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Comparative Analysis of Abrasiveness, Density, and Water Absorption of Laterite Interlocking Bricks and Rice Husk Ash Sandcrete Blocks in Acidic Environment

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Abstract

Nigeria's housing affordability issues demand innovative and, sustainable building materials. Rising costs of traditional materials used in the production of sandcrete block such as, cement necessitate the need for alternative ingredients, such as partial cement replacement using rice husk ash and laterite. The durability of Rice Husk Ash Sandcrete Blocks (RHASB) and Laterite Interlocking Bricks (LIB) under acidic conditions remains uncertain. This study examined the effects of Tetraoxosulphate (VI) acid on RHASB and LIB. Laterite Soil was obtained from Olomi Ogbomoso (8^0 14.4^1 2.2^{11}N and 4^0 22.3^1), RHA was obtained from a rice mill in Ajase, Offa, Kwara State (8^0 12^1 15^{11}N and 4^0 48^1 12.3^{11} E). RHA blended cement was thoroughly mixed on site. Acid concentrations at pH 3.0, 3.5 and 4.0 were prepared. Water with pH value of 7.0 was used as control. LIB and RHASB were produced and immersed in acid solutions for 3, 7, 14, and 28 days. The abrasiveness, density and water absorption of the samples were measured. The percentage of abrasiveness for RHASB at pH 3.0, 3.5, 4.0, and 7.0 were 4.34, 3.62, 3.55, and 2.87%, respectively. The corresponding values for LIB were 10.94, 10.39, 8.54, and 6.84%, respectively. The density of RHASB at pH 3.0, 3.5, 4.0, and 7.0 were 1,074, 1,076, 1,081, and 1,138 kg/m^3 at 7, 14, 21 and 28 days, respectively. The corresponding values for LIB were, 3,886, 4,038, 4,141, and 3,493 kg/m^3, respectively. The water absorption of RHASB was 3.3%, and LIB was 6.7%. LIB exhibit better performance in Tetraoxosulphate (VI) solution. However, both samples of RHASB and LIB lost more weight at lower pH, showing decreased durability in Tetraoxosulphate (VI) solution. LIB exceeds density minimum requirements and its better suited for high-density, stable applications in acidic environments.

Keywords: Tetraoxosulphate (VI) acid, Laterite Interlocking Bricks, Rice husk Ash, Sandcrete blocks, Durability, Density, Water Absorption.

Introduction

The durability of any building material is its ability to withstand weathering and deterioration. However, the capacity of building materials to absorb water easily and retain it for extended periods makes them susceptible to chemical and environmental decay (Ephraim and Rowland, 2015). Sandcrete blocks are widely used in Nigeria as structural building units, available in various sizes and with either solid or hollow cores. The constituent typically include fine aggregate and cement in varying ratios (Adebanjo *et al*., 2024). These blocks serve as load bearing or partitioning units in construction, satisfying key characteristics such as compressive strength, density, and water absorption, among others (Ukpata and Enang, 2025). The materials used and the production process influence the block's properties and suitability for different applications. Accordingly, in Nigeria's construction industry, sandcrete blocks are crucial for physical infrastructural development, especially in residential, commercial, and public projects (Adebanjo *et al*., 2024). Rice husk ash sandcrete blocks

(RHASB) can be manufactured by partially replacing cement with rice husk ash. Its behaviour in various acidic environments is essential to ensure its durability and suitability for specific conditions. Studies have examined the use of rice husk ash as a partial replacement for cement in hollow sandcrete blocks and lateritic bricks for cost savings (Chijioke *et al*., 2020). Rice husk, a byproduct of rice processing which is removed during rice harvest, is generated in large quantities worldwide and is primarily composed of cellulose, hemicellulose, lignin, and silica (Singh and Singh, 2020). Rice husk ash is a significant agricultural waste with up to 78% of rice and 22% of rice husk being produced during milling (Onyelowe *et al*., 2021). Rice husk ash (RHA) is produced by burning rice husk, which increases silica reactivity at around 700°C (Pranowo *et al*., 2017). Onyelowe *et al*. (2021) and Das *et al.* (2022) studied RHA's chemical, morphological, and its physical properties. It was discovered that, the silica content in the RHA was 86%, which aligns with previously published research and suggests high potential reactivity of RHA as a pozzolanic or cementing agent (Pranowo *et al.,* 2017).

Laterite consists of residual sedimentary rocks that are reddish or brownish, soft, highly porous, and have worm-like structures (Amit *et al.,* 2018). It is noted for its local availability and applications in civil engineering, such as road construction and landfilling. As it is abundant, expanding its use could reduce building costs and promote affordable housing (Arinze *et al*., 2022).

Additionally, laterite can serve as an eco-friendly, cost-effective fine aggregate for brick manufacturing, which can decrease block costs and support building development in Nigeria (Arinze *et al*., 2022). The choice of walling material depends on cost, availability, durability, aesthetics, and climatic condition (Effiong and Ewah, 2025). Laterite bricks can be stabilized with small amounts of cement, lime, or pozzolans, and help reuse waste like rice husk ash and fly ash. It offer excellent fire and heat resistance thus, making them ideal for hot climates with interlock mortar free (Olopade, *et al.,* 2022). Lateritic bricks are durable and affordable. Several researchers (Prasad and Parthasarathy, 2018, Muraleed, 2017, Ogunleye, 2023; and Olopade, *et al*., 2022) have investigated the mechanical properties of LIBs, including water absorption, density, compressive strength, and durability.

According to Hadigheh, *et al*. (2017) acids affect cement both externally and internally, but adequate compaction and low permeability can minimize this impact. It was indicated that exposure duration and acid type are crucial for understanding external attack. Thus, this study examined the performance of Rice husk ash sandcrete blocks and Laterite Interlocking Bricks under continuous exposure to acidic environment. Tetraoxosulphate (VI) (H_2SO_4) acid was employed to simulate such conditions. The parameters analyzed include density, water absorption, and abrasiveness.

Materials and Method

Natural river sand was obtained within the locality of Ogbomoso while Laterite soil was obtained in Olomi, Ogbomoso (8^0 14.4^1 4.22^{11}N and 4^0 22.3^{11}E). Sand and Laterite were allowed to dry for 48 hours to reduce moisture content. RHA, obtained from a rice mill in Ajase Offa, Kwara State (8^0 12^1 15^{11}N and 4^0 48^1 12.3^{11} E), was used. The RHA was calcinated at a temperature of 700°C. Portland cement, grade 32.5, Dangote brand, was used for the study. RHA-blended cement was thoroughly mixed on site. Tetraoxosulphate (VI) acid H_2SO_4 was obtained from the Department of Biochemistry, LAUTECH, Ogbomoso. The water used was potable water.

Production of Rice Husk Ash Sandcrete Block.

The rice husk ash sandcrete block (RHASB) were produced using a fabricated steel mould measuring 450 x 225 x 225 mm (9 inches). Cement and sand were measured in a ratio of 1:8 by volume in line

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with the provision in NIS 087:2000. Raheem and Kareem (2017) recommended 15% replacement of RHA for cement suitable to use for structural purposes. The materials were then thoroughly mixed manually until a homogeneous mixture with a consistent colour was achieved with w/c ratio of 0.24. The composite mixture was poured into the mould, and the mixture was vibrated with a rammer for one minute to ensure proper compaction, as recommended by (Arinze *et al*., 2022).

The block was removed from the mould and placed on a smooth surface for curing after 24 hours. Water was sprinkled on the blocks at least twice daily for proper curing over 28 days.

Preparation of Laterite Samples

The laterite samples were air-dried for seven days in a cool, dry place. Air drying was necessary to facilitate the grinding and sieving of the laterite. After drying, grinding was carried out using a punner and a hammer to break up the lumps in the soil. Particle size distribution was performed on fine aggregate and laterite as recommended by Putri, (2025).

Production of Lateritic Interlocking Bricks

The interlocking bricks were produced using a locally fabricated steel mould that measured 250 × 130 × 220 mm^3. The production process comprises the batching, mixing, casting and compaction of the bricks. The materials used for the production of LIB were measured by weight, such as, Laterite 271.53 kg and 27.15 kg of cement, to produced 23 bricks with w/c of 0.24. The mixing was done on a clean, impermeable surface free from harmful materials. The measured laterite was spread evenly with a shovel, then cement was added and mixed thoroughly. The fabricated steel mould was cleaned, oiled, and filled in 3 layers, each compacted with 35 blows. Excess was scraped off, and the mould was levelled. After 2 hours, the bricks were demoulded, marked, and air-dried for 24 hours under a polythene shade. Water was sprinkled, and bricks were allowed to cure. They were then stacked in rows for density and durability tests in accordance with the National Building Code (2006).

Preparation of Acidic Solutions

Acid media were prepared using 250 liters of drums and concentrated Tetraoxosulphate (VI) acid (H_2SO_4). The deionized water was first tested using pH meter to determine its alkalinity. Concentrated acid was added slowly to the water and stirred thoroughly. The pH was measured after every addition of acidic solution, and the process was stopped at every pH value needed, which were 3.0, 3.5, and 4.0, respectively. The controlled solution had a pH of 7 (neutral), Samples of RHASB and LIB were immersed in various acid concentrations while observations were recorded on the physical appearance and weight of each samples before and after immersion into different acidic solutions. The samples were cured in acidic solution for 7, 14, 21, and 28 days. Density, Water absorption, and Abrasiveness tests were carried out on each sample block at each curing day. Protective clothing and equipment were worn to reduce the risk of injury.

A. Abrasiveness

According to Raheem, *et al*. (2012), abrasion determines the resistance of an object to surface wear caused by friction, scraping, or rubbing against another material. Abrasive resistance is measured using equation (1).

$$\text{Abrasive Resistance} = \frac{Vl}{F\,x\,T}\ \% \qquad 1$$

Where:

V_L = Volume loss due to abrasion.

F= Force applied

T = Time/number of abrasion cycles.

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B. Density Test

The density of the blocks was conducted according to Ogunleye (2023). Density is measured using Equation (2):

$$\text{Density test} = \frac{\text{mass of dry sandcrete block}}{\text{actual volume}} \quad (\text{Kg/m}^3) \qquad 2$$

C. Water Absorption

Water absorption indicates the apparent porosity of the blocks (Ogunleye, 2023). It is measured using Equation (3).

$$\text{Water Absorption} = \frac{Mw - Md}{Md}\ x\ 100 \qquad 3$$

Where:

M_w = Mass of wet block

M_d = Mass of dry sandcrete block

Results and Discussion

The results obtained from the various tests are presented and discussed in subsequent sub sections.

Abrasiveness

Figure 1 shows the results of the abrasion tests for RHASB. The percentage of abrasion at pH 3.0, 3.5, 4.0, and the control of 7.0 were 4.34, 3.62, 3.55, and 2.87%, respectively. The results indicated that resistance to abrasion increases as the pH of the acid solution decreases. A high percentage of material was abraded from RHASB in the pH 3.0 solution, indicating significant surface degradation of 4.34%. The weight loss for RHA sandcrete blocks ranged from 2.87 to 4.34%. The control samples pH 7.0 exhibited the lowest weight loss for RHASB, indicating higher durability. Meanwhile, Figure 2 shows the results of the abrasion tests for LIB. The percentage of abrasion at pH 3.0, 3.5, 4.0, and the control of 7.0 were 10.94, 10.39, 8.54, and 6.84%, respectively. Interlocking bricks made from laterite showed a wider range of abrasion, from 6.84 to 10.94%. The control samples pH 7.0 had the lowest weight loss for LIB, indicating higher durability. The rate of abrasion resistance obtained for both RHASB and LIB were higher than those in the findings of Adetoro and Oladapo (2020) which ranges from 1 to 2% as well as those obtained by Raheem *et al.*, (2012) that ranges from 0.35 to 1.26 %. This could be as a result of different methods of stabilization adopted and as well the curing method used.

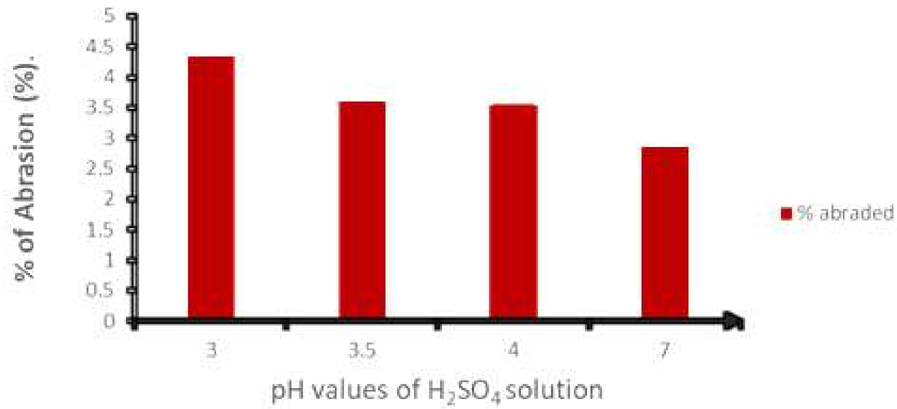

Figure 1: Abrasiveness of Rice Husk Ash Sandcrete Block at 28 days

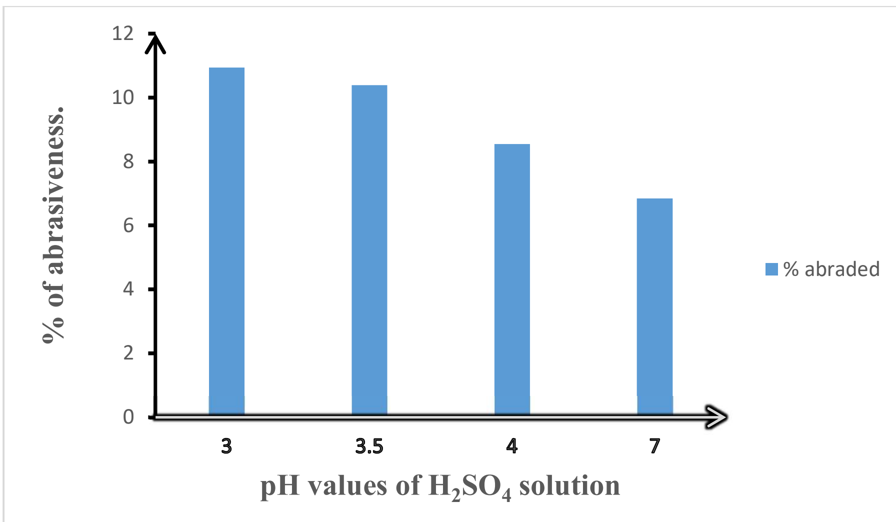

Figure 2: Abrasiveness of LIB at 28 days

Density of Rice Husk Ash Sandcrete Blocks

Figures 3 shows the density of rice husk ash sandcrete blocks (RHASB) in acid environment. The density of RHASB at pH 3.0 are 1,069, 1,070, 1,071, and 1,074 kg/m3for curing ages 7, 14, 21 and 28 days, respectively. The corresponding values at pH 3.5 are 1,071, 1,072, 1,074, and 1,076 kg/m3; and at pH 4.0, the values were 1,072, 1,076, 1,078, and 1,081 kg/m3; while for pH 7 (the control) they are 1,107, 1,118, 1,131, and 1,138 kg/m3, respectively. At 28 days of curing, RHASB with pH 4.0 and the control sample with pH 7 exhibited the highest density values. According to NIS 087:2000 and Muraleed (2017) density minimum value of 1500 kg/m3 at 28 days was specified for conventional sandcrete blocks. The results obtained for RHASB were below the minimum recommended. This is an indication that RHASB can be used where low dead loads are required like in high rise building

Density of Laterite Interlocking Bricks

Figure 4, show the density of laterite interlocking bricks (LIB) in acid environment.

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At curing ages 7, 14, 21 and 28 days, the density of LIB at pH 3.0 were, 3957, 3944, 3922, and 3886 kg/m3, respectively, while at pH 3.5 the values were 4147, 4128, 4089, and 4038 kg/m3. At pH 4.0, the density were 4,227, 4,206, 4,171,while for the control with pH 7 they were, 3404, 3451, 3464, and 3493 kg/m3, respectively. The density increases as the pH level increases from 3.0 to 4.0, indicating that the bricks may be more stable in slightly acidic environments. The control sample at pH 7.0 has a density of 3493 kg/m³, which is approximately 38.96% lower than that of Raheem, et al. (2012). This is due to the acidic environment in which in the LIB were subjected. According to the Nigerian Building and Road Research Institute (NBRRI) standards, the minimum bulk density for laterite bricks is 1810 kg/m³. All density values obtained in this study exceed this minimum requirement

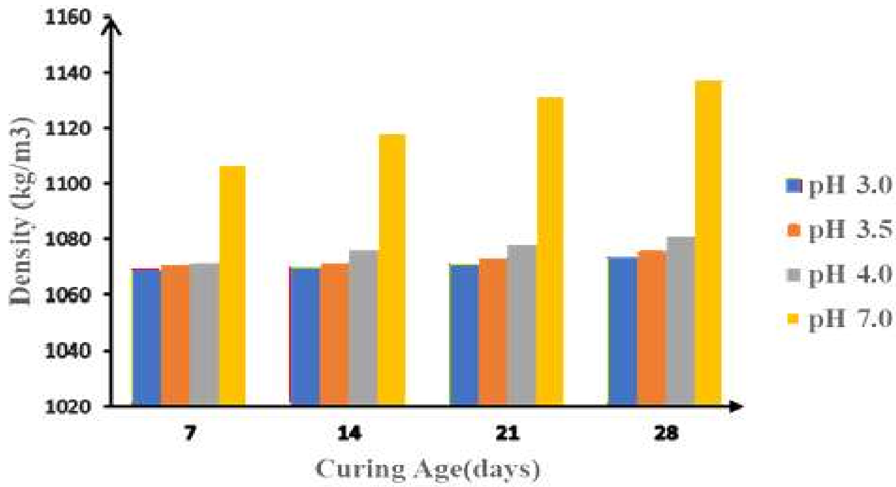

Figure 3: Density of Rice husk Ash Sandcrete Block

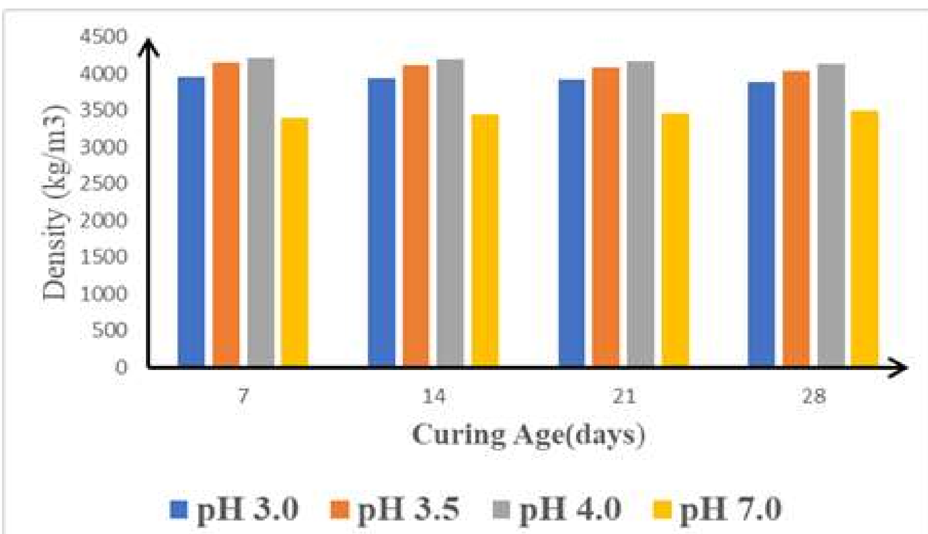

Figure 4: Density of Laterite Interlocking Bricks

Water Absorption

Tables 1 and 2 show the results water absorption of the rice husk ash sandcrete block (RHASB) and laterite interlocking blocks (LIB), respectively It could be observed from Table 1 that water absorption rate for RHASB was 3.3%, while that of LIB from Table 2 was 6.7%. The Nigerian Industrial Standard

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(2004) recommends a maximum water absorption rate of 3% for conventional sandcrete blocks. Rice Husk Ash Sandcrete Block with a water absorption rate of 3.3% is slightly above the recommended 3% for conventional sandcrete blocks. The Nigerian Building and Road Research Institute (NBRRI, 2006) recommends maximum of 12% water absorption for laterite interlocking bricks. In this study, LIB has a water absorption rate of 6.7% which falls within the specified requirement. The water absorption results from this research were significantly lower compared to the findings of Balaji, *et al*., (2020) which ranged from 8.9 to 13.7%, and slightly higher than those reported by Raheem, *et al*. (2012), ranging from 2.90 to 1.26%. This could be attributed to the higher percentage of cement (10%) added to the laterite for producing LIB and the void filling effect of the rice husk ash on the RHASB .

Table 1: Water Absorption for Rice Husk Ash Sandcrete Block

SAMPLE	MASS OF DRY SAMPLE (kg)	AVERAGE MASS OF DRY SAMPLE (kg)	MASS OF WET SAMPLE (kg)	AVERAGE MASS OF WET SAMPLE (kg)	WATER ABSOPRTION RATE (%)
1	25.75		26.40		
2	25.50	25.68	26.15	26.53	3.31
3	25.80		27.05		

Table 2: Water Absorption for Lateric Interlocking Bricks

SAMPLE	MASS OF DRY SAMPLE (kg)	AVERAGE MASS OF DRY SAMPLE (kg)	MASS OF WET SAMPLE (kg)	AVERAGE MASS OF WET SAMPLE (kg)	WATER ABSOPRTION RATE (%)
1	14.20		15.10		
2	14.25	14.18	15.25	15.13	6.70
3	14.10		15.05		

Conclusions

Based on the findings from this study, the following conclusions can be drawn:

i. RHASB and LIB lost more weight at lower pH levels, indicating less durability in acids. Laterite bricks degraded more in acid exposure.

ii. RHASB does not meet the density standards for conventional sandcrete blocks, while LIB exceeds the minimum density requirement for laterite bricks. These results suggest RHASB is suitable where low dead load is required while LIB could be more appropriate for applications where high density and stability are essential.

iii. Both RHASB and LIB met the minimum requirements specified for water absorption rate in block or brick production,

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