Proliferation of Sandcrete Block Industries in Nigeria: A Quality Assessment of Industrial Mould Blocks in Benin City

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Abstract

The proliferation of sandcrete block industries in Nigeria has significantly impacted the construction sector. Sandcrete blocks serve as essential building materials, constituting over 90% of physical infrastructures in the country. These blocks are widely used for both load-bearing and non-load-bearing walls in Nigeria. This study focuses on the quality assessment of industrial mold blocks in Benin City, Nigeria. The objective is to evaluate the compliance of block manufacturers with specified standards. The research involves field studies, sampling, and laboratory experiments. The study revealed that some sandcrete blocks had low compressive strength values, as low as 0.66 N/mm^2. The water absorption capacity of certain blocks was as high as 16.95%, indicating poor quality. The study concludes that the quality of sandcrete blocks in the study area is not adequately compliant with the approved standards.

Keywords: sandcrete, industrial blocks, quality assessment

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Introduction

One of the most critical issues African countries faces is the supply of suitable housing. The rate of urbanization in Nigeria is significantly increasing, which has led to an increase in population that has never been seen before and has resulted in a strong demand for housing. Because Nigeria is the most populous country in Africa, the country's real estate market has been expanding, which has led to an increase in the need for housing supplies. Nigeria's construction industry has exceeded many other industries within the country's economy over the past few years. In the years to come, this industry is anticipated to continue to extend its current expansion rate. Despite this, the sector is facing difficulties regarding the widespread use of materials that do not meet the required standards, which has resulted in considerable losses in the housing construction industry (Awoyera et al., 2021; Imafidon & Ogbu, 2020; Nicholas et al., 2022; Ogbemudia et al., 2021; Orikpete et al., 2023).

Concern over the recent collapse of a building in Nigeria is mounting. The growing usage of non-standard building materials has been widely cited as one of the main reasons for building collapses. Buildings comprise most of Nigeria's physical infrastructure, and the recent spate of building collapses has raised questions about the quality of regularly used building materials like Sandcrete blocks and the ongoing need to determine if they are suitable for development. Non-compliance with laws has been one of the main causes of the production of inferior building materials and, to some extent, insufficient housing development in the Nigerian construction sector. As a result, it is impossible to establish standards based on how construction materials function in the industry. There is a greater risk of collapse when composite material compliance is neglected (Ikechukwu & Ezeokonkwo, 2016)

Typical building material in Nigeria and other African countries, sandcrete blocks are essential in forming our built environment. Precast composite masonry units are manufactured by compacting the mixed elements in a mold. They are made of a mixture of cement, sand, and water and are molded into different sizes. They are vital building materials (Alejo, 2020; Ogunbayo et al., 2021; Oyekan & Kamiyo, 2011; Sholanke et al., 2015). They are frequently used to construct structures meant to be aesthetically pleasing to people. Nigeria's most well-liked, reasonably priced, and extensively used masonry substance for constructing walling units for homes, businesses, and industries is sandcrete (Odeyemi et al., 2018). Moreover, Nigeria has been using sandcrete blocks for a long time. There are two types of walling units: load-bearing and non-load bearing. Given the significance of concrete as a building material, concrete quality, and longevity should be given top priority by architects, contractors, and other building stakeholders (Okafor & Egbe, 2017). The fundamental characteristics of the parts, the link between the mix ratio, and the material's production features all affect the quality of composite materials, such as sandcrete blocks (Uche, 2018). The mechanical properties of sandcrete blocks significantly affected how long-lasting the structures made of them were.

They are appropriate for hoarding construction sites, building partitions, fences, barrier construction, and building both load-bearing and non-load-bearing structures. The sandcrete blocks used as walling units need load-bearing walls that are strong enough to support the imposed load. Sandcrete blocks are a superior substitute for clay bricks in structures because they offer insulation against heat, airborne particles, and sound. Because they are lightweight, larger building structure units may be produced more quickly, which speeds up the operation and erection of building structures. Additionally, sandcrete blocks are easily molded and cut, making it simple to hammer screws and nails into them. It is also possible to fasten screws and nails into sandcrete blocks. There are signs that several sandcrete companies nationwide do not adhere to the defined specifications for blocks, despite the Nigerian Industrial Norm having established a standard for sandcrete blocks (Oyekan & Kamiyo, 2011). The increasing disregard for sandcrete specifications that meet local building requirements or ensure high-quality work has played a significant role in Nigeria's building challenges. The Nigerian Industrial Standard's primary goal is to regulate block quality by ensuring that all producers follow the minimal specifications. In Nigeria, it is also a standard reference guide for making sandcrete bricks. When building load-bearing walls, the quality of the Sandcrete blocks is a crucial consideration. According to the Nigerian Industrial Standard (NIS 87: 2007), non-load-bearing blocks should have a minimum compressive strength of 2.5 N/mm2, and load-bearing units should have a mean compressive strength of 3.45 N/mm2.

The quality of sandcrete blocks produced in Nigeria has been the subject of numerous unrelated investigations. Anosike (2021), for instance, evaluated the production management techniques used to construct high-quality sandcrete blocks in a few areas of Owerri Municipality, Imo State, Nigeria. The study's findings showed that the average compressive strength values from the sampled commercial blocks were as low as 1.92N/mm2, and the water absorption rate was roughly 17%. The characteristics of sandcrete hollow blocks made by Kogi's block factories in Idah were ascertained by Wasiu and Makoji (2017). The outcome showed that the values obtained are below the load-bearing sandcrete block standard. The quality of machine-vibrated hollow sandcrete blocks used in Lagos metropolis buildings was examined by Awolusi et al. (2015). The findings demonstrated that the producers' blocks had compressive strengths ranging from 0.21N/mm2 to 1.26N/mm2 for 225mm thick blocks and from 0.28N/mm2 to 0.95N/mm2 for 150mm thick blocks, which were significantly lower than the minimum standard requirements of 3.45N/mm2 and 2.5N/mm2, respectively. The compressive strength characteristics of sandcrete blocks made in the Calabar metropolitan were examined by Ewa (2013). The results showed that the sandcrete block was of low quality.

The research showed that nearly all sandcrete blocks tested in different environments were low-quality and did not meet the Nigerian Industrial Standard's requirements. One of the possible consequences of using inferior blocks during construction is the development of building cracks. This is more prone to happen when load-bearing units are built with inferior blocks. The blocks' porosity increases in the presence of substantial water, which weakens and eventually disintegrates the blocks. According to studies, the price of building blocks is significantly impacted by the sharp increase in cement prices and the demand for cement. Because of this, most commercial block producers have dropped their production requirements to provide more affordable blocks and increase earnings.

More than 90% of residential buildings constructed in poor nations, particularly in West Africa, are made of hollow sandcrete bricks (Sojobi et al., 2021). In Nigeria, laterite is a standard commercial activity for producing sandcrete blocks. However, there are not enough accurate calibrations based on the ideal mix proportions of these aggregates to make blocks that satiate different standards' minimal criteria (Ewa et al., 2022). Despite inconsistent literature suggesting as much in other Nigerian sites, there is still a dearth of data-driven results to support the notion that Benin City Metropolis produces low-quality sandcrete blocks. As a result, the study looks at the caliber of sandcrete blocks produced in various parts of Nigeria's Edo State, including Benin City.

Materials and Methods

Commercial Sandcrete blocks made in specific block factories in the Benin Metropolis, Edo State, were used for this study. Ninety (90) nine-inch hollow Sandcrete blocks were collected from sixteen (18) block industries in the Benin metropolis, with five (5) blocks collected from each factory. Observation of the processes and techniques involved in production, including batching, curing, mix proportion, age of block, and quality assurance, was carried out. Laboratory testing was done on the block samples to see how they compared to the Nigerian standard for sandcrete blocks in terms of standard specifications. The block measurement, water absorption capacity, and compressive strength tests were conducted using the procedures described in the previous study (Abubakar & Omotoriogun, 2022).

Table 1: shows block production details.

Block Industry	Batching	Mix Proportion	No of block per bag	curing duration	No of days (age)	Material testing
A	Volume	1:16	43	3	4	No
B	Volume	1:18	46	2	4	No
C	Volume	1:16	42	3	3	No
D	Volume	1:18	40	3	4	No
E	Volume	1:16	45	3	3	No
F	Volume	1:18	42	2	3	No
G	Volume	1:14	45	4	3	No
H	Volume	1:18	40	3	3	No
I	Volume	1:14	40	3	3	No
J	Volume	1:18	40	3	4	No
K	Volume	1:16	46	2	3	No
L	Volume	1:18	45	2	4	No
M	Volume	1:16	46	2	4	No
N	Volume	1:16	42	3	4	No
O	Volume	1:16	42	4	3	No
P	Volume	1:18	40	2	3	No
Q	Volume	1:18	45	4	3	No
R	Volume	1:16	46	3	3	No

Source: Field survey

Results and Discussion

The findings from the field survey are outlined in Table 1, which details the batching technique, mix proportion, mode of production, source of materials, composition of components, mixing process, curing method, age of blocks, and quality assurance measures. Observation of the moulding styles of the selected block industries shows that all blocks are mechanically produced using the electrical vibrating machine, while some are manually manufactured using manual labor. At the same time, batching techniques were nearly the same throughout the several industries that were examined. In each of these businesses, a wheelbarrow was used to measure the appropriate volume of sand, and the mix ratio that was utilized was determined by the specific industry. However, observation showed that the standard mix ratio of 1:8, according to the Nigerian Industrial Standard, was not adopted in all the factories visited. Their mix ratio was 1:14 -1:18 to produce 40-46 nine-inch blocks per bag of cement. Moreover, none of the block factories used the recommended water-cement ratio of 0.6. The operator controlled the amount of water added to obtain a workable mixture without bulking compensation.

Manual mixing using shovels and spades was standard practice in every industry analyzed. It was found that uneven mixing occurred more often when there was a large volume of items to mix. However, the rest of the blocks were made by combining fine sand with granite fines in varied quantities, which led to a decline in quality as cracks quickly appeared in the blocks. For curing, spurting the blocks with water twice daily in an open area and for 2-3 days was similar in all industries. None of them underwent the recommended 7-day curing process stipulated in the Nigerian Industrial Standard (NIS 87: 2007). Importantly, no experts own or run any block industries under review. Thus, neither the material nor the finished products go through any quality control.

Table 2 shows the composition of the sands

Block	Sharp sand	Fine sand	Granite fines
A	80	40	0
B	100	0	0
C	80	0	20
D	40	20	40
E	60	0	0
F	100	0	0
G	100	0	0
H	100	20	0
I	80	0	0
J	80	0	0
K	100	0	0
L	100	0	40
M	100	0	0
N	100	0	0
O	60	0	40
P	60	20	0
Q	40	0	0
R	100	0	0

Source: Field survey

Most manufacturers used the sharp sand they extracted from rivers and streams as fine aggregates, while the remaining industries used a combination of fine sand and granite fines in various ratios to create the blocks. The percentage of fine aggregates used in the selected block industries is shown in Table 2.

The outcome demonstrates that the length, width, and depth of the blocks produced in the industries under review complied with acceptable block standards as stipulated by the Nigerian Industrial Standard (NIS 87: 2007). However, the industries failed to comply with the web thickness standard of 50mm. Thus, only the L and N, with average web thickness measurements of 52.01 and 54.43mm, exceeded the minimum specified web thickness of 50mm. The principal causes of decreased web thickness are the use of deformed molds and the poor tuning of the machine molds. While it is true that cutting down on web thickness can save resources and money, it also reduces the density and effective area of the blocks, which is what gives them their compressive strength.

Table 3 shows the mean dimension of sampled sandcrete blocks.

Block industry	*M* (mm) length	*M* (mm) width	*M* (mm) height	*M* (mm) web thickness
A	458.0	231.2	230.6	38.60
B	456.2	228.2	230.6	40.68
C	459.4	229.6	230.0	36.25
D	458.6	228.8	230.0	39.46
E	457.0	230.8	228.6	41.27
F	453.8	228.6	228.2	40.01
G	453.8	225.2	226.0	40.02
H	455.0	225.2	230.0	40.27
I	457.2	229.4	230.6	36.81
J	459.6	229.6	229.6	37.62
K	456.0	227.0	226.8	36.97
L	460.6	231.5	230.5	52.01
M	457.6	227.8	227.0	36.46
N	460.0	230.0	230.0	54.43
O	457.2	227.6	231.2	37.62
P	457.0	229.4	230.0	40.06
Q	457.0	229.4	230.0	40.06
R	457.0	229.4	230.0	40.06

Source: Field survey

Figure 2 summarizes the blocks' mean water absorption capacity from the chosen factories. Except for those from block factories B, H, P, and Q, the average water absorption capabilities of all examined blocks exceeded the NIS-specified standard value of 12%.

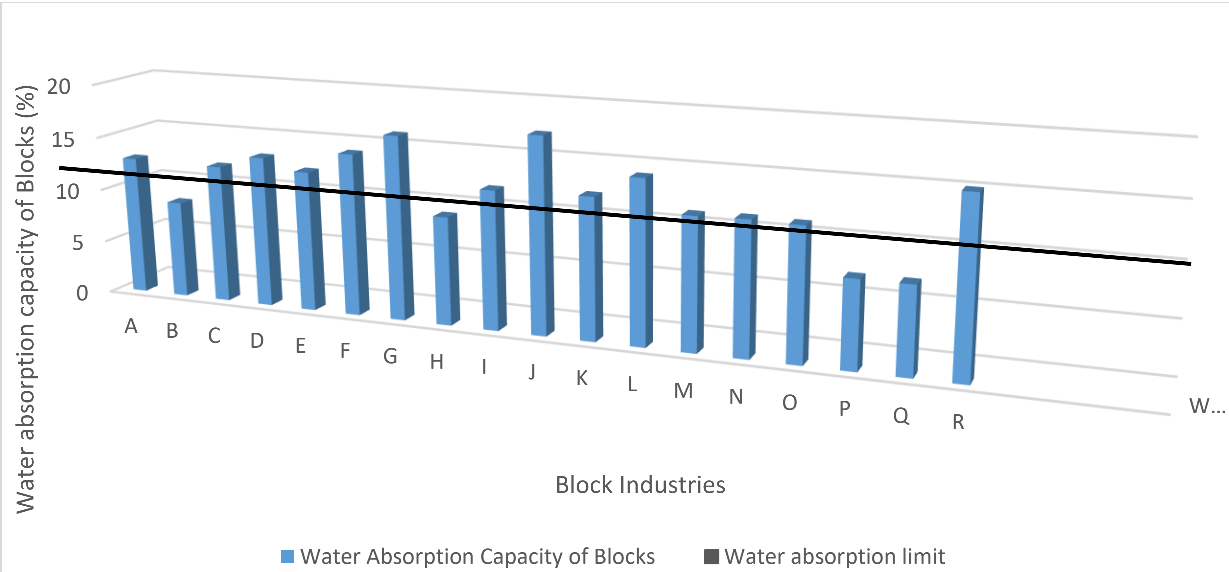

Fig. 2: Mean Water Absorption Capacity (%)

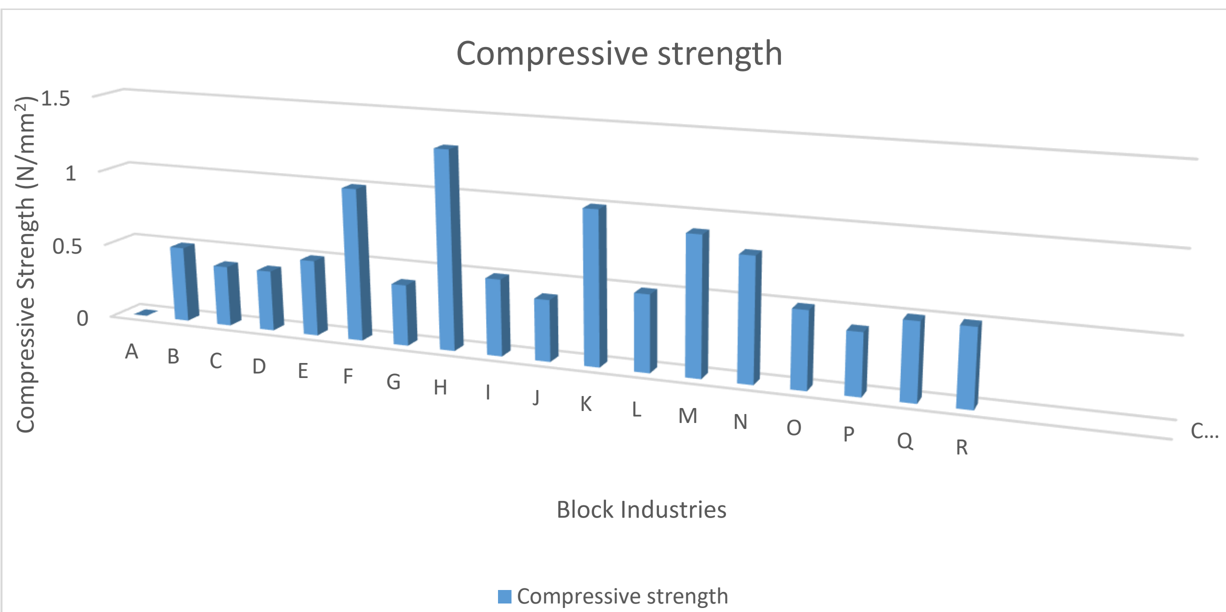

Fig. 3: Mean Compressive Strength (N/mm2)

The compressive strength of each block ranged between 8.61-16.44%, blocks from D recording ranged between 0.18- 1.26N/mm2, and the mean highest water absorption capacity of 16.44% and K compressive strength of five (5) blocks for each factory recording the most negligible value of 8.61%. Poor mix ratio ranged between 0.27-1.12N/mm2. Blocks from factory H, inadequate curing, inadequate compaction, and poor recorded the highest mean compressive strength of 1.12N/mm2, while those from factory A recorded the lowest value of 0.27N/mm2. In factories H, K, Q, and R, it was seen that sharp sand was being partially replaced with granite fines. As a result, these firms' blocks had greater compressive strength than those made just from a combination of sharp sand and plaster sand. This is because granite and cement come together to form powerful bonds. The Nigerian Industrial Standard (NIS 87: 2007) stipulates that the lowest compressive strength of a single non-load bearing sandcrete block shall not be less than 2.5N/mm2, and the average compressive strength of blocks should not be below 3.45N/mm2. These values, however, are significantly below the standard specification. These values fall short of the Nigerian Building Code's recommendation that individual blocks have a minimum compressive strength of 2.0N/mm2.

The compressive strength of the blocks was significantly below the standard value for load-bearing and non-load-bearing blocks, according to the data, which points to weak quality control procedures among the producers. Nevertheless, there was a wide range in the compressive strength of blocks from the same manufacturer's stock. Given the massive volume of ingredients often used, this may result from irregular mixing caused by the manual mixing mode used in all factories. The outcome also suggests that the prescribed mix proportion of (1:8) was not followed, as blocks made in factory H with the most robust mix (1:14) had the highest compressive strength in comparison to those made in factory A with the lowest mix of (1:19). The blocks were only correctly and insufficiently cured for the required seven days in a covered area, which is the mechanism for continuous hydration of cement necessary for strength growth. The decrease in block web thickness, which effectively reduced the area available for resisting load, also contributed to the blocks' poor compressive strength. Previous studies have established similar trends in other parts of the country (Adese & Olajide, 2021; Ajao et al., 2018; Wasiu & Makoji, 2017).

Conclusion

The results obtained from the present study suggest that most local block factories have no idea if there are agreed-upon standards for making Sandcrete blocks. As a result, some firms engaged in questionable methods during the manufacturing process. None of the companies adequately cured the blocks before shipping them to clients for use in the building. The mix proportions utilized ranged from 1:14 to 1:19, far lower than the usual mix ratio 1:8. None of the factories checked the blocks for quality by testing their raw materials or finished goods. The management of the factories was placed in the hands of people who knew little about production standards. The blocks collected from each factory fell well within what is considered acceptable in terms of length, width, and height. Due to the use of deteriorated molds and improper tuning of the machine molds, the web thickness of most blocks did not meet the required standard value.

Consequently, the volume and area for resisting loads were effectively reduced, reducing the blocks' density and strength properties. The water absorption capacities of all the tested blocks, except those from factories B, H, K, and L, were more significant than the maximum value of 12 percent specified. The improper mix ratio and insufficient curing procedures will likely be

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blamed for this result. These blocks have a higher water permeability rate, making them less durable and more prone to failure due to this property. The gathered blocks are of poor quality and unsuitable for use in a building as their compressive strengths are much lower than the NIS standard standards. Using these blocks would cause walling units to crack, especially in structures where the roof weight is to be supported by the walls, and in the worst situations of flooding, it would cause a complete collapse.

Recommendations

The authorities should mandate that block producers implement better curing practices, use appropriate mix ratios compactions properly, and employ mechanical mixers. The obligation to ensure that construction blocks meet standards should fall on the shoulders of the Standard Organisation of Nigeria (SON), the Nigerian Society of Engineers (NSE), and other relevant regulatory authorities. Defaulters should be subject to penalties and punishments to deter future offenses. Sandcrete blocks can enhance their characteristics and minimize production costs by incorporating laterite, granite fines, quarry dust, and sawdust. Sandcrete block manufacturers should be strongly urged to make use of these admixtures.

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