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Mechanical Performance Evaluation of Sandcrete Blocks Commercially Produced in Amassoma, Nigeria

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ABSTRACT
The increasing frequency of building collapses in Nigeria has raised significant safety concerns. This study aimed to evaluate the suitability of sandcrete blocks used for construction in the Amassoma region of Bayelsa State, Nigeria. A total of 100 sandcrete blocks were sampled from local factories, and their compressive strength was determined following ASTM International procedures. Field observations indicated that factory managers did not adhere to the Nigerian Industrial Standard (NIS) or any recognized international guidelines for sandcrete block production. Test results showed that the compressive strength of 6-inch blocks ranged from 0.87 to 2.53 N/mm², while 9-inch blocks ranged from 1.03 to 2.93 N/mm². Only 20% of the blocks met the minimum NIS requirements. Blocks produced with granite fines exhibited higher compressive strength compared to those without. The findings highlight the urgent need for regulatory monitoring to ensure that commercially produced sandcrete blocks comply with NIS standards [1]–[4].
Keywords: *Sandcrete blocks, Compressive strength, Granite fines, NIS standards, Nigeria*

I. INTRODUCTION

Various traditional materials are widely used in modern civil engineering, with sandcrete and concrete blocks forming a significant portion of building materials. Sandcrete and concrete blocks are composite materials consisting of cement, water, coarse aggregate, fine aggregate, and other admixtures. Their engineering properties depend on the cement or fine aggregate volume, curing method, and cement-to-water ratio [5–7]. The majority of buildings in Nigeria use sandcrete blocks of different sizes and shapes [8]. Solid and hollow forms are common [9]. Adequate strength and stability are essential to withstand atmospheric conditions and the intended use [10,11]. Special treatments and granite fines improve structural qualities [12–14]. Substandard building materials are increasingly used due to cost and availability issues, exposing buildings and occupants to hazards [15,16]. Poor-quality materials have low compressive and tensile resistance, leading to structural failure [17]. Studies have linked substandard materials to building collapses and fires in Nigeria [18,5]. NIS recommends minimum compressive strengths: load-bearing walls 3.45 N/mm², non-load-bearing walls 2.5 N/mm² [15,16]. Research shows most blocks in Nigeria fail to meet these standards [1,3,4,9]. This study aims to appraise the quality of sandcrete blocks in Amassoma, Bayelsa State.

II. MATERIALS AND METHODS

Study Area Description

Amassoma is a town located in Bayelsa State, southern Nigeria, with an estimated land area of approximately 268 km² and a population of about 500,000 inhabitants [2]. The region experiences two main climatic seasons: a rainy season, with annual rainfall exceeding 1800 mm, often causing flooding, and a dry season, characterized by high temperatures and low relative humidity. The local economy is predominantly driven by fishing, farming, small-scale trading, and civil construction activities. Amassoma has several educational institutions, administrative offices, and local markets. The growing demand for housing and commercial infrastructure has led to an increased requirement for building materials, particularly sandcrete blocks, which are widely used in the construction of residential and commercial buildings. The region's environmental conditions and socio-economic activities directly influence the production and quality of sandcrete blocks, making it an important area for evaluating building material standards.

Sandcrete Blocks Procurement

For this study, ten sandcrete block factories were randomly selected from the Amassoma region to represent the different production practices in the area. At each factory, a total of ten hollow sandcrete blocks were collected, comprising five 9-inch blocks and five 6-inch blocks. All sampled blocks were approximately 28 days old, ensuring that they had attained sufficient curing age for reliable compressive strength testing. The blocks were carefully transported to the Civil Engineering Department, Niger Delta University, where standardized laboratory procedures were employed to determine their compressive strength, following the ASTM C109/C109M-02 guidelines [1,5].

Field Observations

a) **Cement brands:** Dangote and BUA Portland limestone (Grade 42.5).
b) **Fine aggregates:** riverbed sharp sand.
c) **Granite fines:** partially used by some factories.
d) **Curing:** partially adopted, mainly irrigation [12,13].

Compressive Strength Test

The compressive strength of the sandcrete blocks was determined according to the procedure outlined in ASTM C109/C109M-02. Each block was subjected to axial compression until it reached microstructural failure. The applied compressive load was gradually increased until the block's material could no longer withstand the stress, causing it to fracture.

The compressive strength (in N/mm²) was calculated using the formula:

Compressive Strength = Crushing Force (N) / Net Area (mm²)

Where:

a) The net area for a 9-inch hollow block is 67,500 mm².
b) The net area for a 6-inch hollow block is 33,750 mm².

This method is commonly employed to evaluate the structural integrity of sandcrete blocks and other construction materials, as it directly correlates with the material's capacity to withstand applied loads in real-world conditions. The results from this test provide critical insights into the quality and suitability of the blocks for use in construction, particularly in load-bearing structures [6,7].

Sieve Analysis

Sieve analysis of the fine aggregates was performed in accordance with **IS 2720 (Part 4):1985**. The results indicated that the aggregates were poorly graded, failing to meet the **Unified Soil Classification System (USCS)** criteria, where well-graded sand should have a coefficient of uniformity (Cu) greater than 6 and fines content less than 5% [14,16]. **Figures 1, 2, and 3** illustrate the results of the sieve analysis conducted on the fine aggregates used in the production of the sandcrete blocks.

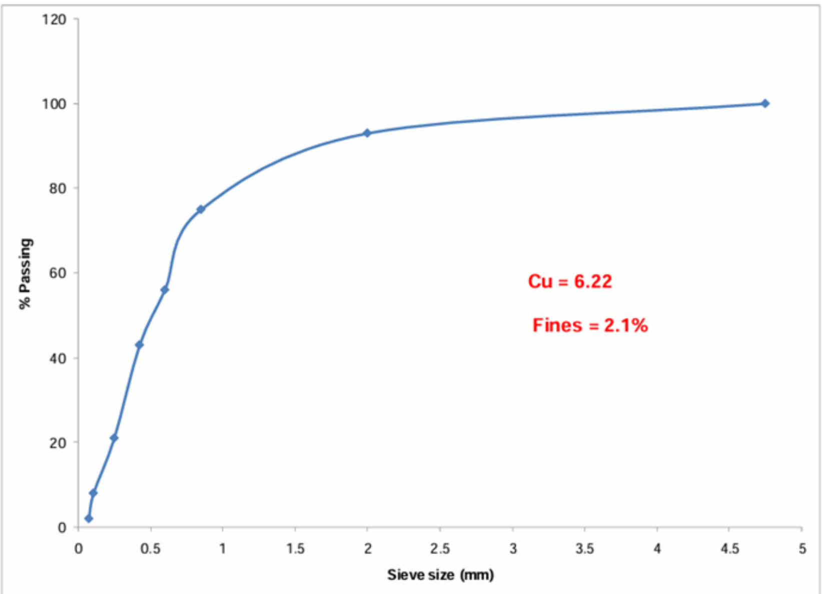

Figure 1. Sieve analysis of fine aggregate from blocks factories 1, 2 and 4.

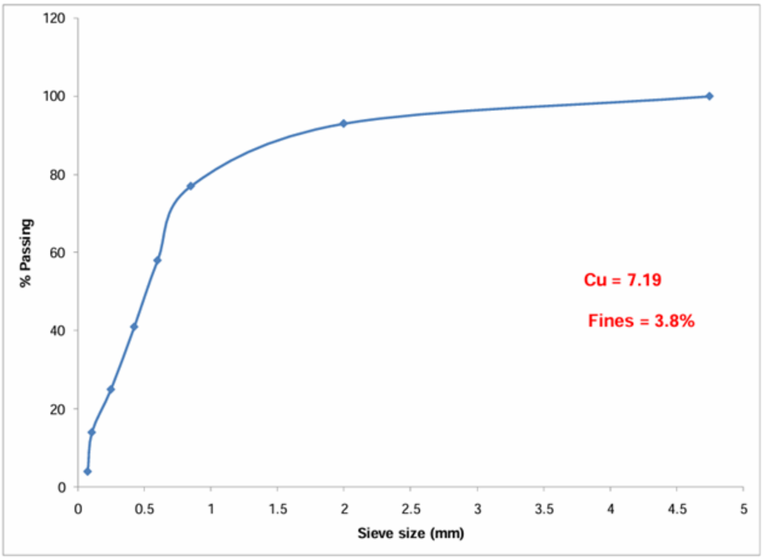

Figure 2. Sieve analysis of fine aggregate from blocks factories 3, 5 and 8.

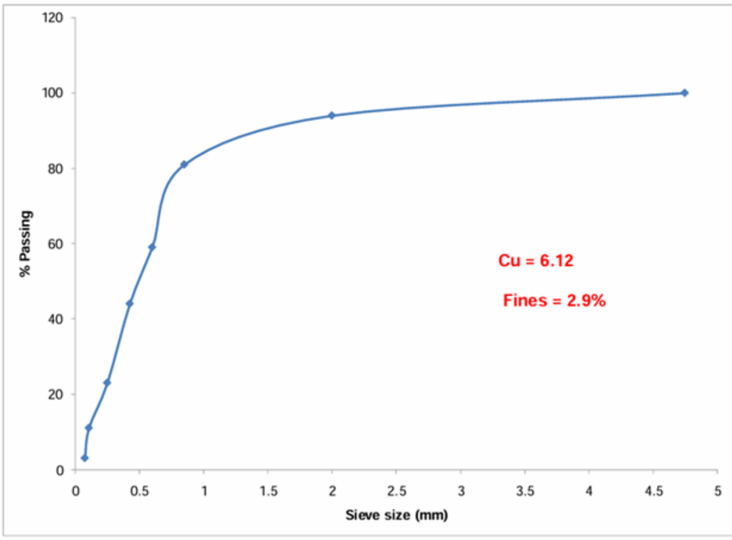

Figure 3. Sieve analysis of fine aggregate from blocks factories 6, 7, 9 and 10.

Table 1. Sandcrete block production procedures adopted.

Factory	Manager	Mix ratio	w/c (%)	Treatment	Mixing method	Production method	Batching method
1	Mason	1:10	ND	Granite fines	Mechanical	Mechanical	Volumetric
2	Mason	1:12	ND	Granite fines	Mechanical	Mechanical	Volumetric
3	Mason	1:16	ND	None	Manual	Manual	Volumetric
4	Mason	1:12	ND	Granite fines	Mechanical	Mechanical	Volumetric
5	Mason	1:12	ND	Granite fines	Mechanical	Mechanical	Volumetric
6	Mason	1:14	ND	None	Mechanical	Mechanical	Volumetric
7	Mason	1:14	ND	None	Manual	Manual	Volumetric
8	Mason	1:10	ND	None	Mechanical	Mechanical	Volumetric
9	Mason	1:14	ND	None	Mechanical	Mechanical	Volumetric
10	Mason	1:18	ND	None	Manual	Manual	Volumetric

ND = not determined.

Table 2. Effect of block size and producers on sandcrete block's compressive strength.

Size	Between/ within groups	Sum of squares	df	Mean square	F	p-value
Six	Between groups	9.56	9	1.062	99.55	1.25E-14*
	Within groups	0.21	20	0.011		
	Total	9.77	29			
Nine	Between groups	11.18	9	1.242	128.46	1.05E-15*
	Within groups	0.193	20	0.010		
	Total	11.37	29			

*Significant at p ≤0.05, according to DMRT.

Table 3. Summary table of the sandcrete block compressive strength at day 28.

Factory code	Compressive strength (MPa)	
	6-inch	9-inch
1	2.53^{g}±0.06*	2.93^{g}±0.15*
2	1.93^{e}±0.15	2.30^{e}±0.10
3	1.47^{c}±0.06	1.83^{c}±0.06
4	2.33^{f}±0.06	2.20^{f}±0.10
5	2.67^{g}±0.15*	2.83^{g}±0.06*
6	1.43^{c}±0.06	1.57^{d}±0.12
7	1.70^{d}±0.10	1.53^{d}±0.12
8	2.20^{f}±0.10	2.47^{f}±0.06
9	1.23^{b}±0.15	1.33^{b}±0.06
10	0.87^{a}±0.06	1.03^{a}±0.12

± Standard deviation; means sharing the same superscript letter in the sample column are not significantly different (p ≤ 0.05) according to Duncan's Multiple Range Test (DMRT). * indicates compressive strength values that meet the NIS requirements for non-load-bearing walls.

Statistical Analysis

ANOVA via SPSS 20.0 determined effects of block size and factory on compressive strength. Means separated using Duncan's Multiple Range Test (DMRT) at 5% significance.

III. RESULTS AND DISCUSSION

Block Production

Cement-sand ratio varied between 1:10 and 1:18. Volumetric batching was used in all factories, though accuracy varied. 40% of producers partially replaced sand with granite fines. Mechanical production methods used in 70% of factories; manual methods in 30%. Water volume and curing methods were inconsistent [7,12,13].

Sieve Analysis

Figures 1–3 show that the fine aggregates used in the sandcrete blocks were poorly graded. According to USCS, fine aggregates are well-graded if the coefficient of uniformity (Cu) >6 and fines <5% [14,16]. Poorly graded sand reduces particle interlock and void filling, adversely affecting compressive strength [12,16].

Sandcrete Block Compressive Strength

ANOVA results showed block size and factory significantly affected compressive strength (p ≤0.05).

a) **6-inch blocks:** 0.87–2.53 N/mm²
b) **9-inch blocks:** 1.03–2.93 N/mm²

Only 20% met NIS standard for non-load-bearing walls; none met 3.5 N/mm² for load-bearing walls. Higher strength observed in blocks with granite fines. Variation attributed to skill of supervisors, batching accuracy, water content, and curing method. Excess water and poor curing reduce strength [5,6,12,13].

IV. CONCLUSION

Most sandcrete blocks in Asaba do not meet NIS standards for load-bearing walls; only few meet standards for non-load-bearing walls. Compliance with NIS guidelines is generally poor. Regulatory agencies should organize training and monitoring to improve block quality [1–4,12,13].

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