International Journal of Spectrum Research in Science & Engineering (IJSRSE)
2(2), April-June, 2026, Pages 54-61
© Noble City Publishers ISSN: 3092-9512

Doi: https://www.ijsrjournal.com/ijsrse.v2i2.2026.ijsr-330136

Assessment of the Underutilisation of Timber As A Structural Building Material in Nigerian Residential Construction

[1]Udemba Uchechukwu A., [2]Oninla Ibukunoluwa, [3]Christian T. Odefadehan

Department of Architecture, Caleb University, Imota, Lagos.

ABSTRACT

Despite Nigeria's abundant forest resources and the long-established use of timber in traditional architecture, residential construction across the country continues to rely almost entirely on cement-based systems. This study assessed the extent, causes, and consequences of the underutilisation of timber as a structural building material in Nigerian residential construction, and evaluated its potential as a technically and economically viable alternative. The research adopted a qualitative and descriptive approach using an extensive review of academic literature, professional reports, and policy documents. Findings revealed that timber possesses demonstrated structural adequacy for low-rise residential buildings, superior thermal performance in tropical climates, and significantly lower embodied energy compared to reinforced concrete. However, its adoption is constrained by cultural perception, regulatory bias toward concrete, inadequate timber treatment infrastructure, deforestation concerns, and the absence of standardised design codes for timber structures in Nigeria. The study recommends policy reform to formally recognise structural timber in Nigerian building regulations, investment in sustainable forestry and timber processing, and integration of timber design into architectural and engineering curricula.

Keywords: *Timber construction, residential housing, structural timber, sustainable building materials, Nigerian construction industry, housing affordability, tropical architecture*

INTRODUCTION

The built environment in Nigeria reflects a historical abandonment of indigenous materials and construction techniques. Nigerians are confronted with a myriad of housing problems, which are essentially connected with the hardships they face in securing and retaining a residence. This situation is particularly evident in Lagos state due to the cosmopolitan nature of the state, which has placed great demands not only on housing but also on physical and social amenities.(Odefadehan et al., 2023). Cement-based construction, introduced during colonial administration, became a symbol of modernisation and social status (Falade, 2019). Over time, this symbolism transformed into a rigid building culture in which alternatives are rarely evaluated or adopted (Adedeji, 2021). Most urban residential buildings in Nigeria are now constructed with reinforced concrete frames infilled with sandcrete blocks, a pattern that has remained largely unchanged for decades (Ede, Olofinnade & Joshua, 2014).

Yet Nigeria is endowed with substantial timber resources, including a variety of hardwood and softwood species distributed across its tropical forest zones in the south and savannah woodlands in the north. Research has consistently demonstrated that timber performs adequately as a structural material for low-rise residential buildings, offers excellent thermal comfort in hot and humid climates, and carries a significantly lower embodied energy and carbon footprint compared to reinforced concrete or steel (Ede & Okundaye, 2014). Despite this evidence, timber remains marginalised in Nigerian housing construction. The consequences of continued cement dependence are severe. The cost of cement and its constituent materials has risen sharply, pricing out many low and middle-income households and contributing to a national housing deficit estimated at over 17 million units (Ibem & Amole, 2021). Concrete buildings absorb and retain solar heat, producing uncomfortable indoor temperatures in Nigeria's tropical climate and increasing household energy expenditure on mechanical cooling (Nwankwo, 2022). Carbon emissions from cement production add to Nigeria's environmental burden at a time when the country has made commitments under the Paris Agreement.

The underutilisation of timber therefore represents a missed opportunity at the intersection of housing affordability, environmental sustainability, and cultural heritage. This study examines the technical potential of timber as a structural building material, the barriers preventing its adoption, and the conditions required for a meaningful transition in Nigerian residential construction practice. Nigeria's housing crisis has been extensively documented. Studies estimate a deficit of over 17 million housing units, with demand growing at approximately 900,000 new units per year (Ibem & Amole, 2021). Construction cost is the principal barrier, and material expenditure accounts for more than half of total project cost (Bamigboye, 2023). The persistent price increases in cement and reinforcing steel directly translate into unaffordable housing for the majority of the population.

In this context, timber offers a credible alternative. Research comparing a five-bedroom duplex constructed in concrete versus timber found that timber framing could reduce structural cost by over 50 percent while meeting safety requirements (Ede, Olofinnade & Joshua, 2014). Furthermore, timber requires significantly less fossil fuel energy to process than concrete or steel: rough sawn timber requires approximately 750 MJ/m³ compared to 4,800 MJ/m³ for concrete and 26,600 MJ/m³ for steel (Abumaje & Baba, 2014). These figures suggest that material culture in the Nigerian building sector can be meaningfully improved through a structured shift toward timber. Beyond economics, the climatic case for timber is compelling. Concrete structures in hot humid regions such as Lagos and Port Harcourt store solar heat during the day and release it at night, resulting in persistent thermal discomfort (Nwankwo, 2022). Timber, by contrast, has lower thermal mass and better insulative properties, contributing to naturally cooler indoor environments without mechanical cooling. As electricity supply in Nigeria remains unreliable, passive thermal comfort represents both an environmental and economic advantage.

Nevertheless, timber construction faces systemic barriers that have prevented uptake despite the evidence base. Building regulations in Nigeria do not formally recognise timber as a primary structural material for residential buildings (Salami, 2023). Mortgage institutions and building approval agencies default to concrete standards (Lawal, 2021). Cultural associations between timber houses and poverty, rural living, and impermanence further discourage uptake among urban populations (Kolawole, 2022). The central research problem therefore lies in the contradiction between the technical and economic viability of timber for Nigerian residential construction and its persistent marginalisation in practice. This contradiction has direct consequences for housing affordability, environmental performance, and the survival of indigenous material knowledge.

The aim of this study is to assess the extent, causes, and consequences of the underutilisation of timber as a structural building material in Nigerian residential construction and to propose viable strategies for its broader adoption. The following objectives guide the study:

- To examine the historical context and current status of timber use in Nigerian residential construction.
- To evaluate the structural, thermal, and environmental performance of timber relative to conventional cement-based systems.
- To identify technical, institutional, and socio-cultural barriers to timber adoption.
- To assess stakeholder perception of timber as a structural material.
- To propose policy and practice strategies for promoting timber use in Nigerian housing.

The study supports the Sustainable Development Goals, particularly SDG 11 on sustainable cities through its focus on affordable housing solutions (United Nations, 2023). It contributes to SDG 12 through promotion of responsible material use and to SDG 13 through the reduction of carbon emissions associated with cement production (Okon, 2023).

LITERATURE REVIEW

Historical Role of Timber in Nigerian Architecture

Pre-colonial Nigerian societies constructed dwellings from earth, timber, bamboo, and vegetable materials suited to local climatic conditions (Okeke, 2020). Timber was extensively used for structural frames, flooring, wall infill, and roofing, particularly in forest belt communities in the south-west and south-south geopolitical zones. These buildings provided natural thermal comfort and were maintained using community labour and locally available materials. The arrival of European colonisers introduced Portland

cement and imported iron as markers of modernity, gradually displacing indigenous systems (Falade, 2019). After independence, concrete construction was adopted as the official image of progress in government estates and public institutions (Adebayo, 2021), effectively delegitimising timber and earth techniques in formal construction practice.

Structural Capacity of Timber for Residential Buildings

Research conducted in Nigeria has confirmed the structural adequacy of available timber species for low-rise residential applications. Ede, Olofinnade and Joshua (2014) conducted a structural and economic comparison of a five-bedroom duplex designed in both reinforced concrete and timber, demonstrating that the timber option satisfied structural requirements at substantially lower cost. A review of the physical and mechanical properties of Nigerian timber species found adequate compressive and bending strength for typical residential loading conditions (Abumaje & Baba, 2014). The study concluded that timber is one of the few construction materials that has served all ages of human civilisation and that its strength characteristics, when properly assessed, support its safe use in residential construction. Internationally, the structural performance of timber in low and mid-rise buildings has been extensively validated. Skullestad, Bohne and Lohne (2016) demonstrated that high-rise timber buildings can serve as a climate change mitigation measure, while life cycle assessment studies consistently show timber outperforming concrete and steel in environmental metrics (Sandanayake et al., 2018). These findings have greater relevance in Nigeria where most residential demand is concentrated in one to three storey buildings that fall well within timber's proven structural range.

Thermal and Environmental Advantages of Timber

The thermal performance of building materials is a critical consideration in Nigeria's hot humid climate. Concrete walls and roofs absorb significant solar radiation during the day and release stored heat at night, creating sustained discomfort that drives household demand for energy-intensive cooling (Nwankwo, 2022). Timber, with lower thermal conductivity and thermal mass, produces naturally cooler interior environments in tropical conditions. International research confirms that timber buildings consume less energy during occupation than equivalent concrete structures (Dodoo, Gustavsson & Sathre, 2014). From an environmental perspective, timber's advantages are substantial. Rough sawn timber requires approximately 750 MJ/m³ of embodied energy compared to 4,800 MJ/m³ for concrete and 26,600 MJ/m³ for steel (Abumaje & Baba, 2014). Timber stores approximately 250 kg/m³ of carbon dioxide during its service life and releases only 15 kg/m³, contrasted sharply with steel, which releases 5,320 kg/m³ and stores none (Ede, Olofinnade & Joshua, 2014). Cement production contributes approximately 7 to 8 percent of global carbon dioxide emissions (International Energy Agency, 2022), making any shift toward timber in construction a meaningful climate action.

Barriers to Timber Adoption in Nigeria

Despite the evidence base, timber faces persistent barriers in the Nigerian construction sector. Cultural perception remains among the most powerful. Urban Nigerians associate concrete houses with permanence, status, and investment value, while timber buildings are associated with rural poverty and impermanence (Kolawole, 2022). Adedeji (2021) found that even when alternatives perform adequately, clients fear social stigma from neighbors and family members. These attitudes explain why technical evidence alone has not shifted practice. Regulatory and institutional constraints compound this. Building approval agencies in Lagos and most Nigerian states require structural calculations based on reinforced concrete codes (Salami, 2023). There are currently no nationally recognised design standards for structural timber in residential buildings, creating legal and professional liability concerns for architects and engineers (Danjuma, 2023). Mortgage and housing finance institutions classify concrete buildings as preferred collateral, effectively excluding timber houses from the formal housing finance system (Lawal, 2021). Infrastructure limitations also present serious challenges. Nigeria's timber processing industry is underdeveloped, with limited capacity for kiln drying, pressure treatment, and standardised grading of structural members (Petithaus, 2024). Without treated and graded timber, concerns about termite infestation, moisture damage, and fire susceptibility remain legitimate. Unsustainable logging and widespread deforestation in Nigerian forests further complicate advocacy for increased timber use without accompanying reforestation and sustainable forestry policies (Nwagwu et al., 2023).

Professional and Policy Landscape

Professional training in architecture and engineering in Nigeria continues to prioritise reinforced concrete design, limiting exposure to timber structural systems at the formative stage of practitioners' careers (Salami, 2023). The Nigerian Building and Road Research Institute (NBRRI) has produced some guidance on alternative materials but has not issued binding standards for structural timber in housing. Without institutional recognition, timber construction remains in a regulatory grey zone that discourages uptake. International precedents offer instructive models. Canada, Finland, and Austria have established comprehensive timber building codes that have enabled significant growth in mass timber construction. In the African context, studies from Kenya and South Africa demonstrate the feasibility of adapting international standards to local timber species and building traditions. Nigeria, with its forest resources and growing housing demand, is well positioned to develop similar frameworks if the regulatory and professional will can be mobilised (Nwagwu et al., 2023).

RESEARCH METHOD

This study adopted a qualitative and analytical research approach based on an extensive review of academic literature, policy documents, professional guidelines, and industry reports related to timber construction and housing in the Nigerian building industry. The qualitative approach was considered appropriate for exploring contextual challenges, professional practices, perceptual barriers, and emerging trends in building material adoption (Yin, 2020). Sources were drawn from peer-reviewed journals, research institution reports, architectural education literature, and sustainable development policy frameworks. Literature was retrieved from academic databases including Google Scholar, Scopus, and ResearchGate, using search terms including timber construction Nigeria, sustainable building materials Nigeria, structural timber tropical Africa, housing affordability Nigeria, and alternative building materials. Sources were assessed for relevance, credibility, and recency. Priority was given to empirical studies and institutional reports from Nigeria and comparable sub-Saharan African contexts.

Findings and Discussions

Historical and Current Status of Timber in Nigerian Residential Construction

Evidence from literature confirms that timber played a central structural role in Nigerian domestic architecture prior to colonisation and that its displacement was driven by socio-political rather than technical factors. The colonial introduction of cement as a symbol of modernity (Falade, 2019), followed by post-independence government reinforcement of concrete as the standard of official construction (Adebayo, 2021), effectively removed timber from the professional and regulatory mainstream. Today, timber survives primarily as a roofing and finishing material in Nigerian residential buildings, with its structural potential almost entirely unrealised in formal practice. The scale of this underutilisation is significant. Studies estimate that Nigeria's housing deficit now exceeds 17 million units (Ibem & Amole, 2021) and that conventional concrete construction has become prohibitively expensive for most households. Yet the country retains substantial forest resources in its southern zones, and existing research demonstrates the structural adequacy of Nigerian timber species for the residential building types in greatest demand. The persistence of this contradiction suggests that the barriers to timber adoption are primarily institutional and cultural rather than technical.

Structural and Economic Performance of Timber

The technical case for structural timber in Nigerian residential buildings is well established. Comparative analysis of a five-bedroom duplex demonstrated that a timber-framed structural system satisfied all relevant load requirements while reducing construction cost by more than 50 percent relative to the equivalent concrete design (Ede, Olofinnade & Joshua, 2014). This cost advantage is particularly significant given that material expenditure constitutes the largest single component of residential construction budgets in Nigeria, where cement-related items alone account for more than half of building expenditure (Bamigboye, 2023). Multiple Nigerian timber species including Iroko, Ekki, Opepe, and Obeche have been evaluated and found to possess adequate structural properties for residential applications (Abumaje & Baba, 2014). Their mechanical properties, including compressive strength parallel to grain and modulus of rupture, are within ranges accepted by international structural timber standards. The

availability of these species in Nigeria's timber markets, though subject to supply chain inconsistencies, represents a realistic foundation for expanded structural use if processing quality can be standardised.

Thermal and Environmental Benefits

The thermal performance of timber in Nigeria's climate represents a compelling practical advantage. Lagos, Ibadan, Abuja, and Port Harcourt all experience sustained high temperatures and humidity that make indoor thermal comfort a significant concern for occupants. Concrete buildings in these cities are well documented as sources of significant thermal discomfort due to their high heat retention (Nwankwo, 2022). Timber structures, with lower thermal mass and better insulative characteristics, offer naturally cooler indoor environments that reduce or eliminate the need for mechanical cooling. Given that electricity supply in Nigeria remains severely constrained, with most households relying on fuel-powered generators to supplement the national grid, the potential for timber construction to reduce household cooling energy demand has direct economic and environmental implications. Buildings that stay cooler without air conditioning reduce household expenditure, reduce generator fuel consumption, and reduce carbon emissions. These compound benefits align with Nigeria's Nationally Determined Contribution targets under the Paris Agreement (Federal Ministry of Environment, 2021). The carbon footprint comparison between timber and concrete is especially striking. While cement production is responsible for approximately 7 to 8 percent of global CO_2 emissions (International Energy Agency, 2022), sustainably harvested timber sequesters carbon throughout its service life. A transition of even a fraction of Nigeria's residential building stock toward timber structural systems would produce measurable reductions in the nation's construction sector emissions.

Barriers to Adoption

The findings confirm that the barriers to timber adoption are multi-dimensional and mutually reinforcing. Cultural perception operates as perhaps the strongest constraint. The association of concrete with prosperity, permanence, and modern identity is deeply embedded in Nigerian urban culture (Kolawole, 2022). Research participants in previous studies reported that clients would not purchase or inhabit timber-structured houses out of concern for social perception, regardless of demonstrated structural performance (Adedeji, 2021). This perception barrier cannot be overcome through technical persuasion alone; it requires sustained public communication, demonstration projects, and cultural reframing. Regulatory constraints compound the perception barrier. The absence of a recognised national standard for structural timber in residential buildings means that any architect proposing a timber-framed house operates without a legal and professional framework (Danjuma, 2023). Building control agencies trained exclusively in concrete assessment lack the tools to evaluate timber submissions, creating administrative delays and additional scrutiny that discourage uptake. This regulatory vacuum reflects the broader institutional prioritisation of concrete as the default building material (Salami, 2023). Infrastructure limitations prevent the supply side from meeting potential demand even where the will to use timber exists. Most timber sold in Nigerian markets is unseasoned, untreated, and ungraded, which legitimately raises concerns about dimensional stability, termite resistance, and fire performance (Petithaus, 2024). Without investment in drying kilns, treatment facilities, and quality grading systems, the structural reliability of available timber cannot be guaranteed. This supply chain weakness is a genuine technical barrier that distinguishes Nigeria's situation from countries where structural timber markets are well developed.

Stakeholder Perception and Attitudes

Analysis of professional literature reveals mixed and evolving attitudes toward timber among Nigerian construction stakeholders. Younger architects and building practitioners show increasing interest in sustainable materials, partly driven by international discourse on climate change and green building (Okon, 2023). However, senior practitioners and institutional clients remain firmly oriented toward concrete, citing client expectations, regulatory comfort, and professional liability concerns (Salami, 2023). Homeowners in Nigerian urban areas overwhelmingly prioritise resale value and social signalling in their material choices, factors that currently favour concrete (Lawal, 2021). Until financial institutions formally recognise timber houses as acceptable mortgage collateral, and until demonstration projects prove that timber houses can hold and appreciate in market value, homeowner attitudes are unlikely to shift. The

challenge is therefore systemic: perception, regulation, and finance must shift together before individual decision-making can change.

Discussion

The findings confirm that the underutilisation of timber in Nigerian residential construction is the product of interconnected historical, cultural, regulatory, and infrastructural factors rather than any fundamental technical deficiency. Timber possesses demonstrated structural adequacy, superior thermal performance in the Nigerian climate, and a substantially lower environmental footprint than concrete. The cost advantages are significant and directly relevant to the national housing affordability challenge (Ede, Olofinnade & Joshua, 2014; Bamigboye, 2023).The path toward broader timber adoption requires simultaneous action on multiple fronts. Regulatory frameworks must formally recognise structural timber, supply chains must be upgraded to produce reliable treated and graded material, professional education must expand to include timber structural design, and public communication must address the cultural stigma associated with timber housing. These interventions are mutually dependent: none will succeed without the others. However, international experience from countries including Canada, Sweden, and increasingly South Africa demonstrates that this transition is achievable with coordinated policy and industry action (Sandanayake et al., 2018; Nwagwu et al., 2023).

CONCLUSION

This qualitative study demonstrates that the underutilisation of timber in Nigerian residential construction represents a significant missed opportunity at the intersection of housing affordability, environmental sustainability, and indigenous material knowledge. Timber possesses the structural properties, thermal performance characteristics, and environmental credentials needed to serve as a viable and superior alternative to reinforced concrete for low-rise residential buildings. Its marginalisation is the product of historical legacy, cultural stigma, regulatory inertia, and infrastructure weakness rather than inherent technical limitation. In a country facing a housing deficit of over 17 million units, persistently high construction costs, and escalating environmental pressures, the case for timber transition is both compelling and urgent. The study therefore calls for coordinated policy reform, supply chain investment, educational restructuring, and market innovation to unlock the potential of timber as a mainstream residential building material in Nigeria. With appropriate institutional support, structural timber can contribute meaningfully to closing the housing gap while reducing the construction sector's environmental footprint.

RECOMMENDATIONS

Policy and Regulation

Federal and state governments should commission the development of a Nigerian Standard for Structural Timber in Residential Buildings, drawing on existing research on local timber species and adapting relevant international codes. Building approval agencies in Lagos and other states should receive training in timber structural assessment so that innovative submissions are evaluated promptly and fairly (Salami, 2023). Carbon reduction policies should include incentives for low-embodied-energy construction, creating a financial advantage for timber relative to concrete (Okon, 2023).

Sustainable Forestry and Timber Processing

Expanded use of timber in construction must be accompanied by robust reforestation and forest management policies to prevent net deforestation. Nigeria's Forest Management Department and state forestry agencies should establish community-based timber plantation programmes that can supply certified construction-grade timber sustainably (Nwagwu et al., 2023). Investment in kiln drying, pressure treatment, and standardised grading facilities will address the quality and reliability concerns that currently deter structural timber use (Petithaus, 2024).

Education and Professional Practice

Schools of architecture, civil engineering, and building technology must integrate structural timber design into core curricula alongside reinforced concrete (Abumaje & Baba, 2014). Continuing professional development programmes should retrain practicing architects and engineers in timber structural

assessment and detailing. Demonstration housing projects in partnership with state housing corporations and development agencies in Lagos, Abuja, and other major cities can build professional confidence and public awareness (Kolawole, 2022).

Financial and Market Mechanisms

Mortgage institutions and housing finance agencies should revise their valuation frameworks to formally recognise certified timber residential buildings as eligible collateral (Lawal, 2021). Pilot programmes offering preferential financing for homes built with certified sustainable materials, including timber, can stimulate early-adopter demand and generate proof-of-concept evidence for the broader market. Collaboration between research institutes, timber processors, and private developers can establish quality benchmarks that eventually support standard valuation (Danjuma, 2023).

REFERENCES

Abumaje, E. A., & Baba, Y. D. (2014). An assessment of timber as a sustainable building material in Nigeria. Journal of Environmental Technology and Science, 2(1), 1–12.

Adebayo, T. (2021). Colonial legacies and building material culture in Nigerian cities. Journal of African Urban History, 8(2), 33–49.

Adedeji, Y. (2021). Housing materials and sustainability in tropical Africa. Journal of Built Environment Studies, 12(2), 44–58.

Bamigboye, K. (2023). Cost components of housing delivery in Nigeria. Quantity Surveying Forum, 6(1), 33–47.

Creswell, J. (2018). Research design: Qualitative and quantitative approaches (5th ed.). Sage.

Danjuma, S. (2023). Barriers to adoption of sustainable materials. African Building Technology Journal, 5(2), 60–72.

Dodoo, A., Gustavsson, L., & Sathre, R. (2014). Lifecycle carbon implications of conventional and low-energy multi-storey timber building systems. Energy and Buildings, 82, 194–210. https://doi.org/10.1016/j.enbuild.2014.07.013

Ede, A. N., & Okundaye, K. (2014). Advantages of timber over concrete for low-cost housing in developing countries. International Journal of Innovative Research in Science, Engineering and Technology, 3(7), 14712–14719.

Ede, A. N., Olofinnade, O. M., & Joshua, O. (2014). Structural, economic and environmental study of concrete and timber as structural members for residential buildings in Nigeria. International Journal of Engineering and Technology, 14(1), 107–115.

Falade, J. (2019). Colonial influence on Nigerian architecture. History of the Built Form, 7(1), 15–28.

Federal Ministry of Environment. (2021). Nigeria's updated nationally determined contributions. Federal Republic of Nigeria.

Ibem, E. O., & Amole, D. (2021). Housing policy and deficit in Nigeria: A critical review. International Journal of Housing Policy, 21(2), 210–229. https://doi.org/10.1080/19491247.2020.1742649

International Energy Agency. (2022). Global status report for buildings and construction. IEA.

Kolawole, D. (2022). Social perception of earth architecture. Journal of Cultural Studies, 11(2), 120–134.

Lawal, O. (2021). Mortgage valuation and material preference in Nigerian housing markets. Real Estate Review, 10(1), 55–69.

Nwagwu, C., Oyewole, M., & Agboola, O. (2023). Life cycle assessment of Nigerian residential building archetypes: Implications for sustainable construction policy. Buildings and Cities, 4(1), 452–471. https://doi.org/10.5334/bc.307

Nwankwo, C. (2022). Thermal performance of concrete houses in hot humid Nigeria. Energy and Buildings in Africa, 8(3), 70–84.

Odefadehan, C. T., Oladipo, D.-A., Ugwumba, F., Olufemi, O., & Department of Architecture, Caleb University, Imota, Lagos. (2023). GENDER INEQUALITY: INVESTIGATING HOUSING ACCESSIBILITY CHALLENGES AMONGST FEMALE NYSC CORP MEMBERS IN LAGOS, NIGERIA. In Journal of Behavioural Studies (Vols. 1–1).

Okeke, P. (2020). Traditional Nigerian dwellings. Journal of Vernacular Architecture, 5(1), 10–26.

Okon, E. (2023). Carbon footprint of Nigerian construction. Environmental Impact Review, 6(2), 95–110.
Petithaus. (2024). Seven reasons Nigerians avoid building with wood: And solutions for affordable homeownership. Retrieved from https://www.petithaus.com/article/7-reasons-nigerians-avoid-wood-and-solutions-for-homeownership
Salami, K. (2023). Professional attitudes to non-conventional materials. Architects Forum Nigeria, 9(1), 22–35.
Sandanayake, M., Lokuge, W., Zhang, G., Setunge, S., & Thushar, Q. (2018). Greenhouse gas emissions during timber and concrete building construction: A scenario-based comparative case study. Sustainable Cities and Society, 38, 91–97. https://doi.org/10.1016/j.scs.2018.01.020
Skullestad, J. L., Bohne, R. A., & Lohne, J. (2016). High-rise timber buildings as a climate change mitigation measure: A comparative LCA of structural system alternatives. Energy Procedia, 96, 112–123. https://doi.org/10.1016/j.egypro.2016.09.112
United Nations. (2023). Sustainable Development Goals Report 2023. UN Press.
Yin, R. K. (2020). Case study research and applications: Design and methods (6th ed.). Sage Publications.