NAU Journal of Civil Engineering (NAUJCVE) January/February 2026
Nnamdi Azikiwe University Journal of Civil Engineering (NAUJCVE)

Volume-5, Issue-1, pp-148--155

www.naujcve.com
Research Paper Open Access

Evaluation Of Locally Produced Burnt Clay Bricks For Sustainable Housing Development In Nigeria

[1]Iaren T. Cornelius, [2]Bemshima Raphael, [3]Orkuma T. Stephen

[1]Department of Civil Engineering, Mudiame University, Irrua, Edo State, Nigeria

[2,3]Department of Civil Engineering , Joseph Sarwuan Tarkaa University, Markurdi, Markurdi, Nigeria

[2]bemshimatraphael@gmail.com, [3]orkumastephen@gmail.com

Corresponding Author: *[1]cornelius.iaren@mudiameuniversity.edu.ng*

ABSTRACT : *The rising cost of building materials has become a major constraint to the provision of low-cost housing in Nigeria, particularly in the face of the current economic downturn. Cost considerations remain a critical factor in building construction, and although cement-based technology is widely adopted due to its convenience, it is relatively expensive. This has created the need to explore cheaper and locally available alternatives to cement-based construction materials in order to promote affordable yet durable housing for the Nigerian population. This study investigates the suitability of locally produced burnt clay bricks as an alternative to conventional sand–cement blocks. The research involved on-site observations of the brick production process, as well as laboratory analyses of the geotechnical properties and chemical composition of the soil used in brick production. A total of eight locally produced burnt brick samples were tested to determine their compressive strength, water absorption capacity, and efflorescence characteristics. The results showed mean compressive strengths of 5.824 N/mm² and 2.945 N/mm² for domestic pavement bricks and walling bricks, respectively. The average water absorption values were 10.82% for pavement bricks and 10.27% for walling bricks, with pavement bricks exhibiting slightly higher water absorption. The findings indicate that locally produced burnt bricks possess properties that make them a viable and cost-effective alternative to sand–cement blocks for low-cost housing applications.*

KEYWORDS: *Locally produced burnt bricks, Lateritic soil, Compressive strength, Low-cost housing, Sustainable construction materials.*

Date of Submission: 20-12-2025 Date of acceptance: 25-02-2026

I. INTRODUCTION

The persistent rise in the cost of building materials has remained one of the most critical challenges confronting the delivery of affordable housing in Nigeria. This challenge has been exacerbated by recent economic downturns, inflation, and the heavy dependence of the construction industry on imported or energy-intensive materials such as cement. Housing provision, particularly for low- and middle-income populations, is therefore increasingly constrained by escalating construction costs, making affordability a central concern in housing policy and practice (Ogunsemi & Jagboro, 2021; World Bank, 2023). In response, the promotion of locally available and cost-effective building materials has been widely recognized as a viable strategy for reducing construction costs, conserving foreign exchange, and enhancing housing accessibility in developing economies (Akinwumi et al., 2022).

In Nigeria, sand–cement blocks remain the dominant walling material for residential buildings, largely due to their ease of production and widespread acceptance. However, the production of cement is capital-intensive, energy-demanding, and environmentally burdensome, contributing significantly to construction costs and carbon emissions (Andrew, 2023). These drawbacks have renewed interest in alternative masonry units derived from local materials, particularly burnt clay bricks, which have a long history of use in traditional and contemporary construction worldwide. Burnt clay bricks are produced by firing molded clay or lateritic soil at elevated temperatures, typically between 800°C and 1,100°C, resulting in improved mechanical strength, durability, and resistance to moisture when compared to unfired or sun-dried earth blocks (Zhang et al., 2021).

Nigeria is richly endowed with lateritic and clayey soils suitable for brick production, especially within its tropical climatic zone, where intense weathering promotes the formation of iron- and alumina-rich soils. These soils, when properly processed and fired, have been shown to produce bricks with satisfactory structural and durability properties for low-rise construction (Adedeji & Akinmusuru, 2020; Oyelami et al., 2022). Studies indicate that soils containing moderate clay fractions, balanced with sand and silt, offer adequate plasticity for molding while minimizing shrinkage, cracking, and deformation during drying and firing (Kumar et al., 2020). Where natural soil composition is unsuitable, blending lateritic soils with clayey or granular materials and incorporating organic admixtures such as rice husk ash or sawdust can further enhance brick performance by improving firing efficiency, reducing density, and controlling porosity (Mahmoud et al., 2021).

Despite these advantages, the adoption of locally produced burnt bricks in Nigeria remains limited. This is partly due to inconsistent production quality, lack of standardization, inadequate technical evaluation, and social perceptions that associate brick masonry with outdated or inferior construction methods. Furthermore, limited empirical data on the engineering performance of locally produced burnt bricks—particularly in comparison with conventional sand–cement blocks—has hindered their acceptance by professionals, developers, and regulatory authorities (Adebayo et al., 2023). Addressing these concerns requires systematic assessment of the physical, mechanical, and durability properties of locally produced burnt bricks using standardized laboratory testing methods.

Against this background, this study evaluates the suitability of locally produced burnt clay bricks as an alternative walling material to sand–cement blocks for low-cost housing in Nigeria. The research focuses on bricks produced using locally sourced lateritic and clayey soils under non-industrial conditions and assesses their compressive strength, water absorption characteristics, and surface durability through efflorescence testing. By examining these key performance indicators, the study seeks to determine whether locally produced burnt bricks can meet minimum requirements for structural and non-structural masonry applications while offering cost and sustainability benefits.

The significance of this study lies in its potential contribution to affordable housing delivery, sustainable construction practices, and local material development in Nigeria. Demonstrating the technical viability of locally produced burnt bricks could encourage their wider adoption, reduce reliance on cement-based materials, and stimulate local economies through small-scale brick production enterprises. However, the study also acknowledges limitations related to variability in soil composition, production methods, and the absence of seismic considerations, as unreinforced brick masonry may be unsuitable for earthquake-prone regions. Nevertheless, within the Nigerian context—where seismic activity is minimal—burnt clay bricks remain a promising and underutilized resource for addressing housing deficits in a cost-effective and environmentally responsible manner.

II. MATERIALS AND METHODS

This study adopted an experimental research approach involving field observation and laboratory testing to evaluate the suitability of locally produced burnt clay bricks as an alternative to sand–cement blocks for low-cost housing. The brick production process was observed on-site at a local brick-making facility operated by indigenous producers using non-industrial methods. Samples produced from lateritic and clayey soils were subjected to standardized laboratory tests to assess their physical, mechanical, and durability properties.

2.1 Local Burnt Brick Production Process

Locally produced burnt clay bricks are masonry units formed by mixing lateritic or clayey soils with water, molding into rectangular shapes, drying, and firing at elevated temperatures. In the observed local process, the bricks were produced using readily available materials such as lateritic soil, clay, firewood, and water, without mechanized control or industrial standardization. The resulting bricks typically exhibit reddish-brown to yellowish-brown coloration, characteristic of iron-rich lateritic soils.

For brick earth suitability, soil properties such as plasticity, shrinkage, and particle size distribution are critical. In practice, locally sourced soils from riverbanks were preferred due to their relatively balanced clay–sand composition and ease of excavation, which also minimized transportation costs. The brick production site was therefore strategically located near a riverbank to enhance economic efficiency.

2.2 Soil Selection and Preparation

The selection of soil was based on observable field characteristics and traditional knowledge of brick makers, complemented by laboratory evaluation. Lateritic soil was excavated after the removal of topsoil to eliminate organic matter and impurities such as roots, stones, and debris. The excavated soil was spread on leveled ground and exposed to weathering for several weeks to improve workability. Prior to use, the soil was blended with selected additives where required to achieve a workable and cohesive brick earth suitable for molding and firing.

2.3 Brick Manufacturing Operations

The manufacture of locally produced burnt bricks involved five main operations: winning, tempering, molding, drying, and firing.

2.3.1 Winning

Winning refers to the excavation and preparation of brick earth. The lateritic soil was excavated in shallow layers, cleaned of impurities, and allowed to weather naturally. Weathering improved the soil's plasticity and reduced the likelihood of cracking during drying and firing.

2.3.2 Tempering

Tempering involved breaking down the soil lumps, adding water, and kneading the mixture manually underfoot until a homogeneous and plastic mass was achieved. The mixture was then covered and allowed to mature for improved consistency. Two mix proportions were employed:

I. Laterite : stone dust : fly ash : water (1:2:4 by volume)
II. Laterite : water (control mix)

The tempered soil was prepared until it was soft enough to be molded without cracking.

2.3.3 Molding

Molding was carried out manually using wooden hinge molds. The tempered soil was pressed firmly into the mold to fill all corners, excess material was removed using a wooden striker, and the surface was smoothened with a hand trowel. The mold was then lifted carefully to release the green brick. This hand-molding technique was selected due to its widespread use in local production and its suitability for low-cost applications.

2.3.4 Drying

Freshly molded bricks (green bricks) contained high moisture content and were therefore dried gradually to prevent cracking and distortion. The bricks were first air-dried under shade for approximately three days and covered with leaves or paper to control the rate of moisture loss. They were later turned and allowed to dry for an additional three days before being stacked loosely in open air. Final drying occurred at ambient temperature (25–30°C), with total drying time ranging from two to six weeks depending on weather conditions.

2.3.5 Firing (Burning)

Firing was carried out using an intermittent clamp kiln, which is commonly adopted in local brick production. The dried bricks were stacked around a raised platform with firewood arranged strategically to promote uniform heat distribution. Firing was conducted gradually to allow residual moisture to escape, followed by sustained heating and slow cooling.

Temperature monitoring showed progressive heating over approximately six hours. Although precise industrial firing temperatures were not attainable, gradual heating improved ceramic bonding and minimized warping. Proper stacking ensured relatively uniform color and strength development across the bricks.

2.4 Materials

The materials used in the production process included lateritic soil, water, fine aggregate (sand), fly ash, and stone dust. Lateritic soil was required to be plastic when mixed with water, capable of retaining shape during molding, and able to fuse during firing.

2.4.1 Water

Water was required for tempering and molding. A readily available water source was necessary to sustain production without competing with domestic water needs. Approximately 7 litres of water were required to produce eight bricks.

2.4.2 Fine Aggregate

Fine aggregate was used to adjust soil grading, reduce shrinkage, and prevent sticking of bricks to the mold. In the absence of sand, alternatives such as ash, sawdust, or fine dry soil were used.

2.4.3 Fly Ash

Fly ash served as an additive to improve particle packing and enhance bonding through pozzolanic action. It also contributed to improved firing efficiency and reduced fuel consumption. The chemical composition of the fly ash used is presented in Table 1.Sourced from ASTM C618 standard specifications.

Table 1 Chemical Characteristics of Fly Ash

Constituent	Percentage
SiO_2	44.9–47.6
Al_2O_3	21.9–24.3
Fe_2O_3	2.1–3.5
CaO	0.85–1.2
MgO	0.20–0.60
SO_4	1.2
Loss on ignition	3.4

2.5 Equipment Used

Simple hand tools were employed, including hoes, shovels, machetes, buckets, wooden molds, carrying boards, wheelbarrows, head pans, and water drums. These tools reflect the low-technology nature of the local production process and its suitability for small-scale adoption.

2.6 Laboratory Testing of Bricks

To determine suitability for building construction, the produced bricks were subjected to standard acceptance tests.

2.6.1 Dimensional Accuracy Test

Four bricks were randomly selected, cleaned, and arranged in contact on a flat surface. Their combined length was measured using a steel tape to assess dimensional uniformity against nominal brick dimensions (225 × 100 × 75 mm).

2.6.2 Water Absorption Test

The water absorption test was conducted to evaluate brick porosity and durability.

Water absorption (%) was calculated using:

$$\text{Water Absorption} = \frac{W_2 - W_1}{W_1} \times 100 \quad (1)$$

where:

(W_1) = oven-dry weight of brick (kg), (W_2) = saturated weight after 24 hours immersion (kg). Results were later summarized using bar charts to compare pavement and walling bricks.

2.6.3 Efflorescence Test

Efflorescence was assessed by partially immersing bricks in distilled water and allowing evaporation under controlled conditions. The presence of white salt deposits on brick surfaces was visually examined and classified as nil, slight, moderate, heavy, or serious efflorescence based on surface coverage.

2.6.4 Compressive Strength Test

Compressive strength was determined using a compression testing machine. Bricks were immersed in water for 24 hours, capped with cement mortar (1:1), and loaded until failure.

Compressive strength (N/mm^2) was calculated as:

$$\text{Compressive Strength} = \frac{P}{A} \quad (2)$$

where:

(P) = maximum applied load at failure (N), (A) = loaded area of brick (mm^2)

2.6.4 Sieve Analysis

Sieve analysis was conducted to determine particle size distribution of the lateritic soil used equation 3 and 4.

$$\% \text{ Retained} = \frac{\text{Weight retained}}{\text{Total sample weight}} \times 100 \quad \textbf{(3)}$$

$$\% \text{ Passing} = 100 - \% \text{ Retained} \quad (4)$$

III. RESULTS AND DISCUSSION

3.1 Compressive Strength Analysis

Compressive strength tests were conducted on eight (8) locally produced burnt bricks, comprising four domestic pavement bricks and four walling bricks. The test was carried out using a compression testing machine, and compressive strength was determined as the ratio of maximum crushing load to the loaded area of the brick.

For all samples, the nominal brick dimensions were:

- Length = 225 mm
- Breadth = 100 mm
- Loaded area, (A = 225 \times 100 = 22{,}500 , \text{mm}^2)

The compressive strength was computed using equation 2

3.1.1 Domestic Pavement Bricks

Table 3.1: Compressive Strength Results for Domestic Pavement Bricks

Sample No.	Length (mm)	Breadth (mm)	Area (mm²)	Crushing Load (kN)	Compressive Strength (N/mm²)
1	225	100	22,500	101.25	4.50
2	225	100	22,500	142.77	6.35
3	225	100	22,500	155.96	6.93
4	225	100	22,500	124.15	5.52

$$\textbf{Mean Compressive Strength} = \frac{4.50 + 6.35 + 6.93 + 5.52}{4} = \mathbf{5.82\ N/mm^2}$$

3.1.2 Walling Bricks

Table 2: Compressive Strength Results for Walling Bricks

Sample No.	Length (mm)	Breadth (mm)	Area (mm²)	Crushing Load (kN)	Compressive Strength (N/mm²)
1	225	100	22,500	80	3.56
2	225	100	22,500	70	3.11
3	225	100	22,500	65	2.89
4	225	100	22,500	50	2.22

$$\textbf{Mean Compressive Strength} = \frac{3.56 + 3.11 + 2.89 + 2.22}{4} = \mathbf{2.95\ N/mm^2}$$

The results in Table 1 and 2 indicate that locally produced burnt clay bricks possess adequate mechanical and durability properties for low-cost housing applications. Domestic pavement bricks exhibited a higher mean compressive strength (5.82 N/mm²) compared to walling bricks (2.95 N/mm²), largely due to the inclusion of fly ash and aggregates in the pavement brick mix. This confirms that material composition significantly influences brick performance.

Water absorption results further demonstrate that both brick categories are durable, with average absorption values well below the recommended 20% limit. The absence of visible salt deposits during efflorescence testing indicates minimal soluble salts, suggesting good long-term surface durability.

Graphical representations of compressive strength results **(Figures 1 and 2)** illustrate consistent strength variation among samples, with pavement bricks showing superior load-bearing capacity. These findings support the viability of locally produced burnt bricks as a cost-effective alternative to sand–cement blocks for non-load-bearing and light-load applications.

Volume-5, Issue-1, pp-148--155

www.naujcve.com
Research Paper Open Access

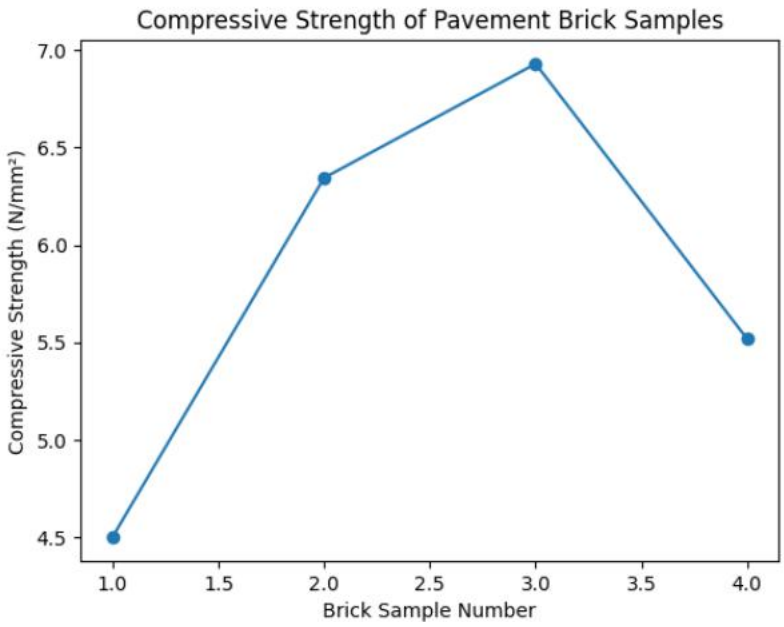

Fig 1: Compressive strength vs Pavement Brick Samples

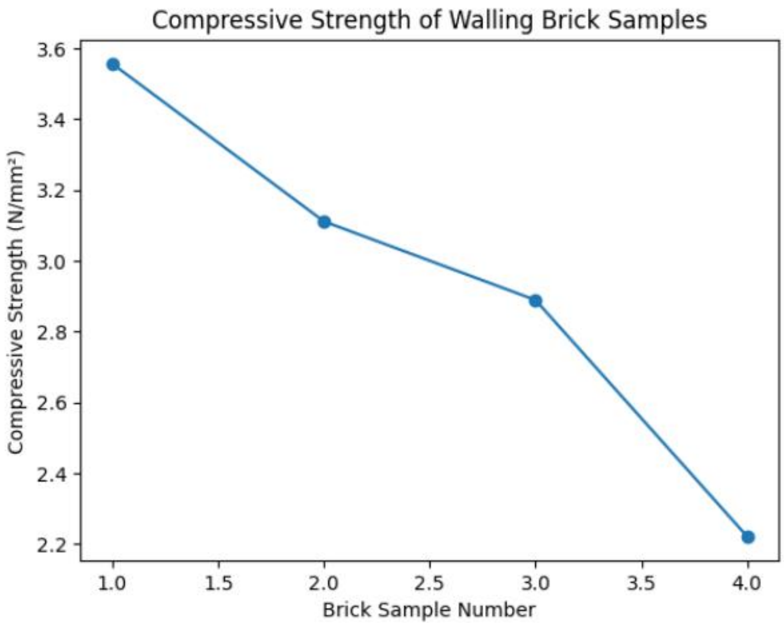

Fig 2 Compressive Strength of Walling Brick Sample

3.2 Water Absorption Test

Water absorption tests were conducted to evaluate the porosity and durability of the bricks. The percentage water absorption was calculated using equation 2.

Table 3: Water Absorption Test Results

Sample No.	Dry Weight (W_1) (kg)	Wet Weight (W_2) (kg)	Water Absorption (%)
1	2.20	2.470	12.27
2	2.19	2.371	8.27
3	2.76	3.040	10.15
4	2.70	3.010	11.48

Average water absorption (walling bricks) = 10.27%

Average water absorption (pavement bricks) = 10.82%

All values are below the **20% maximum limit** recommended for building bricks, indicating satisfactory durability.

3.3 Sieve Analysis of Lateritic Soil

Sieve analysis was conducted to determine particle size distribution of the lateritic soil used equation 3 and 4

Table 4: Sieve Analysis Results

Sieve Size	Weight Retained (kg)	% Retained	% Passing
2.00 mm	0.0676	17.69	82.31
1.18 mm	0.0951	24.88	75.12
600 µm	0.0650	17.01	82.99
425 µm	0.0398	10.41	89.59
300 µm	0.0388	10.15	89.85
150 µm	0.0385	10.07	89.93
75 µm	0.0203	5.31	94.69
Pan	0.0171	4.47	95.53

The grading indicates a well-distributed lateritic soil suitable for brick production.

3.4 Implications for Local Brick Utilization

Encouraging the use of locally produced burnt bricks can significantly reduce construction costs, promote the use of indigenous materials, and support sustainable housing development in Nigeria. With improved standardization and quality control, these bricks can be effectively integrated into mainstream construction practices.

IV. CONCLUSION

The results obtained from the experimental investigations carried out on locally produced burnt lateritic bricks provide useful insight into their suitability as alternatives to conventional sand–cement blocks for low-cost housing applications.

4.1 Durability Characteristics

Durability assessment was carried out through the water absorption test. The results revealed that the locally burnt lateritic bricks exhibited average water absorption values of **10.82% for pavement bricks** and **10.27% for walling bricks**. These values fall well below the **maximum permissible limit of 20% by weight**, as specified by Rajput (2006) for burnt clay bricks used in building construction.

This indicates that the bricks possess adequate resistance to moisture ingress and are unlikely to suffer rapid deterioration when exposed to normal environmental conditions. The results further suggest that the pore structure of the bricks is sufficiently compact to ensure long-term serviceability in building applications.

4.2 Strength Characteristics

The compressive strength test results show that the locally burnt bricks achieved average compressive strength values of **5.824 N/mm²** for domestic pavement bricks and **2.945 N/mm²** for walling bricks. These values satisfy the requirements stipulated in **NIS 87:2004** for masonry units.

It was also observed that bricks produced using **laterite blended with fly ash and stone dust** exhibited higher compressive strength compared to bricks produced with laterite and water alone. This improvement in strength can be attributed to better particle packing and enhanced bonding within the brick matrix. Consequently, such bricks are suitable for both **pavement and walling applications**, while bricks produced solely from laterite and water are more appropriate for **walling units** where lower load-bearing capacity is acceptable. These findings confirm that locally sourced materials, when properly processed, can yield construction units that meet established structural standards.

4.3 Implications for Housing Development in Nigeria

The study demonstrates that the use of locally produced burnt lateritic bricks offers a viable solution to the challenges posed by rising cement prices and housing shortages in Nigeria. The adoption of these bricks can significantly reduce construction costs while promoting the use of indigenous materials and technologies.

Moreover, encouraging local brick production can stimulate rural and urban employment, reduce dependence on imported construction materials, and contribute to sustainable development within the construction sector.

4.4 Recommendations

Based on the findings of this study, the following recommendations are made:

1. **Government Support and Policy Incentives**: Federal and State Governments should actively encourage the production and use of locally burnt bricks by providing incentives such as tax reliefs, grants, and technical support to private entrepreneurs engaged in low-cost building material production.
2. **Establishment of Small-Scale Brick Industries**: Small-scale brick manufacturing units should be established in suitable locations, preferably **within every two local government areas** of a state where appropriate lateritic soil is available. These units need not be highly sophisticated, as locally adaptable technologies can deliver satisfactory production quality.
3. **Research and Development**: Greater emphasis should be placed on research into locally available raw materials. Existing research institutions should be strengthened, or specialized research centers established, to further investigate improved mix ratios, firing techniques, and performance characteristics of burnt bricks.
4. **Public Awareness and Acceptance**: The general public should be encouraged to embrace the use of locally produced bricks for building construction. Public sensitization will help dispel misconceptions that such materials are outdated, highlighting instead their affordability, durability, and structural adequacy.
5. **Quality Improvement in Brick Production:** Local brick producers should focus on improving surface finish and dimensional accuracy of bricks to reduce excessive mortar and plaster consumption, thereby further lowering overall construction costs.

References

Adedeji, Y. M. D., & Akinmusuru, J. O. (2020). Performance evaluation of burnt clay bricks produced from Nigerian soils. *Journal of Building Engineering, 32*, 101486. https://doi.org/10.1016/j.jobe.2020.101486

Adebayo, A. O., Adekunle, A. A., & Oyekan, G. L. (2023). Barriers to the adoption of alternative masonry units in Nigeria's construction industry. *Construction Economics and Building, 23*(2), 45–60.

Akinwumi, I. I., Booth, C. A., & Olubanwo, A. O. (2022). Local building materials and affordable housing delivery in developing countries. *International Journal of Construction Management, 22*(9), 1621–1632.

Andrew, R. M. (2023). Global CO_2 emissions from cement production. *Earth System Science Data, 15*(4), 1901–1920. https://doi.org/10.5194/essd-15-1901-2023

Kumar, R., Singh, S., & Kaur, M. (2020). Effect of soil composition on the engineering properties of fired clay bricks. *Materials Today: Proceedings, 32*, 871–876.

Mahmoud, A. A., El-Sayed, A. M., & Hassan, M. M. (2021). Sustainable lightweight fired clay bricks incorporating agricultural waste. *Journal of Cleaner Production, 279*, 123845.

Ogunsemi, D. R., & Jagboro, G. O. (2021). Construction cost escalation and affordable housing delivery in Nigeria. *Journal of Financial Management of Property and Construction, 26*(3), 329–345.

Oyelami, A. C., Akinwumi, I. I., & Oladipo, I. O. (2022). Engineering properties of lateritic soils for fired brick production. *SN Applied Sciences, 4*(6), 172.

World Bank. (2023). *Nigeria housing market and affordability assessment*. World Bank Publications.

