of these alternative materials, comparative studies evaluating their thermal insulation properties in brick form remain limited, especially in the context of developing countries where cost and material availability are critical constraints (Olufowobi et al., 2014). This research aims to fill that gap by systematically assessing and comparing the thermal performance of bricks made from laterite, clay, fly ash, and RHA. By combining empirical thermal conductivity testing with structural and moisture content evaluations, this study provides a comprehensive understanding of the suitability of these bricks for energy-efficient housing. The findings aim to support decision-makers, builders, and engineers in adopting sustainable materials that meet both performance and environmental criteria.

Materials and Methods

Materials Used

The primary raw materials used in this study include clay, laterite, fly ash, and rice husk ash (RHA). Ordinary Portland Cement (OPC) was used as the binding agent in all formulations. Laterite and clay were sourced locally from Ibadan, Nigeria. Fly ash was obtained from a thermal power plant in Lagos, while rice husk ash was procured from a rice mill in Ilorin. Each material was dried, sieved to remove large particles, and tested for particle size distribution and chemical composition using X-ray fluorescence (XRF).

Brick Formulations

Four types of bricks were prepared:
Type A: Conventional clay bricks (70% clay, 30% sand).
Type B: Laterite bricks (60% laterite, 30% sand, 10% cement).
Type C: Fly ash bricks (60% fly ash, 30% sand, 10% cement).
Type D: RHA bricks (60% RHA, 30% sand, 10% cement).
Each mixture was homogenized with water to achieve workability, molded into 230 mm × 110 mm × 75 mm rectangular shapes, and air-cured for 7 days, followed by oven drying at 105°C to ensure consistent moisture levels.

Testing Methods

Thermal conductivity was determined using the **guarded hot plate method** as per **ASTM C177**. Brick specimens were placed between heated and cold plates, and the rate of heat transfer through the sample was recorded.

Other Tests Conducted

Moisture content (ASTM D2216), Bulk density, Compressive strength (ASTM C67), Porosity analysis using water saturation method. Each test was performed on three replicates per brick type, and average values were used for analysis.

Results and Discussion

Thermal Conductivity

The result of thermal conductivity of different brick are shown below.

Table 1: The Thermal Conductivity of Different Brick

Brick Type	*Composition*	*Thermal Conductivity (W/mK)*
A	Clay (70%), Sand (30%)	0.82
B	Laterite (60%), Sand (30%), Cement (10%)	0.67
C	Fly Ash (60%), Sand (30%), Cement (10%)	0.54
D	RHA (60%), Sand (30%), Cement (10%)	0.49

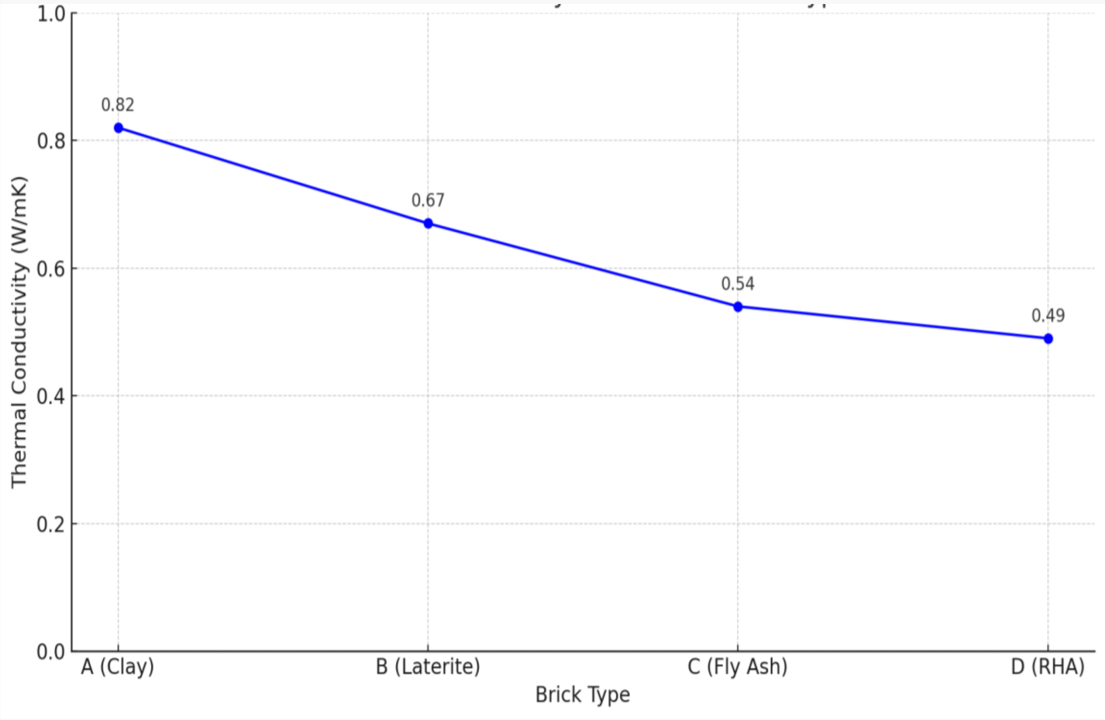

Figure 1: The Thermal Conductivity of Different Brick

Bricks made with RHA (Type D) showed the lowest thermal conductivity, indicating superior insulation. This can be attributed to the fine, porous structure of RHA and its high silica content, which hinders heat flow. Fly ash bricks (Type C) also exhibited strong insulation performance.

Compressive Strength and Porosity

Table 2: The Results of the Compressive Strength and Porosity

Brick Type	*Compressive Strength (MPa)*	*Porosity (%)*
A	8.2	18.7
B	9.4	15.5
C	10.1	14.2
D	9.8	12.9

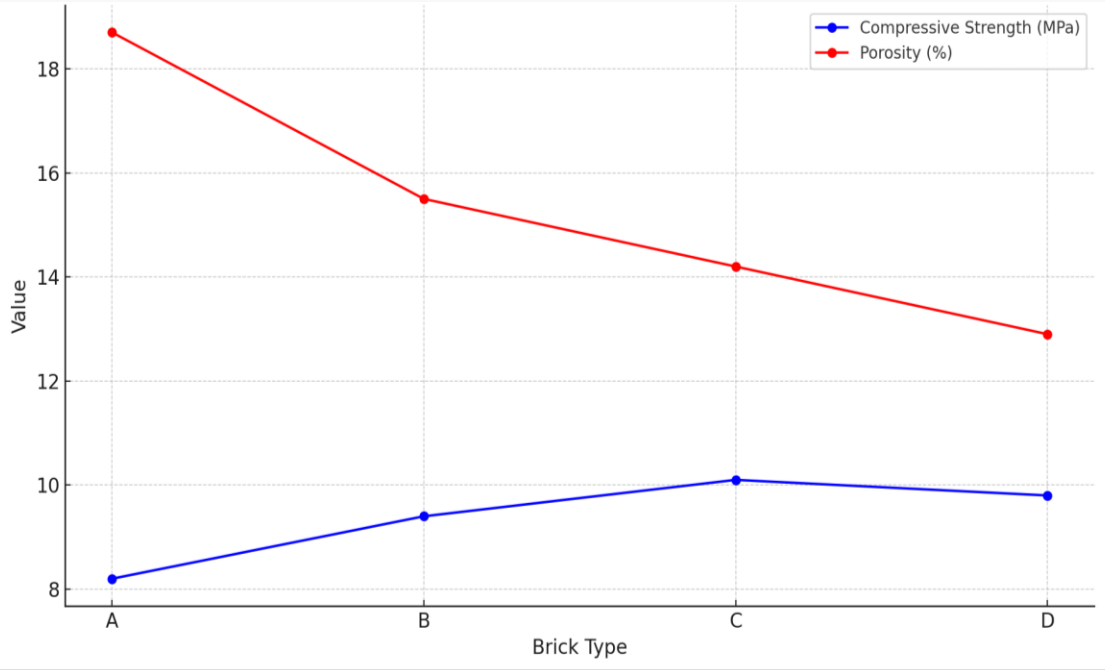

Figure 2: Graph of compressive strength and porosity of different brick types

RHA and fly ash bricks not only exhibited better insulation but also maintained adequate compressive strength (> 9MPa), suitable for non-load-bearing and some load-bearing applications. Their lower porosity also contributes to their thermal resistance. The study confirms that the use of industrial by-products like fly ash and RHA improves the thermal performance of bricks. These materials create microvoids that disrupt heat flow. The thermal conductivity of RHA bricks is about 40% lower than that of conventional clay bricks. The improved thermal insulation can significantly reduce cooling energy demand, supporting sustainable building initiatives in warm climates. Additionally, using these waste materials diverts large quantities of industrial waste from landfills and reduces the environmental impact of brick manufacturing.

Conclusion

This study presents a comprehensive comparative assessment of the thermal insulation properties of bricks produced from both local and industrial by-products, focusing on their potential application in energy-efficient and sustainable construction. The research analyzed the thermal conductivity and structural performance of bricks made with conventional clay, laterite, fly ash, and rice husk ash (RHA). Among the samples tested, bricks incorporating RHA and fly ash demonstrated the most promising results in terms of thermal insulation, with thermal conductivity values of 0.49 W/mK and 0.54 W/mK respectively. These values are considerably lower than those observed in conventional clay bricks (0.82 W/mK), indicating their superior ability to resist heat flow and maintain cooler indoor environments. Importantly, the study confirms that the improved thermal properties of RHA and fly ash bricks do not come at the expense of mechanical performance. The compressive strength of these bricks remained within acceptable limits for non-load-bearing and even some load-bearing applications, reinforcing their viability for structural use. The integration of these by-products into brick production addresses two major construction challenges: the need for better thermal performance in buildings, especially in hot and humid regions, and the demand for more sustainable building materials that reduce environmental impact. By using industrial waste materials such as fly ash—a by-product of coal combustion—and RHA—a residue from agricultural processes—this approach not only enhances the performance characteristics of the bricks but also contributes significantly to waste reduction. The reuse of such materials supports circular economy principles and aligns with global efforts to minimize construction-related carbon emissions. Furthermore, the energy savings achieved through improved thermal insulation translate into reduced demand for artificial cooling systems, lowering operational energy costs and greenhouse gas emissions over the lifecycle of buildings. The findings of this study strongly advocate for the adoption of RHA and fly ash bricks in both rural and urban housing developments, particularly in regions with high ambient temperatures. These alternative bricks offer a cost-effective, environmentally responsible solution for constructing buildings that are not only durable and strong but also energy efficient. As governments and industries move toward greener construction practices, the use of such innovative materials can play a pivotal role in transforming the built environment. In conclusion, the research highlights that leveraging locally available and industrial waste materials for brick production is both a practical and impactful strategy for improving building performance. Promoting the adoption of RHA and fly ash bricks can contribute meaningfully to sustainable development goals, reduce the ecological footprint of the construction industry, and foster innovation in green building technologies.

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Volume 6, Number 3 | 2025 | 11-16 | *DOI: https://doi.org/10.5281/zenodo.16229391*

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