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CLAY BLOCKS AS A COOLING MECHANISM MATERIAL FOR RESIDENTIAL BUILDINGS IN THE TROPICAL REGIONS IN NIGERIA

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Abstract

The seasonal climatic changes in the country generate extreme heat waves, demanding the need for natural cooling techniques in the building industry and reducing the energy consumption of artificial applications (air-conditioning). The qualities and benefits of clay as a building material that enhances natural comfort in residential buildings is the focus of this study. However, there hasn't been much research done on whether the choice of mud materials is influenced only by their inherent benefits. Buildings in these categories were reviewed as part of a blended examination strategy that combined quantitative (poll questionnaire) and subjective (inquiry questions) research methods. According to the findings, the red clay sample is recommended for use in the production of structural tiles, pipes, roof tiles, interior floors, etc., in situations where heat conductivity is of secondary consideration. It also recommends further research into the improvement of clay as a structural material, noting that gray clay sample has certain characteristics that make it more suitable as a building material for local building construction in the tropics.

Keywords: *Building industry, Clay earth blocks, Cooling mechanism material, Heat conductivity, Residential buildings*

1.0 Introduction

Man has been using clay earth, an affordable building material, for a very long time. It is easy to unearth from the start and requires little preparation, which suggests that energy and tiresome cycles are reduced. Mud blocks, clay bricks, clay roofs, clay floor tiles, and clean tools are examples of clay applications that are created locally in nearby creation plants using standard clay and water mixtures. They are adaptable, energy-efficient, resilient, fashionable, and economical. Additionally, it is used to obtain a wonderful bargain on many traditional structural tactics for protection. It is also possible to save money on energy bills because buildings that use clay as a heat separator will use less energy (Lake, 2012). Satisfied that clay building does not use more energy than necessary, homes will be able to maintain comfortable temperatures during the middle of the year and stay warm during the winter months. Because of its exceptional protective qualities, high capacity to store heat, and ability to reduce energy consumption in buildings, clay earth is regarded as an affordable, reliable building material.

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
ISSN: 2736-0814

According to Norton (1972) and Bamigbala (2001), clays are categorized into different forms according to how well they satisfy the user's needs. These include red earthy wave clays, stone-wave clays, ball clays, and kaolin. Clays are also categorized according to their color and availability; as a result, there are red, gray, white, and yellow clays (Bamigbala, 2001). The varied colors of clays were caused by variations in their mineral compositions, including kaolinite, montmorillonite, illite, chlorite, and attapulgite.

An experimental study carried out by Ojo et al (2009) used the Lee's Disc apparatus to assess the thermal conductivity of clay samples in a tropical climate. The findings are represented in Table 1. This was done to improve the clay's characterization parameters for a range of building applications.

Table 1: The Cooling temperature with time of disc A for clay samples

Yellow	Red	Gray	White	Time (second)
83.0	92.0	110.0	99.0	0.0
72.0	84.0	106.0	96.0	30.0
65.0	79.0	105.0	94.0	60.0
57.0	77.0	103.0	93.0	90.0
50.0	75.0	101.0	92.0	120.0
46.0	73.0	100.0	91.0	150.0

Source: Adapted from Ojo et al. (2009)

Table 2: The Calculated thermal conductivity for different clay samples

Samples	Thermal conductivity ($Wm^{-10}C^{-1}$)
Red	3.82×10^{-2}
Yellow	1.08×10^{-1}
Grey	1.457×10^{-1}
White	7.05×10^{-2}

Source: Adapted from Ojo et al. (2009)

The gray clay sample has a high conductivity value, as seen in Table 2. As a result, it can withstand compressional stress to a fair degree. Additionally, the results showed that the samples' resistivity values were extremely low, indicating that very little current passes through them. Consequently, structures built using any of these samples in tropical climates will not experience significant current during the rainy season. A good clay material should be able to withstand compressional forces to a tolerable degree (Owate and Edike, 1996). Furthermore, clay materials for tropical constructions should possess a comparatively high electrical resistance. The gray clay sample was found to have these qualities based on the aforementioned deductions, and it was recommended that it be utilized as a local building material. Additionally, in situations where heat conductivity is a secondary factor, red clay samples are recommended for use in the manufacturing

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
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of structural tiles, pipelines, roof tiles, interior floors, etc.

Building materials made of clay earth are solid, healthful, and provide thermal protection. Structures constructed with earth-building materials can thus have a lifespan of more than a century. Additionally, they have less encapsulated carbon than certain other structural materials, making them less hazardous and requiring less maintenance in the current system of structures. Similarly, clay contributes significantly to energy reserve funds and stores heat during the colder months and coolness during the late spring. Low energy is needed for preparedness and handling, and working with clay is harmless to the ecosystem in the assembled climate. Clay bricks are known for their exceptional thermal insulation qualities, which help create a home that stays warm in the winter and cool in the summer (Desi, 2011). It is against this background that this study seeks to determine the advantages and protections of using clay as a building material with a view to ascertain the problems of using clay as an affordable building material; identify the factors impeding clay's adoption as a sustainable building material and eventually create an angles that enhances the usage of clay as a cost-effective building material.

2.0 Literature Review

Properties of Clay as a Building Material

Clay's qualities as a building material include strength, fire resistance, durability, acoustic protection, dimensional accuracy, and natural cordialness. According to Hebert and Chaney (2011), clay is a solid breathing building material that enhances the surrounding air while maintaining and supplying stickiness in general. These results in a sound room environment with a usually controlled amount of wetness. In actuality, non-consumed blocks can absorb several times as much moisture as consumed blocks in a two-day period when the overall stickiness increases from half to 80% (Abdurrahman, 2010). In the winter, clay buildings retain heat, while in the late spring, they retain coolness. Planning and working with clay building materials will therefore make a substantial contribution to the energy reserve funds. It is safe for the environment to operate with clay earth when low energy is required for clay ready, preparation, and utilization.

Abidin (2010) stated that the world uses just around 1% of the energy needed to make bricks. Convenience becomes more and more necessary as the world's population grows. Many people have comfortable, safe, and sound homes owing to the strength,

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
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moderateness, and durability of clay bricks, blocks, rooftop tiles, and pavers. Additionally, they combine innovative and forward-thinking development tactics with traditional design heritage. To sum up, clay earth products provide significant solutions for energy conservation and reducing emissions of substances that damage the ozone layer in the environment. Among its many qualities is its ability to retain and store heat from the sun, which enables clay blocks to support even loads, such as those caused by earthquakes. Nevertheless, it should be constructed in areas with significant seismic disturbing affects and offers indisputable levels of security against intruders. In the event of a fire, the water overflow can be collected and stored, while clay tiles are dormant materials that do not burn and do not emit harmful gasses.

Element Influencing the Usage of Clay

In order to address global convenience in offices, homes, and other establishments, building designers are increasingly using clay as a practical building material. Additionally, clay is a necessary component used in many construction processes. Clay is used in the manufacturing of adobe, cob, string wood, shattered earth designs, and building materials such as clay mortar, clay floor tiles, clay paints, and clay pottery (clay-wienerberger.com). Since the beginning of human history, clay has been used as a building material. Blocks, burned bricks, tiles, cleaning supplies, and roofing materials are all made from clay soil that has been dating back. China clay, primarily kaolinite, is used in medication fabrication and as filler. Extended clays are used as a lightweight material to create extended squares that are used for environmental protection. The segments of the accompanying architectural structures were assembled using clay (Umaru et al 2012).

i. Clay material and floor tiles:

It provides substantial solutions for energy reserve funds and reduces emissions of substances that damage the ozone layer in the environment. Often referred to as earthenware or porcelain tiles, clay floor tiles are made by combining mud clay as a common fixing, finishing them in an oven, and then solidifying them. When mud floor tiles are coated, their surface becomes water-safe and they take on a variety of colors.

ii. Heat Sinks and Stacks:

The purpose of warmth sinks is to remove heat from specific areas in order to prevent overheating. Mud floors are occasionally used as warmth sinks, removing heat from stoves, furnaces, and other devices to prevent damage because soil is heat safe and can transfer heat. Because of their unity, the virtue of clay,

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
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and their ability to bear extreme heat, it was more common for the entire chimney stack to be made of clay blocks. Most smokestacks are made of dirt blocks up to the rooftop level, and then the stack is polished off with red blocks because ball clay is so versatile, functional, and strong in the event of a fire, it is used as a raw material for sterile items, emergency clinics, and toilet tiles.

iii. Plasters and Rendering:

For millennia, clay mortars have been widely used for construction in the Assembled Realm and undoubtedly all over the world. Despite the lack of widespread awareness, the Assembled Realm is probably home to more than 1,000,000 earth-based constructions, many of which include mud mortars. The fact that clay mortars are painted or have a thin layer of lime clay applied to them, both internally and externally, is always not taken into consideration. Even after hundreds of years, many mud mortars continue to function well in both traditional buildings and upscale estates, where they were used for intricate protections, moldings, and other purposes. For a variety of reasons, including breathability, adaptability, reversibility, and aesthetic qualities, clay mortars have distinctive and, from different angles, exceptional qualities that make them highly suitable for notable structural situations (Su W et al, 2010).

iv. Clay as a Binder:

Clay is frequently used in construction as binders, as well as for castles, civic and religious structures, and monuments like China's long great wall and Yemen's 35-meter-tall Tarim minaret. Wall binders are made of clay. They are unquestionably the least expensive binders at sites, notwithstanding the drawback that they weaken when wetted (Berger et al, 2011).

Properties of Clay for Environmental Protection

According to Lake (2012), clay construction materials are environmentally friendly and meet many government grading and green building requirements. Clay's large thermal mass also contributes to its superior insulating qualities. The interior of the building is kept warmer in the winter and cooler in the summer because to its excellent heat absorption and release capabilities. In addition to lowering energy consumption and related carbon emissions, this improves the comfort of the interior environment (Kefas et al, 2007). Clay's three key characteristics—plasticity, porosity, and verification—set it apart from other building materials.

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
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Protection aspects provided by Clay components in Buildings

In developing nations, particularly those in tropical regions, people are generally becoming aware of the advantages of using clay for construction. These advantages include the ability to warm rooms in the winter and cool them in the summer, the fact that clay is readily available in most places, and the low cost of extracting, processing, and producing building materials like bricks, blocks, tiles, pipes, and sanitary appliances. Another advantage is that adding color additives can result in improved qualities and aesthetics. In order to investigate the feasibility and essential characteristics of clay blocks for building protection in the built environment, clay material was employed as the primary instrument in this study.

As previously mentioned, the methodology used in this study is a mixed methods approach that uses questionnaires and interview questions to gather data from appropriate respondents in the built environment, academicians, and the construction industry. The methods used in this study include both qualitative and quantitative data collections. Similarly, clay's substantial thermal mass gives it excellent protective qualities. The building's interior becomes hotter in the winter and cooler in the summer due to its effective heat delivery and store retention. In addition to reducing energy interest and associated fossil fuel byproducts, this improves the indoor environment (Kefas et al, 2007). Versatility, porosity, and confirmation are the three basic characteristics of clay that set it apart from other building materials.

3.0 Methodology

A blended research technique was adopted for this research study. The techniques incorporate a review of previous works in the area, subjective inquiry (questions), observations and quantitative research strategies.

4.0 Results and Discussion

Tables 3 and 4 show the outcome of the interview questions for qualitative data. Ten (10) respondents were interrogated of whom are architects, artist, builders and civil engineers (4 are Architects, 3 are Civil engineers, 2 are Artists and a Builder). The professionals have 5 to 15 years' experience in the construction industry. The respondents have a wide experience in various types of projects that involved the use of clay materials.

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
ISSN: 2736-0814

Table 3: Respondents Background

Respondents	Qualification of Respondents	Professional Body	Type of Projects	Years of Experience
Respondent 1	Architect	ACRON/ NIA	Building Works	5
Respondent 2	Architect	ACRON	Building Works	5
Respondent 3	Artist	NAEA	Sculpture &Craft works	6
Respondent 4	Architect	ACRON	Building Works	7
Respondent 5	Civil Engineer	CORREN	Building & Roads	15
Respondent 6	Builder	NIOB	Building Works	6
Respondent 7	Civil Engineer	-	Building & Roads	4
Respondent 8	Artist	NAEA	Sculpture &Craft works	9
Respondent 9	Civil Engineer	CORREN	Building & Roads	10
Respondent10	Architect	ACRON/ NIA	Building Works	11

Source: Author's field survey 2024

Table 4: Respondents Perception for Utilization of clay blocks as a building material.

1 Familiar with characteristics of clay	Respondents
Very familiar	7
Familiar	2
Not familiar	1
2 Used in the past and present projects	**Respondents**
Strongly used	3
Moderately used	5
Not used	2
3 Percentage of incorporating clay in projects	**Respondents**
60% - 90%	3
25% - 80%	2
20% - 30%	4
3% - 8%	1
4 Percentage of clay products used in most projects	**Respondents**
70% - 90%	3
60% - 80%	5
25% - 70%	1
20% - 30%	1

Source: Author's field survey 2024

The result above shows the response of various professionals in the built environment and the frequency of utilization of clay in their various projects.

5.0 Conclusion and Recommendations

In order to promote sustainability in the built environment, this study examined the qualities, benefits, and advantages of clay as well as its application as a building material. Red clay sample is

Ilaro Journal of Environmental Research & Development (2025) 7 (1), 71– 78
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recommended for use in the production of structural tiles, pipes, roof tiles, interior floors, etc., in situations where heat conductivity is of secondary importance. Gray clay sample has certain qualities that make it more appropriate as a building material for local building construction in the tropics. From this study, the white clay sample has the lowest thermal conductivity and emissive power, while the gray clay sample has the highest. In light of these findings, the study concludes that clay's cost gives customers greater value and benefits in built environments. In view this, the study recommends that in non-industrial countries, governments, partners, non-administrative associations, and scientists should adopt and develop a comprehensive programme that can enhance the use of clay objects, particularly in urban and provincial areas. Additionally, the study recommends further research that will enhance social, economic, and environmental supportability aspects of clay buildings.

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