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ASSESSING THE AWARENESS OF THERMAL PERFORMANCE OF EARTH AS A WALL MATERIAL AND SUSTAINABLE BENEFITS AMONG BUILDING INDUSTRY PROFESSIONALS IN KATSINA

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ABSTRACT

This paper is aimed at studying the ecological and sustainability issues in earth construction for housing purpose with a view to find out how enlightened the building professionals are on what we need to be concern about in using earth materials. The study intended to appraise the level of awareness among the building industry professionals on the sustainable benefits of using compressed earth brick as a wall material for housing and schools in Katsina State. In the past, houses and schools were built with earth, and their indoor thermal environments were friendly and more energy-efficient compared with the nowadays walling material. In order to accomplish the purpose of the study, a cross-sectional online survey design was adopted to collect the relevant data for evaluating the awareness level of the sustainable benefits of compressed earth bricks amongst the professionals in Katsina State. The study looked at environmental factors; strategies for sustainable ecological development and benefits of rammed earth as ecological stable material. This paper examined the effect of the usage of earth materials for constructions process in buildings and its sustainability, the impacts on the environment and way of preventing the possible implications that may result when used.

Keywords: Sustainability, Thermal Performance, Energy-Efficient, Compressed Earth, Building Industry Professionals, Rammed Earth, Katsina State

INTRODUCTION

The building sector accounts for a significant proportion of global energy consumption and carbon emissions, making sustainable material selection a critical concern in contemporary construction (UNEP, 2020). In response, there is growing interest in low-impact materials such as earth, which has been used for centuries in traditional architecture across Africa and other regions (Walker et al., 2012).

Earthen wall materials exhibit high thermal mass, enabling them to absorb heat during the day and release it at night, thereby moderating indoor temperature fluctuations (Minke, 2012; Houben & Guillaud, 1994). This property is particularly beneficial in hot-dry climates such as Katsina State, where passive cooling strategies are essential for thermal comfort (Givoni, 1998).

Despite these advantages, the use of earth as a walling material has declined due to modernization, urbanization, and the perception that it is inferior to conventional materials like concrete and fired bricks (Olotuah, 2002). This shift has contributed to increased reliance on energy-intensive building systems.

Building professionals play a crucial role in material selection and construction practices. Their awareness and perception significantly influence the adoption of innovative and sustainable materials (Abanda & Byers, 2016). However, studies indicate that there is limited awareness of the full thermal and environmental benefits of earthen materials among professionals in developing countries (Maini, 2010).

This study, therefore, assesses the awareness of building industry professionals in Katsina State regarding the thermal performance and sustainability benefits of earth as a wall material.

About Katsina State

Katsina state is a state in northern Nigeria, and has its capital as Katsina (Figure 1). Nigeria lies between longitudes 3 degrees and 14 degrees and scopes 4 degrees and 14 degrees, it's situated on the Gulf of Guinea in West Africa. Its neighbours are Benin, Niger, Cameroon, and chad. The lower course of the Niger River flows south through the western part of the country into the Gulf of Guinea. Katsina is one of the seven states that form Nigeria's North-West geopolitical zone. Within the country, It is bordered by Jigawa and Kano states to the east; Kaduna to the south and Zamfara to the west. It shares an international border with the Republic of Niger to the north.

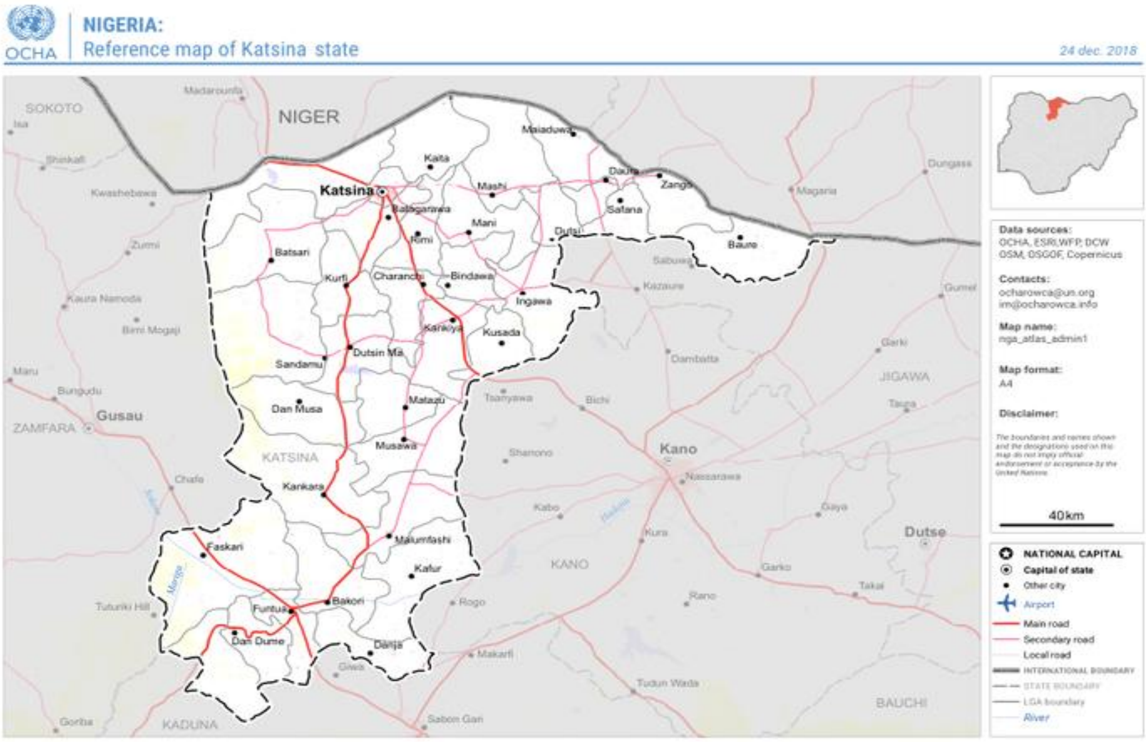

Figure 1: Map of Katsina Metropolice showing Borders withing and Outside the Country
(Source Google.com)

Raw Earthen Material

Raw earth is a natural soil resulting from the decomposition of rock, typically containing sand, silt, and a small but essential proportion of clay, which acts as a binder (Morel et al., 2021; Gallipoli et al., 2017; Aubert et al., 2021).

raditional earthen materials used in buildings are mainly untreated natural soil (also called raw soil materials) for walls, floors, plasters, roadbeds, and embankments (Zhang et al., 2024).

The use of earth as a wall material has garnered renewed interest due to its potential for sustainable construction, energy efficiency, and thermal comfort. However, the level of awareness among building industry professionals regarding these benefits varies significantly across regions and professional groups. Recent studies indicate that while some professionals, such as architects in North-Western Nigeria, demonstrate a high level of awareness about the sustainable benefits of compressed earth bricks including availability, renewability, recyclability, affordability, and enhanced indoor thermal environments there remain notable gaps in knowledge and practice globally (Maimagani et al., 2021; Mba et al., 2024). Validated assessment tools like the Awareness of Thermal Performance of Earth and Sustainable Benefit Assessment Scale (ATESBAS) have been developed to measure this awareness reliably (Mba et al., 2024). Despite growing recognition of earth's environmental advantages such as low embodied energy, carbon footprint reduction, and superior hygrothermal properties barriers persist due to limited technical knowledge, regulatory challenges, market resistance, and insufficient professional training (Nina et al., 2023; Carcassi et al., 2024; Filho et al., 2025). This review synthesizes current research on professional awareness, technical performance data, and the broader context influencing adoption in the building sector.

Earth materials were shown to exhibit low embodied carbon as opposed to conventional materials. The production of earth-based walls was shown to require 62–71% less energy and reduce up to 91% of embodied emissions as opposed to conventional assemblies, with light straw clay as the best-performing assembly for multiple climates. Beyond their low carbon, affordability, bio- and geo-degradability, earth materials sorb volatile organic compounds (VOCs) from indoor air, acting as passive removal materials (Figure 2). Lastly, when left unbaked, earth materials act as relative humidity "flywheels", absorbing and desorbing moisture to provide stable, often optimal levels of relative humidity for occupants (Construction and Building Materials Volume 142, 1 July 2017).

Despite these advantages, earth buildings have not been comprehensively implemented in mainstream construction.

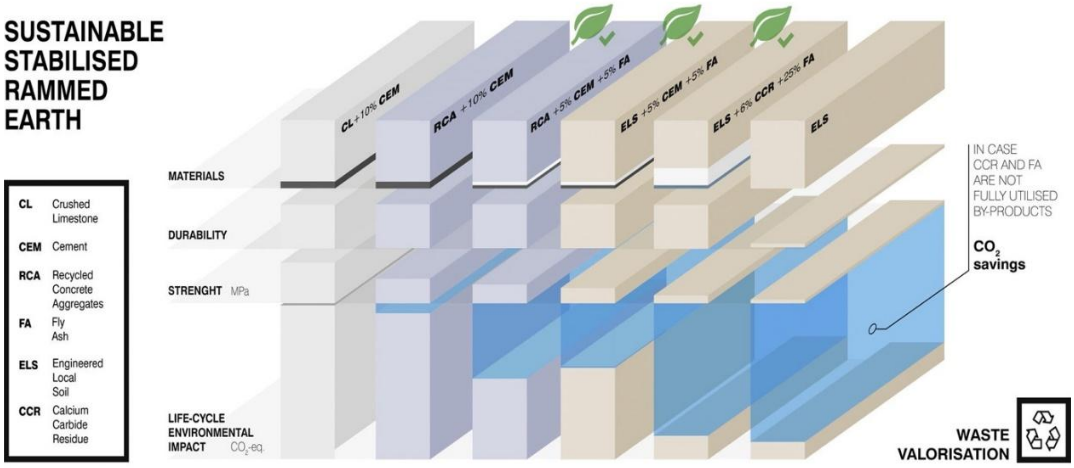

Figure 2: Construction and Building Materials Volume 142, 1 July 2017

Evidence on Thermal Performance and Sustainable Benefits of Earth Walls

Hygrothermal Properties of Raw Earth Materials

Raw earth historic and contemporary architectures are renowned for their good environmental properties of recyclability and low embodied energy along the production process. Earth massive walls are universally known to be able to regulate indoor thermal and hygroscopic conditions containing energy consumptions, creating comfortable interior spaces with a low carbon footprint. Therefore, earth buildings are de facto green buildings. As a result of this, some earthen technologies have been rediscovered and implemented to be adapted to the contemporary building production sector (Giuffrida et al., 2019). Nevertheless, the diffusion of contemporary earthen architecture is decelerated by the lack of broadly accepted standards on its anti-seismic and thermal performance. Indeed, the former issue has been solved using high-tensile materials inside the walls or surface reinforcements on their sides to improve their flexural strength. The latter issue is related to the penalization of earth walls thermal behavior in current regulations, which tent to evaluate only the steady-state performance of building components, neglecting the benefit of heat storage and hygrothermal buffering effect provided by massive and porous envelopes as raw earth ones (Caponetto et al., 2019). Different earth techniques (adobe, cob, extruded bricks, rammed earth, compressed earth blocks, light earth) have been considered in order to highlight that earth material can act both as a conductive and insulating meterial depending on how it is implemented, adapting to several climate contests.

Compared Environmental Lifecycle Performances of Earth-Based Walls to Drive Building Envelope Design

Raw earth has useful applications in contemporary buildings as a sustainable and circular construction material. In particular, a life cycle assessment is developed for (a) unstabilized rammed earth (produced in situ), (b) compressed earth blocks (prefabricated in the factory), (c) stabilized rammed earth and (d) light earth, all combined with biobased (natural fibers, e.g., lime hemp, cork) and/or conventional materials for building insulation. Results show benefits in terms of avoided carbon emission, water footprint and embodied energy throughout the production chain and highlight limits and potential improvements (Giuffrida et al, 2024). In addition, the CO2 offset by crops is also estimated based on carbon embedded in natural fibers. In particular, light earth wall systems are the most suitable to minimize environmental impacts, while massive constructive technologies (as unstabilized rammed earth) show a higher dynamic thermal performance for intended use in Mediterranean climates.

Meta-Analytical and Review Evidence

The main earthen constructions such as adobe, compressed earth blocks (CEBs), and rammed earth walls (REWs), have been found to the potential to reduce the environmental impact compared to conventional materials. Through a systematic literature review (2013–2024) and a meta-analysis, the mechanical, thermal, and sustainability properties of these constructions are analyzed (Mora-Ruiz et al., 2025). Emphasis is placed on the use of additives, such as stabilizers and fibers from various industrial and agro-industrial by-products, as leading actors influencing the mechanical and environmental performance of earthen constructions (EnCs). Remarkable improvements in the compressive and flexural strength are found, especially in stabilized CEBs and REWs, where strengths of up to 24 MPa are reached in certain mixtures, comparable to conventional materials such as concrete. This review also shows that numerical methods like finite element modeling (FEM) have been crucial to modeling and predicting the performance of these materials, contributing to the understanding of their dynamic and structural responses.

MATERIALS AND METHODS

This is to assess the validity of the Awareness of Thermal Performance of Earth and Sustainable Benefit Assessment Scale (ATESBAS). A cross-sectional survey design was adopted with a number of selected samples from the northwestern part of Nigeria. The instruments contained 20 items spread among the 2 constructs of benefits of compressed earth brick and application of compressed earth brick. A comprehensive literature search was also conducted using Consensus' academic deep search engine, ResearchGate, Academia, Google scholar and other archives with reference to the awareness and thermal performance of earthen walls. The data collected were entered into Microsoft Excel and analysis was made. The scale was evaluated through content validity with experts and reliability with Cronbach's Alpha technique. The results indicated that the scale has substantial content validity and acceptable reliability values of 0.80 (Benefits of Compressed Earth Brick) and 0.84 (Application of compressed Earth Brick), (Maimagani et al., 2021).

However, one item overall failed to satisfy the condition to be certified as valid and thus, entirely removed from the scale (Application of Compressed Earth Brick). Accordingly, with the satisfaction of measurement requirements by 63 items, it concluded that the developed ATESBAS validated in this study can be used to investigate the awareness of the thermal performance of earth as a wall material and sustainable benefit, among building professionals in Katsina Nigeria. Consequently, Eight unique search groups were used to ensure coverage across awareness surveys, technical performance studies, policy/regulatory barriers, and sustainability education.

RESULTS AND DISCUSSION

Professional Awareness Levels

Surveys among architects in Katsina reveal generally high awareness of the sustainable benefits of compressed earth bricks (CEBs), with no significant differences based on education or years of experience (Maimagani et al., 2021). However, qualitative interviews in other regions (e.g., Minna) suggest that overall knowledge remains low or moderate among architects regarding sustainable materials (Umar et al., 2021), with reluctance to specify unfamiliar materials.

A validated scale (ATESBAS) has been developed for measuring awareness specifically related to thermal performance and sustainability benefits; it demonstrates strong reliability (Cronbach's alpha >0.8) (Mba et al., 2024).

Technical Knowledge Gaps

While many professionals recognize generic sustainability attributes (e.g., local sourcing), fewer are aware of specific thermal or hygrothermal advantages—such as heat storage capacity or moisture buffering—that make earthen walls effective for passive comfort (Giada et al., 2019; Maimagani et al., 2021; Carrobé et al., 2021). Studies show that even when professionals are aware conceptually, detailed understanding is often lacking (Nina et al., 2023; Carcassi et al., 2024).

Barriers to Adoption

Barriers include lack of technical standards/codes for earthen construction (Morel et al., 2021), market resistance due to perceptions that earth is "low-tech," insufficient training opportunities (Nina et al., 2023), and limited demonstration projects (Chan et al., 2022). Regulatory compliance is often prioritized over innovative material choices (Yin et al., 2018).

Sustainable Benefits Recognized

Where awareness exists, professionals cite reduced operational energy demand, lower embodied carbon/energy compared to concrete or fired brick walls (Giuffrida et al., 2024; Ben-Alon et al., 2021), improved indoor air quality due to moisture regulation (Giada et al., 2019), and alignment with circular economy principles (Sinha & Sudarsan, 2025; Filho et al., 2025).

Discussion

The literature indicates that while there is growing conceptual awareness among certain groups especially architects about the sustainable benefits of earth as a wall material (notably in regions where such materials have historical precedent), detailed technical understanding remains limited globally (Maimagani et al., 2021; Umar et al., 2021). The development and validation of scales like ATESBAS provide robust tools for future research into professional knowledge gaps (Mba et al., 2024). However, persistent barriers including regulatory inertia and market perceptions continue to hinder widespread adoption despite strong evidence supporting earth's superior thermal performance and environmental credentials (Morel et al., 2021; Nina et al., 2023; Carcassi et al., 2024).

Efforts to bridge these gaps should focus on targeted education/training programs for professionals; updating codes/standards; increasing demonstration projects; and public policy interventions that incentivize sustainable material choices (Yin et al., 2018; Carcassi et al., 2024). Comparative studies also highlight an "attitude-practice gap," where positive attitudes toward sustainability do not always translate into specification or use in practice due to risk aversion or lack of familiarity with new materials (Abdelaal & Guo, 2021).

Table 1: Key Claims and Support Evidence Identified in these Papers

Claim	Evidence Strength	Reasoning	Papers
Most architects surveyed in North-Western Nigeria are aware of CEB's sustainable benefits	Evidence strength: Strong (8/10)	Supported by cross-sectional survey with statistical analysis showing high self-reported awareness	(Maimagani et al., 2021)
Validated scales can reliably measure professional awareness about earth wall benefits	Evidence strength: Strong (8/10)	ATESBAS shows strong reliability/content validity for assessing this construct	(Mba et al., 2024)
Technical knowledge about specific thermal/hygrothermal properties is often lacking among professionals	Evidence strength: Moderate (6/10)	Multiple reviews/surveys report superficial rather than detailed understanding	(Giada et al., 2019; Nina et al., 2023; Carcassi et al., 2024)
Regulatory barriers are a major obstacle despite proven environmental/thermal advantages	Evidence strength: Moderate (7/10)	Practitioner surveys/literature reviews highlight codes/standards lagging behind science	(Morel et al., 2021; Yin et al., 2018)
There is an attitude-practice gap: positive attitudes do not always lead to use/specification	Evidence strength: Moderate (6/10)	KAP surveys show higher knowledge/attitude than actual practice/adoption rates	(Abdelaal & Guo, 2021)
Overall global awareness among building professionals remains moderate at best outside select regions/groups	Evidence strength: Moderate (5/10)	Qualitative interviews/surveys from multiple countries report variable but generally modest levels	(Umar et al., 2021; Vu & Nguyen, 2021)

Summary

In summary, there is increasing but uneven awareness among building industry professionals regarding the thermal performance and sustainable benefits of earth as a wall material. While validated tools exist for measuring this awareness and some regions/professional groups demonstrate high levels significant gaps persist globally due to regulatory inertia, market perceptions, limited training opportunities, and insufficient dissemination of technical data.

Research Gaps

Table 2: Research Gaps Matrix: Topic by Profession/Policy Group Coverage

Topic/Outcome	Architects	Engineers	Contractors	Policy Makers
General sustainability awareness	6	2	2	GAP
Detailed knowledge: thermal/hygrothermal	4	2	GAP	GAP
Use/specification practices	3	1	GAP	GAP
Barriers/regulatory issues	2	1	GAP	2

Open Research Questions

Future research should focus on expanding validated measurement tools across diverse contexts; investigating interventions that effectively increase both knowledge and practical adoption; exploring policy mechanisms; and addressing persistent misconceptions.

Table 3: Open Questions: Future Directions for Research on Professional Awareness/Adoption

Question	Why
How does targeted professional training affect detailed technical knowledge about earthen wall performance?	Understanding this can inform educational strategies that close knowledge-practice gaps.
What policy interventions most effectively increase specification/use rates for earthen walls?	Identifying successful policies can help overcome regulatory inertia/barriers globally.
How do client perceptions influence professional specification practices for earthen materials?	Client demand may be critical in driving broader adoption beyond professional attitudes alone.

CONCLUSION

While progress has been made in raising conceptual awareness about the sustainable benefits of earth as a wall material among building industry professionals especially architects in Katsina state, significant work remains to translate this into widespread technical understanding and practical adoption worldwide.

REFERENCES

Abdelaal, F., & Guo, B. (2021). Knowledge, attitude and practice of green building design and assessment: New Zealand case. *Building and Environment*.

Asdrubali, F., Grazieschi, G., Roncone, M., Thiébat, F., & Carbonaro, C. (2023). Sustainability of Building Materials: Embodied Energy and Embodied Carbon of Masonry. *Energies*.

Ben-Alon, L., & Rempel, A. (2023). Thermal comfort and passive survivability in earthen buildings. *Building and Environment*.

Ben-Alon, L., Loftness, V., Harries, K., & Hameen, E. (2021). Life cycle assessment (LCA) of natural vs conventional building assemblies. *Renewable and Sustainable Energy Reviews*.

Ben-Alon, L., Loftness, V., Harries, K., & Hameen, E. (2022). Overcoming the Perceptual Gap: Worldwide Perceived Comfort Survey of Earthen Building Experts and Homeowners. *Construction Technologies and Architecture, 1*, 521 - 528.

Bruno, A., Gallipoli, D., Perlot, C., & Kallel, H. (2020). Thermal performance of fired and unfired earth bricks walls. *Journal of building engineering, 28*, 101017.

Carcassi, O., Salierno, R., Falcinelli, P., Paoletti, I., & Ben-Alon, L. (2024). Upscaling Natural Materials in Construction: Earthen, Fast-Growing, and Living Materials. *Sustainability*.

Carrobé, A., Rincón, L., & Martorell, I. (2021). Thermal Monitoring and Simulation of Earthen Buildings. A Review. *Energies, 14*, 2080.

Chan, M., Masrom, M., & Yasin, S. (2022). Selection of Low-Carbon Building Materials in Construction Projects: Construction Professionals' Perspectives. *Buildings*.

Charai, M., Mezrhab, A., & Moga, L. (2022). A structural wall incorporating biosourced earth for summer thermal comfort improvement: Hygrothermal characterization and building simulation using calibrated PMV-PPD model. *Building and Environment*.

Filho, J., Santos, G., Zapata, J., & Brito, D. (2025). Construção com terra e sustentabilidade urbana. *Labor e Engenho*.

Giada, G., Caponetto, R., & Nocera, F. (2019). Hygrothermal Properties of Raw Earth Materials: A Literature Review. *Sustainability*.

Giuffrida, G., Dipasquale, L., Pulselli, R., & Caponetto, R. (2024). Compared Environmental Lifecycle Performances of Earth-Based Walls to Drive Building Envelope Design. *Sustainability*.

Giuffrida, G., Detommaso, M., Nocera, F., & Caponetto, R. (2021). Design Optimisation Strategies for Solid Rammed Earth Walls in Mediterranean Climates. *Energies, 14*, 325.

Hema, C., Messan, A., Lawane, A., Soro, D., Nshimiyimana, P., & Moeseke, G. (2021). Improving the thermal comfort in hot region through the design of walls made of compressed earth blocks: An experimental investigation. *Journal of building engineering*, *38*, 102148.

Maimagani, S., Majid, R., & Chung, L. (2021). Professional Architects Awareness on the Sustainable Benefits of Compressed Earth Brick as a Wall Material in North-Western Nigeria. *, 11*, 1024-1036.

Maimagani, S., Majid, R., & Chung, L. (2021). Validation of Awareness of Thermal Performance of Earth and its Sustainable Benefit Assessment Scale. *, 11*, 1015-1023.

Mba, E., Okeke, F., Igwe, A., Ozigbo, C., Oforji, P., & Ozigbo, I. (2024). Evolving trends and challenges in sustainable architectural design; a practice perspective. *Heliyon*, *10*.

Michalak, J., & Michałowski, B. (2022). Understanding Sustainability of Construction Products: Answers from Investors, Contractors, and Sellers of Building Materials. *Sustainability*.

Mora-Ruiz, V., Soto-Paz, J., Attia, S., & Mejía-Parada, C. (2025). Sustainable Earthen Construction: A Meta-Analytical Review of Environmental, Mechanical, and Thermal Performance. *Buildings*.

Morel, J., Charef, R., Hamard, E., Fabbri, A., Beckett, C., & Bui, Q. (2021). Earth as construction material in the circular economy context: practitioner perspectives on barriers to overcome. *Philosophical Transactions of the Royal Society B*, *376*.

Nina, J., Eires, R., & Oliveira, D. (2023). Earthen Construction: Acceptance among Professionals and Experimental Durability Performance. *Construction Materials*.

Okoye, P., Odesola, I., & Okolie, K. (2021). Optimising the Awareness of Benefits of Sustainable Construction Practices in Nigeria. *Baltic Journal of Real Estate Economics and Construction Management*, *9*, 62 - 77.

Orr, J., Drewniok, M., Walker, I., Ibell, T., Copping, A., & Emmitt, S. (2019). Minimising energy in construction: Practitioners' views on material efficiency. *Resources, Conservation and Recycling*.

Sinha, S., & Sudarsan, J. (2025). Building a Greener Future: How Earth Blocks Are Reshaping Sustainability and Circular Economy in Construction. *Architecture*.

Umar, I., Lembi, J., & Emechebe, L. (2021). Assessment of Awareness of Architects on Sustainable Building Materials in Minna, Nigeria. *, 5*, 50.

Vijayan, D., Mohan, A., Revathy, J., Parthiban, D., & Varatharajan, R. (2021). Evaluation of the impact of thermal performance on various building bricks and blocks: A review. *Environmental Technology and Innovation*, *23*, 101577.

Vu, K., & Nguyen, B. (2021). Sustainable Material Awareness, Belief and Readiness in Housing Development. *Built Environment Journal*.

Yan, Y., & Song, Y. (2021). Research on application and thermal performance of raw earth material in building envelope. *Journal of Physics: Conference Series*, *1777*.

Yin, B., Laing, R., Leon, M., & Mabon, L. (2018). An evaluation of sustainable construction perceptions and practices in Singapore. *Sustainable Cities and Society*, *39*, 613-620

Zhang, Y., Jiang, S., Quan, D., Fang, K., Wang, B., & , Z. (2024). Properties of Sustainable Earth Construction Materials: A State-of-the-Art Review. *Sustainability*.

Abanda, F. H., & Byers, L. (2016). An investigation of the impact of building orientation on energy consumption in a domestic building. *Energy*, 97, 517–527.

Givoni, B. (1998). *Climate considerations in building and urban design*. Wiley.

Houben, H., & Guillaud, H. (1994). *Earth construction: A comprehensive guide*. Intermediate Technology Publications.

Maini, S. (2010). Earthen architecture for sustainable habitat. *Auroville Earth Institute*.

Minke, G. (2012). *Building with earth: Design and technology of a sustainable architecture*. Birkhäuser.

Olotuah, A. O. (2002). Housing problems in Nigeria. *Architectural Science Review*, 45(4), 311–317.

UNEP. (2020). *Global status report for buildings and construction*. United Nations Environment Programme.

Walker, P., Heathcote, K., Lawrence, M., & Siddall, R. (2012). *Modern earth buildings*. Woodhead Publishing.