European Journal of Applied Sciences – Vol. 12, No. 06
Publication Date: December 25, 2024
DOI:10.14738/aivp.1206.18094.
Akeke, G. A., Ewa, D. E., Takim, S. A., & Enang, A. E. (2024). Enhancing Access to Affordable Housing Through the Improved Mechanical and Durability Properties of Mud-Crete Blocks. European Journal of Applied Sciences, Vol - 12(06). 811-823.

Enhancing Access to Affordable Housing Through the Improved Mechanical and Durability Properties of Mud-Crete Blocks

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ABSTRACT

The results of an experimental study using cement, rice husk ash (RHA), sand, and laterite as constituents to create solid mud-Crete blocks' mechanical and durability characteristics are presented in this work. RHA and laterite partially replaced cement and sand respectively in percentages of 10, 20 and 30%. Grade 32.5 Portland Limestone Superset cement was used and the experimental procedure carried out on the blocks included compressive strength, water absorption and fire resistance tests. Curing was by sprinkling and the results showed that at 7 days curing time the average compressive strengths recorded were 2.97N/mm^2 for the control mix, and 2.65N/mm^2, 1.72N/mm^2 and 1.09N/mm^2 for 10, 20 and 30% replacements, and after 28 days curing 3.01N/mm^2, 2.92 N/mm^2 1.93N/mm^2 and 1.31N/mm^2. 7.12%, 8.10%, 8.52% and 8.78% were recorded as average values for water absorption after 28 days of curing for the control mix and the replacements at 10, 20 and 30% respectively. The fire resistance test showed that the specimen had integrity for 8hrs, 6hrs 18mins, 5hrs 6mins and 3hrs 19mins approximately for the control batch, 10%, 20% and 30% replacements respectively.

Keywords: mud-Crete, block, Strength, durability, shelter.

INTRODUCTION

Access to affordable and sustainable housing remains a significant challenge globally, particularly in low-income and developing regions. The housing shortage is exacerbated by the high cost of traditional building materials like burned bricks and concrete. As a sustainable alternative, mud-Crete (a combination of stabilized mud and cement) has gained attention for its potential to provide cost-effective and durable shelter solutions. This literature review explores advancements in the mechanical and durability properties of mud-Crete blocks and their implications for enhancing accessibility to affordable housing. To overcome this limitation, housing must be made accessible and inexpensive for the general public. Nigeria's successive administrations have paid special attention to the lack of cheap housing and its high cost, and they have created a variety of initiatives to increase housing accessibility for the general people. In an attempt to address the housing crisis, the Nigerian government started constructing affordable homes for laborers and low-income workers, as well as setting up industries to generate locally produced building materials. Many nations throughout the world have stressed the need for locally produced building materials, and there is a disparity between the price of traditional building materials and their depletion. [1]. He claimed that by keeping an eye out for inexpensive substitute building supplies, this predicament may be resolved. Nigeria's past and present administrations have developed a number of programs to address the housing issues that the nation's residents confront, but none of them have yet to produce fruitful, tangible outcomes. There is no benefit, stating that the rising cost of housing makes it unaffordable for those with low incomes. This is hardly surprising given how quickly building materials like cement, roofing sheets, sanitary fixtures, planks, blocks, etc. are becoming more and more expensive every day. The soaring cost of cement significantly influences the expense of producing building blocks. These blocks, being essential structural elements of a building, represent a substantial portion of the overall construction budget. According to [2], the primary challenge facing the construction sector in developing countries is the high cost of building materials, many of which rely on imports. Despite this, housing designs aimed at low-income groups often overlook their financial constraints, as these designs are frequently tailored to appeal to wealthier individuals, leaving the economically disadvantaged excluded. Consequently, low-income earners and peasants are seeking more affordable alternatives for obtaining construction materials within their budget. One such method, according to landlords and property developers surveyed in Ogun State's Idiroko area, is to employ 100mm and 125mm strong sand Crete blocks for manufacture.

According to [3], sand Crete blocks are formed or molded using sand, water, and binder-containing cements and defined Sand Crete blocks as comprising of sand, water and binder, an Evaluation of the Solid Sand Crete Blocks' Compressive Strength -The costliest component in the creation of sand-Crete blocks in the Idiroko Area of Nigeria is cement, which is used as a binder. They also confirmed that in order to make their products profitable and accessible to the general public, manufacturers of Sand Crete blocks use less Ordinary Portland Cement (OPC) in their production. They believe that in order to reduce the cost of construction, the general public has come to tolerate these subpar blocks because to the high rate of poverty in West African nations, especially Nigeria. Blocks made of sand Crete have long been used in various countries, including Nigeria [4]. A mixture of sand, cement, and water is used to make Hollow Sand Crete blocks, which are widely used across the world, particularly in Africa. Sand Crete blocks are one of the main expenses of the most typical buildings in various parts of Nigeria [5]. Because of its naturally low compressive strength, it is vulnerable to seismic action. [6] claims that previous studies by other researchers have shown disappointing production results of commercial sand Crete blocks, with compressive strength significantly lower than specified strength for building. Blocks made of Sand Crete can be categorized as solid, hollow, or cellular. These days, sand Crete skin panels and blocks are utilized to improve a building's appearance as well as to limit wind and moisture intrusion [7]. Sand Crete block is defined by the Nigerian Business Preferred as a composite material molded into various sizes using cement, sand, and water. Sand Crete blocks are construction materials that are generally made of ordinary Portland cement, water from streams or boreholes, and sharp sand that has been collected from rivers or streams. The ingredients are combined in the right amounts and molded into the required shapes and sizes [8]. The most typical sizes of Sand Crete blocks are 450mm × 225mm × 225mm and 450mm × 150mm × 225mm. The blocks can be hollow or solid [9]. According to [9], the NIS specifically recognizes two types of blocks: load-bearing type A blocks and non-load-bearing type B blocks. They can both be hollow or solid. Comparing Sand Crete bricks to other materials reveals how inexpensive they are. They offer exceptional resistance to harm without requiring the additional cost of protective devices. They no longer use any environmentally hazardous fabric in their products. Sand Crete blocks don't rust, degrade, or harbor undesirable insects like other building materials can. Sand Crete blocks are widely accepted in many construction structures due to their usefulness and adaptability to various climatic conditions. This is especially true in nations with tropical rainforests that experience high temperatures and precipitation [10]. Again, in the works of [11], varieties of sand Crete blocks are distinctive by NIS, type A (load bearing blocks), and Type B (non-load bearing blocks), and that there are 4 fundamental households of blocks; are solid blocks, hole blocks, perforated blocks, interlocking blocks. About ninety% of buildings constructed in West Africa are constructed with sand Crete blocks, making them important constructing material [12]. After curing, sand Crete block has a relative high compressive strength; variety of minimum power laid out in NIS 87:2007 is among 2.5N/mm2 to 3.45N/mm2, which accelerated with increase in density [13] Sand Crete blocks are produced in lots of parts of Nigeria without reference to any global or countrywide specs, sand Crete blocks are enormously cheap when in comparison to different construction materials. In addition, they've higher resistance to rusting, insect and pest assault, crumbling, and are nonhazardous whilst as compared with different constructing substances [14]

The frequent collapses of buildings in Nigeria, along with the resulting deaths and destruction of homes, have become a great concern. A subpar and outmoded building material, notably sand Crete blocks, was one of the many explanations given for these disasters [15] One very important feature of blocks is their compressive electricity, which is a measurement of how resistant they are to load software when they are in the crushing mechanism. The quality, grading, and density of fine aggregates/sand, curing conditions, satisfactory manage, vibration time, amount of water used, cement-sand blend ratios, hollow space extent, center-web to stop-web ratio, and the type and grade of cement are found to affect the energy of hollow sand Crete blocks [16]. According to [17], the compressive electricity is defined as the average compressive energy of five blocks and, for machine-vibrated blocks, cannot be less than 3.45N/mm2 for load-bearing walls and 0.5N/mm2 for non-load-bearing walls. For hand-compacted blocks, it cannot be less than 2.45N/mm2 for load-bearing partitions and 1.8 N/mm2 for non-load-bearing walls.

Blocks are defined by [18] as Mansory units of big length in all dimensions, except for bricks, but no dimension may be greater than 650 mm, nor may the height exceed the length or six times the thickness of the block. The sizes of the sand Crete blocks vary: they are 225 mm, 150 mm, 125 mm, and 10 mm, in that order. In Nigeria, sand Crete blocks are used in the construction of almost 90% of the country's physical infrastructure [19]. For institutional and commercial properties, they are highly sought-after as an affordable and durable remodeling option [20]. In many parts of the United States of America (Nigeria), sand Crete blocks are produced without regard to neighborhood construction codes or correct shape and satisfactory work. It has been established that throughout the past ten years, the inclusion of mineral admixtures in manufacturing materials has significantly improved their workability, strength, and durability [21]. In an attempt to enhance the aesthetics of the production process and superior materials in 2000, the Old Business Enterprise of Nigeria (SON) presented a guideline that outlined the basic requirements and utilized several designs of sand Crete blocks [22]. The records were evaluated in 2004, and as a result, NIS 87:2004 - general for sand Crete blocks became the industry standard for sand Crete in the United States. Following additional examination, NIS 87:2007 recommended for sand Crete block became the accepted reference report for sand Crete block production in Nigeria. Sand Crete blocks come in two popular sizes: 450mm × 225mm × 225mm and 450mm × 150mm × 225mm. They can be hollow or stable rectangular shapes. The degree of acceptable control used has an impact on compressive strength. According to [23], among other factors, the compressive strength of sand Crete blocks can be affected by a great selection of materials and an appropriate curing procedure. According to [24], if sufficient energy is required, blocks must be allowed to grow for at least 28 days (by means of curing them) before they are laid demonstrating advancements in material selection and curing techniques as a means of improving the extraordinary performance of sand Crete blocks.

One major problem with producing sand Crete hollow blocks is that their tested compressive electricity did not match the required standards, even when they were made with the help of the largest commercial block building enterprises [25]. The majority of the blocks made by commercial block-making companies in Nigeria had 28-day dry strengths ranging from 0.50 to 1.05 N/mm2, according to research on the evaluation of block quality. The cost-effective production of inferior sand Crete hole blocks was justified by a number of factors. Inadequate curing, poor craftsmanship, and a negative cement to sand mix ratio had been the main causes [26]. Thus, the goal of this study is to perform well-conducted experimental investigations into the mechanical houses of mud Crete blocks made from readily available domestic materials in order to reduce building costs.

Affordable Housing and Sustainable Building Materials

The demand for low-cost and sustainable building materials is increasing, driven by rapid urbanization and population growth [27]. Conventional construction materials like cement, steel, and fired bricks are resource-intensive and contribute significantly to environmental degradation [28. The adoption of alternative materials such as mud-Crete, which utilizes locally available soil stabilized with minimal cement, offers a promising solution to this problem [29]. Mud-Crete blocks can be produced using simple and low-energy techniques, making them ideal for rural and peri-urban areas where infrastructure and resources are limited [30]. Their affordability and sustainability are critical to addressing the housing deficit in economically disadvantaged regions.

Durability Properties of Mud-Crete Blocks

The long-term durability of mud-Crete blocks is critical for their adoption in affordable housing projects. Durability is affected by moisture content, exposure to weathering, and resistance to erosion. Cement stabilization significantly improves water resistance and durability, as shown in studies by [31]. Mud-Crete blocks stabilized with cement exhibit lower water absorption rates, reducing their vulnerability to weathering and erosion. Moreover, proper curing methods, such as water curing and controlled drying, enhance the durability of the blocks [32]. Recent studies have explored the use of additives such as fly ash, rice husk ash, and waste plastic fibers to improve durability. For instance, [33] showed that the inclusion of fly ash reduces water permeability and enhances the durability of soil blocks.

Environmental and Economic Implications

One of the primary advantages of mud-Crete blocks is their minimal environmental impact compared to conventional building materials. The production of stabilized soil blocks requires lower energy inputs and generates fewer carbon emissions [24] Additionally, the use of local soil reduces transportation costs, further enhancing affordability [25]. Economic assessments have shown that mud-Crete blocks are 30-50% cheaper than conventional fired bricks or concrete blocks, depending on the availability of raw materials [26] This cost-effectiveness makes them a viable solution for affordable housing projects in developing economies.

Challenges and Future Directions

Despite their benefits, mud-Crete blocks face challenges related to standardization, acceptance, and quality control. Variability in soil properties and the need for skilled labor in stabilization processes can hinder large-scale adoption [27]. Further research is needed to develop standardized guidelines for soil selection, stabilization, and testing.

Advancements in material science, such as the use of nanotechnology and bio-stabilizers, offer new opportunities for improving the mechanical and durability properties of mud-Crete blocks. Future studies should focus on optimizing stabilizer content, reducing production costs, and improving the long-term performance of these blocks.

MATERIALS AND METHODS

Materials

Cement:

The cement type used was the Dangote Superset of grade 32.5

Laterite:
The laterite was gotten from Cross River State Nigeria, with its characteristic red pigmentation.

RHA:
Rice Husk Ash from Obubra Local Government Area of Cross River State, Nigeria, was used for the research work.

Fine Aggregate:
Sand was gotten from the Adiabo beach of the Calabar river, Cross River State, Nigeria.

It was sharp, clean and without dirt and other deleterious materials.

Water:
The water used for the research was free from salt and other deleterious materials

Mold:
Size of mould used was 112.5mm width x 225mm height x 450mm length.

Methods

Using a calibrated container, the quantities were measured in volume according to the predetermined percentages.

First a control mix was done with 100% of cement and sand and no injection of laterite or RHA.

Subsequently, there was replacement of cement and sand with RHA and laterite respectively to 10, 20, and 30%. Mix ratio and water cement ratio adopted were 1:6 and 0.45 respectively.

Laboratory Tests
Both the blocks and the aggregates were subjected to tests. Among the tests carried out are:

Classification:
This was carried out on the block's laterite and sand components. Before the real check was performed, the samples were let out to dry in the sun for a whole day. 200g of the samples were weighed, then loaded into the sieve apertures and subjected to a 5-minute intense vibration period. The proportion of the samples that passed through the sieve sets was calculated by measuring and recording the mass of the samples that were retained in each sieve.

***Sand Crete Blocks Test*:**
Compressive Test:
The blocks obtained from the mixes were labelled and weighed in their dry states and recorded. The compressive tests on the blocks were carried out for early strength at 7 days and also at 28 days of curing. The block's dimensions match the measured and documented inside measurements of the Mold. The sand Crete block's compressive strength was measured using a motorized Concrete Compression Testing Machine in compliance with NIS-87, 2004. The experiments were run after seven and twenty-eight days of melding. Each block was attached to the machine's compression cell and steadily compressed during the testing procedure until failure happened.

The machine recorded the compressive force at the conclusion of each test, and the block's compressive strength was computed. The crushing load was divided by the block's effective surface area to determine the mud Crete blocks' compressive strength.

$$Comp.strength = \frac{Crushing\ load}{Effective\ area} N/mm^2 \quad (1)$$

- One important criterion for determining the quality of mudcrete or sandcrete blocks is the water absorption test. To determine the percentage of water absorption capacity, each block sample with its dry weight previously recorded was submerged in clean water for a full day before being weighed again for the wet weight, as shown.

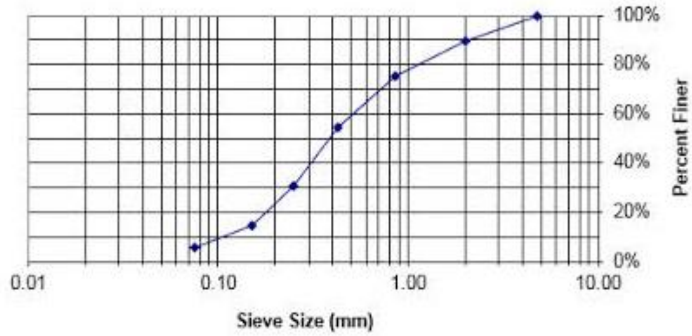
$$Wr = (WW - WD)\ WD \times 100\% \text{ ----} \quad (2)$$

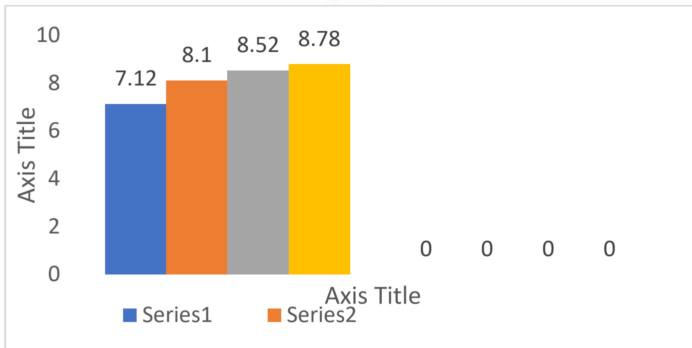
Where: the weight of the wet block after 24 hours in water is WW, and the weight of the dry block is WD. Wr is the capacity for absorbing water.

RESULTS AND DISCUSSION

Absorption of Water

The amount of water that a block absorbs in a given 24-hour period in cold water is known as water absorption. NIS 87:2004 was followed while conducting this exam. The test's outcome is displayed in Figure 1. The amounts of water absorbed by the blocks are within the limit specified by the code (absorbed water shall not exceed 12% of the dry mass). An average of 7.12% was recorded for the control samples; 8.1% for 10% replacement each of sand and cement; 8.52% for 20% replacement and 8.78% for 30% replacement. Knowing the water absorption rate is crucial to understanding how the block will function in damp or moist conditions. Thus, the outcome demonstrates that mud Crete block made with laterite and RHA variants as partial replacements for sand and cement do not fare well with increasing amounts of the variants as far as water absorption in concerned. It is depicted in the histogram below as a steady increase in the water absorption with increase in the laterite and RHA components of the research concrete after 24 hours of curing.





Particle Size Distribution:

The sand fine aggregate component used for the research was tested for particle size distribution and the results are as tabulated in Table 1. It shows a uniform blend of particle sizes that falls into zone 2 of the BS 882 (BS882, 1983). Hence the fine aggregate is suitable for making sand Crete blocks. depicts sharp sand.

Table 1: Sieve analysis table

Sieve No.	Sieve Size (mm)	Mass retained (g)	% Mass retained (g)	% Cumulative	% Passing
4	4.75	0.0	0.0	0.0	100
10	2.0	41.2	10.7	10.7	89.3
20	0.85	55.1	14.3	25.0	75.3
40	0.425	80.0	20.8	45.8	54.3
60	0.250	91.6	23.8	69.6	30.5
100	0.150	60.5	15.7	85.3	14.8
200	0.075	35.6	9.2	94.5	5.6
Pan	-	21.5	5.6	100.1	0.0

Compressive Strength Test:

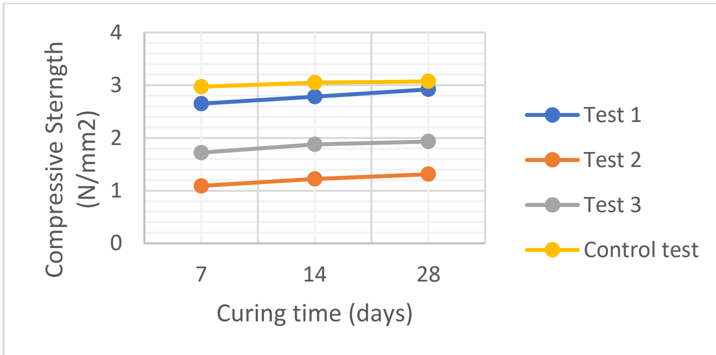
Table 2, summarizes the compressive strength test findings for the mud Crete blocks at 7, 14, and 28 days of curing for the various replacement percentages. NIS 87:2004 states that load-bearing hollow blocks have an average minimum compressive strength of 2.5 N/mm2 for machine compaction. Because of this, a few of the samples met the requirements.

Table 2: Compressive strength results

Curing Time	Compressive strength (N/mm^2)			
	CONTROL	T1	T2	T3

7 days	2.97	2.65	1.72	1.09
14 days	3.05	2.78	1.88	1.22
28 days	3.07	2.92	1.93	1.31

The trend of the outcome of results show that compressive strength of the blocks improve with maturity in curing time



Fire Resistance:
Two of the sample blocks left to cure for 28 days were subjected to heating in order to find out its resistance and durability in the circumstance of a fire incident. The result showed that the specimen had integrity for 8hrs, 6hrs 18mins, 5hrs 6mins and 3hrs 19mins approximately for the control batch, 10%, 20% and 30% replacements respectively, meaning that with the injection of RHA and laterite the blocks become less durable under heating.

CONCLUSION

The study on the mechanical and durability properties of mud-Crete blocks highlights their potential as a sustainable and cost-effective solution for affordable housing. By leveraging locally available materials such as soil, cement, and water, mud-Crete blocks provide a viable alternative to conventional construction materials, significantly reducing production costs and environmental impact. The findings demonstrate that mud-Crete blocks possess adequate strength, durability, and resilience to meet the demands of low-cost housing projects in various climatic conditions. Their adaptability in design and ease of manufacturing further enhance their utility for addressing the global housing crisis. Adoption of this innovative material could bridge the gap in accessibility to affordable shelter, particularly in resource-constrained communities, while promoting eco-friendly construction practices. In conclusion, mud-Crete technology represents a transformative approach to improving housing affordability and sustainability, offering a scalable solution to meet the growing demand for safe, durable, and economical shelters worldwide.

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