Asian Journal of Applied Science and Technology (AJAST)
Volume 8, Issue 4, Pages 53-59, Oct-Dec 2024

Exploratory Analysis of the Compressive Strength of Moulded Clay Bricks

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DOI: https://doi.org/10.38177/ajast.2024.8406

Article Received: 03 September 2024 Article Accepted: 11 November 2024 Article Published: 19 November 2024

ABSTRACT

Sandcrete bricks are made up of sand, cement, and water. This study presents an analysis of the compressive strength development of moulded sandcrete (clay-bricks) over a curing period of 35 days. The objective is to evaluate the structural performance of these materials and determine their suitability for construction applications. Compressive strength tests were conducted at 7, 14, 21, 28, and 35 days. The results demonstrated a continuous increase in compressive strength as curing time progressed. At 7 days, the compressive strength was measured at 1.01 N/mm². By 14 days, the strength increased to 1.44 N/mm², marking a 42.6% improvement. At 21 days, the compressive strength reached 2.53 N/mm², a significant increase of 75.7% from the 14-day mark. The strength rose to 3.29 N/mm² at 28 days, a 30.0% gain, and to 3.95 N/mm² at 35 days, showing a 20.1% improvement. The results showed that the moulded bricks' compression increases dramatically with curing time, qualifying them for use in low- to medium-load bearing structures. This study emphasizes how crucial it is to allow enough curing time to maximize the mechanical qualities of locally made construction materials. As a result, the generated bricks can be used to construct fencing, walls, etc.

Keywords: Exploratory; Development; Moulded; Bricks; Compressive strength; Clay; Sandcrete; Mechanical; Performance; Construction.

1. Introduction

For many years, the construction industry has depended on conventional materials like sandcrete to build vital structures, especially in areas where material availability and cost-effectiveness are crucial. Many low-rise residential and commercial buildings are constructed using blocks and bricks made from sandcrete, a composite material mostly made of sand, cement, and water. Although sandcrete has many benefits, including low cost, ease of manufacture, and good thermal insulation, its mechanical qualities—especially its compressive strength—are what really matter when it comes to how well-suited it is for different construction uses.

In terms of their compressive strength, researchers have experimented with the development and characteristics of sandcrete bricks. Raheem & Adeniyi [1] looked into the impacts of adding pozzolanic elements to sandcrete mixes, such as fly ash and rice husk ash. The outcomes demonstrate that these substances can raise the sandcrete bricks' compressive strength and longevity, particularly during the latter curing phases. Edeh & Achuenu [2] used response surface methods to optimize the design of sandcrete block mixes for optimal compressive strength. After testing several mix ratios and curing durations, a predictive model was developed to determine how to get the best outcomes. The impact of sand grading on the compressive strength of sandcrete blocks was studied by Olusola & Umoh [3]. After analyzing the grades of fine, medium, and coarse sand, the study came to the conclusion that medium-graded sand offered the best combination of workability and strength. The compression of the sandcrete blocks manufactured with various types of cement, such as blended cements and Ordinary Portland Cement (OPC), was compared by Ogunbode & Ayeni [4]. The study reveals that while blended cement blocks initially exhibited a slightly lower strength, they eventually displayed increased durability. Olutoge et al. [5] investigated the use of rice husk ash (RHA) in substitution of some of the cement in sandcrete bricks. They found that using RHA up to 20% in place of cement resulted in bricks with a lower carbon footprint, better resilience to chemical assault, and compressive strength on par with conventional sandcrete bricks. Bamigboye & Adesanya [6] looked into how the strength and longevity of sandcrete blocks were affected by the water-to-cement ratio. It demonstrated the link between the compressive strength of sandcrete blocks and the water-cement ratio, stressing the significance of regulating the ratio to obtain maximum strength and minimum porosity. Emekwisia et al. [7] conducted a research which demonstrated a clear relationship between curing time and the compressive strength of sandcrete bricks. It confirms that curing duration significantly impacts the compressive strength of sandcrete bricks. The data indicates that the compressive strength of the sandcrete bricks increases significantly with extended curing periods, especially between 7 and 21 days. Agbede & Manasseh [8] investigated the impact of partially substituting cement in sandcrete blocks with limestone powder. The results show that adding limestone powder to sandcrete blocks increases their compressive strength and decreases their drying shrinkage. Usman & Idris [9] examined the effects of temperature and humidity on the development of sandcrete block strength throughout the curing phase. Controlled curing conditions have been shown to greatly improve compressive strength. Abdullahi [10] analysed the process of making sandcrete blocks using recycled concrete aggregates. The findings showed that although it might have a slightly lower initial compressive strength than traditional sandcrete, it performs similarly over the long run, making it a sustainable substitute. Ogunbode et al. [11] studied the impacts of using volcanic ash as a pozzolanic ingredient in the production of sandcrete bricks. The outcomes demonstrated that volcanic ash could effectively substitute up to 30% of cement, increasing compressive strength and resistance to sulfate attack. Raheem et al. [12] looked into sawdust as a potential partial sand replacement in sandcrete bricks. Their findings suggest that replacing sawdust by up to 10% could improve the bricks' resistance to heat without significantly impairing their structural integrity. This research therefore aimed at developing clay bricks in order to analyse the effect of various curing periods on the compressive strength.

1.1. Study Objectives

The objectives of this study include: (1) To analyze the compressive strength development of sandcrete bricks over a curing period of 35 days, (2) To investigate the percentage increase in compressive strength at various curing intervals, (3) To determine the suitability of sandcrete bricks for construction applications, (4) To assess the potential of locally produced sandcrete bricks for low- to medium-load bearing structures, (5) To highlight the importance of adequate curing time for optimizing the mechanical properties of sandcrete bricks, and (6) To contribute to sustainable construction practices by promoting the use of locally made materials.

2. Materials and Methods

2.1. Materials

(a) Sand: This sand was produced by natural disintegration of rocks, and is referred to as natural sand. It can also be got from crushing a yard stone or rock, which is also known as crushed stone. The sand used for this work was clean and free from loam, dirt, organic matter.

(b) Cement: The type I ordinary Portland cement, which is classed as general cement for all- purpose application by ASTM C150, was the cement utilized.

(c) Water: The water was pure and devoid of anything that may hurt living things.

Steel rule, digital weighing scale, and compressive strength test machine were other additional materials used for this research.

2.2. Methods

2.2.1. Mixing proportion

The calculation was done using the ratio of 1:6 = 7

Where 1 = The proportion of cement (that is, one bag of cement), and 6 = The total mass of (that is, six wheel barrow full of sand). The measured weight of the sample (i.e. cement + sand) = 820g.

From the ratio above:

Mass of cement, C = 117.1g; Mass of sand = 820g - 177.1g = 702.9g

For 5% clay addition; Mass of clay used = 2.9g = 35.2g; Mass of sand used = 702.9 - 35.2 = 667.7g

For 10% clay addition; Mass of clay used = g = 70.29g; Mass of sand used = 702.9 - 70.29 = 632.61g

For 15% clay addition; Mass of clay used = g = 105.4g; Mass of sand used = 702.9 - 105.4 = 597.5g

For 20% clay addition, Mass of clay used = g = 140.58g; Mass of sand used = 702.9 - 140.58 = 562.32g

For 25% clay addition; Mass of clay used = 175.73g; Mass of sand used = 702.9 - 175.73= 527.17g

For the control sample; This was done without the clay, hence the Mass of sand = 702.9g; Mass of cement = 117.lg

2.2.2. Mixing Procedures

A shovel was used to hand mix the components in the different ratios mentioned above, and they were turned repeatedly until the desired color and consistency were achieved. The mixture was further blended after a small amount of water was sprayed over it to guarantee homogeneity and high workability (Emekwisia et al. [13]).

2.2.3. Moulding

A 75 mm × 75 mm mold was utilized to manually mold the mixed composites employed in this experiment. The blocks were meticulously placed on wooden pallets with gaps between them after being repeatedly rammed with a wooden ram to create compaction. The ram's surface was then polished off.

2.2.4. Curing

Water was sprayed on the bricks for the first three days after they were manufactured. This was done in an attempt to increase the blocks' maximal strength and lessen their brittleness.

2.3. Compressive Strength Test

The purpose of the compressive strength test was to ascertain the strength of the mold-formed brick samples. The samples were analyzed at intervals of 7, 14, 21, 28, and 35 days since the block samples' maximum strength was attained on day 35. A computerized weighing balance was used to record the cubes' weights during the test, and

Asian Journal of Applied Science and Technology (AJAST)
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their dimensions were measured and recorded to the closest 1mm. Under the bed faces of the blocks to be tested, metal plates were carefully positioned to form the core of the compression testing equipment. Following that, an axial load was applied steadily and without shock until failure, at which time the highest load was noted.

2.4. Compressive Strength Expression

The following formula was used to get the compressive strength:

$$\text{Compressive strength} = \frac{\text{Maximum load at failure (N)}}{\text{Cross sectional area of block } (\text{mm}^2)} \qquad \ldots(1)$$

3. Results and Discussion

3.1. Results

The results of the compressive strength test that was performed on developed sandcrete brick samples were stated as follows.

Table 1. Result of compressive strength test of the moulded clay bricks at 35% maximum clay addition

Duration in Days	Dimension (mm^2)	Compressive Strength (N/mm^2)
7	75 x 75	1.01
14	75 x 75	1.44
21	75 x 75	2.53
28	75 x 75	3.29
35	75 x 75	3.95

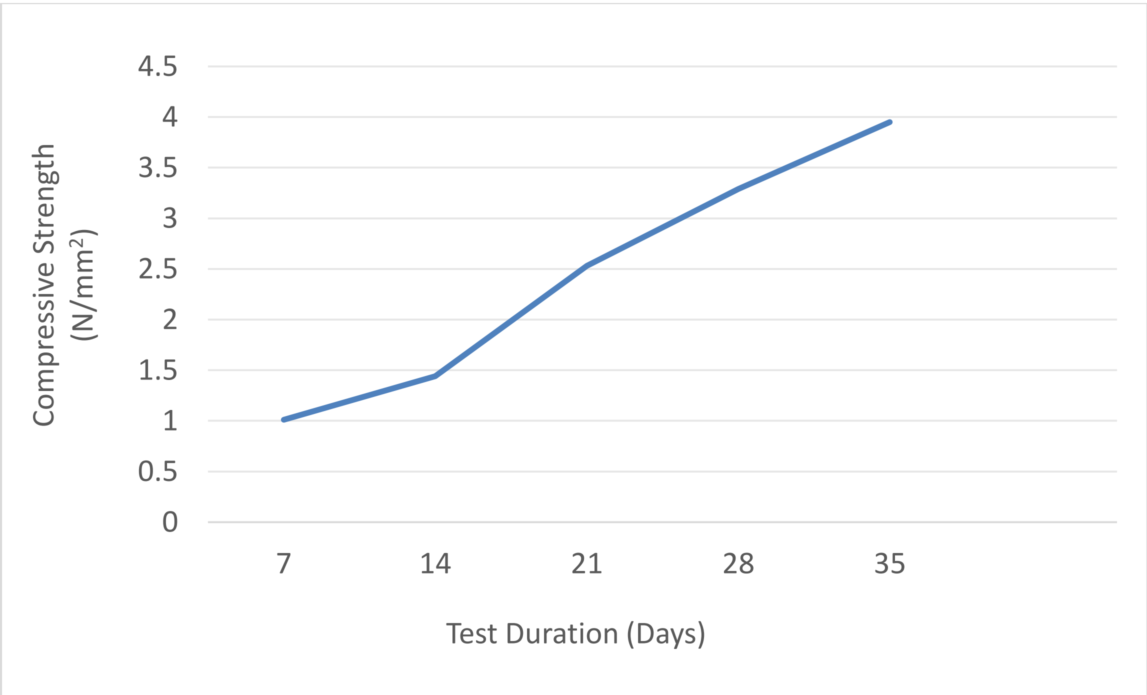

Figure 1. Graph of compressive strength test of the developed clay bricks at 35% maximum clay addition

The compressive strength data indicates a clear trend of increasing strength with time, which is typical for cement-based materials as they undergo hydration. At 7 days, the compressive strength of the clay bricks was 1.01 N/mm², indicating an initial phase of hydration where the formation of calcium silicate hydrate (C-S-H) gel contributes to the early strength. By 14 days, the compressive strength increased to 1.44 N/mm², a 42.6% increase from the 7-day mark. This significant improvement can be attributed to the continued hydration process, leading to more C-S-H gel formation, which enhances the bonding among particles and fills voids within the material. At 21 days, the compressive strength reached 2.53 N/mm², indicating a substantial increase of 75.7% from the 14-day strength. This rapid strength gain suggests a more complete formation of hydration products, resulting in a denser microstructure and improved mechanical properties. The compressive strength at 28 days was 3.29 N/mm², which is a 30.0% increase from the 21-day strength. This stage typically represents the period where the majority of the hydration process is complete, and the rate of strength gain begins to taper off. However, the continued increase in strength indicates that the bricks are achieving a more mature microstructure, leading to better load-bearing capabilities. By 35 days, the compressive strength reached 3.95 N/mm², showing a 20.1% increase from the 28-day mark. This final strength value suggests that even after 28 days, the material continues to gain strength, albeit at a slower rate, as the hydration process approaches completion. The consistent increase in strength over time highlights the importance of adequate curing to achieve optimal material performance.

4. Conclusion

The compressive strength analysis of the clay bricks showed a significant increase in strength with extended curing periods, indicating their potential suitability for use in construction applications that require low to medium-load-bearing capacities. The progressive strength gains from 1.01 N/mm² at 7 days to 3.95 N/mm² at 35 days underscore the importance of proper curing time in developing the mechanical properties of these materials. This study demonstrates that locally produced bricks can meet necessary structural requirements when allowed sufficient curing time, promoting their use in sustainable construction practices. Future research could explore optimizing mix designs and curing conditions to further enhance the mechanical properties of these building materials.

5. Recommendations

Future studies can be done to explore the impact of incorporating materials like fly ash, fiber particles or other eco-friendly additives to enhance the compressive strength and durability of sandcrete bricks. Secondly, to conduct longer period testing on the performance of sandcrete bricks under varied environmental factors (e.g., moisture, temperature changes, and weather exposure). Other alternative curing techniques such as steam curing or water immersion can also be explored and optimized, to determine the strength development over shorter periods. Also, the environmental impact and sustainability of large-scale sandcrete production can be further investigated and the economic feasibility evaluated for use in construction industry.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not–for–profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

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