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PROLIFERATION OF SANDCRETE BLOCK INDUSTRIES IN NIGERIA: A QUALITY ASSESSMENT OF INDUSTRIAL MOULD BLOCKS IN BENIN CITY, EDO STATE, NIGERIA

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Abstract
Nigeria is among the countries that have experienced many building collapses, raising concerns about the quality of building materials and the necessity of examining their suitability for construction. Sandcrete blocks are essential for building construction and are used in the masonry unit for walling and other purposes. There is a growing concern about the proliferation of sandcrete production industries in various locations and the need to ascertain their standards. The present paper assessed the quality of sandcrete blocks produced in Benin City, Edo State, for compliance with existing standards. Sandcrete blocks produced in selected block industries in the Benin Metropolis, Edo State factories were used in the 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. The processes and techniques engaged among manufacturers, including batching, curing, mix proportion, age of block, and quality assurance, were observed. The block samples were subjected to laboratory experimentation to test the standard specifications compared to the established standard specifications in Nigeria. The outcomes of the laboratory tests revealed that the sampled blocks' size, compressive strength, and water absorption capacity fell short of the required standards. The key findings of the field survey revealed deviations from the standards in the mix proportioning, curing procedures, and age of the blocks used in the industries.

Keywords: sandcrete, industrial blocks, quality assessment

Introduction

The provision of adequate housing is one of the significant challenges faced by most African countries. The rate of urbanization in Nigeria is remarkably increasing, which has consequently led to an unprecedented increase in population and resulted in high demand for housing. As the most populated nation in Africa, Nigeria's real estate industry has been proliferating, increasing the demand for housing. Over the last few years, Nigeria's construction industry has surpassed many other sectors of its local economy. It is predicted that this sector will carry on its growth in the coming years. Despite this, the industry is challenged by the proliferation of substandard materials that have led to significant 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).

There is a growing concern about the recent building collapse in Nigeria. Indeed, the primary causes of building collapse have been generally attributed to the increasing use of non-standard building materials. The majority of the physical infrastructures in Nigeria are made up of buildings, and the recent wave of building collapses has renewed concerns about the quality of commonly used building materials like Sandcrete blocks and the necessity of continually investigating their suitability for construction purposes. One of the leading causes of the manufacture of subpar building materials and, to some degree, inadequate home development in the Nigerian construction sector has been non-compliance with regulations. As a result, it has become impossible to set criteria based on how building materials perform in the sector. When compliance with materials of a composite type is disregarded, the threat of collapse increases. (Ikechukwu & Ezeokonkwo, 2016)

Sandcrete blocks are composite materials made from a combination of sand, cement, and water, with cement serving as the binder (Alejo, 2020; Ogunbayo et al., 2021; Oyekan & Kamiyo, 2011; Sholanke et al., 2015), and they are formed by compacting the mixed materials in a mold. They are extensively used in constructing buildings and other structures for the comfort of humanity. Sandcrete blocks are Nigeria's most popular, cost-effective, and commonly used masonry material to construct residential, commercial, and industrial walling units (Odeyemi et al., 2018). In addition, sandcrete blocks have a long history of use in Nigeria. The walling units can either be load-bearing or non-load-bearing walls. Because concrete is a significant construction material, designers, builders, and other users of structures produced with it should prioritize its quality and longevity (Okafor & Egbe, 2017). The quality of a composite material like sandcrete block is a function of the basic properties of the constituent ingredients, the mix ratio relationship, and its production characteristics (Uche Felix, 2018). The mechanical properties of sandcrete blocks greatly influenced the durability of structures built from them.

They could be used for constructing load-bearing and non-load-bearing structures and are also suitable for making partitions in buildings, hoarding construction sites, fencing, and creating barriers. Indeed, the load-bearing walls of the sandcrete blocks utilized as walling units must be strong enough to handle the applied load. Sandcrete blocks provide thermal, airborne, and sound insulation in buildings and are better alternatives to clay bricks. By their lightweight nature, larger units for building structures can be made quickly, thereby making the operation and erection of building structures faster. Sandcrete blocks can also be readily cut and shaped, allowing the easy way to drive screws and nails into them. Sandcrete blocks also provide the ability to drive screws and nails into them quickly. Despite the standard instituted by the Nigerian Industrial Standard for sandcrete blocks, there are indications that several sandcrete producers across the country do not observe the set standards for blocks (Oyekan & Kamiyo, 2011). The growing non-reference to sandcrete specification to suit local building requirements or good quality work has contributed significantly to the building problems in Nigeria. The primary aim of the Nigerian Industrial Standard is to control the quality of blocks by ensuring that all producers adhere to minimum stipulated requirements. It is also a standard reference document for producing Sandcrete blocks in Nigeria. The quality of Sandcrete blocks is an essential area of interest, primarily when used to construct load-bearing walls. Nigerian Industrial Standard (NIS 87: 2007) recommended that the mean compressive strength of load-bearing units is 3.45N/mm2 and that non-load-bearing blocks' lowest compressive strength is not less than 2.5N/mm2.

Numerous disparate studies have examined sandcrete block production quality in Nigeria. For example, Anosike (2021) assessed the production management practice adopted in manufacturing quality sandcrete blocks in selected parts of Owerri municipal, Imo State, Nigeria. The study's results revealed that the mean compressive strength values obtained were as low as 1.92N/mm2 and about 17% water absorption rate from sampled commercial blocks. Wasiu and Makoji (2017) determined the properties of sandcrete hollow blocks produced by block industries in Idah, Kogi. The result indicated that the obtained values fall below the standard for load-bearing sandcrete blocks. Awolusi et al. (2015) investigated the quality of machine-vibrated hollow sandcrete blocks used for construction in the Lagos metropolis. The results showed that the blocks from producers had compressive strengths that were far lower than the minimum standard requirements of 3.45N/mm2 and 2.5N/mm2, respectively, ranging from 0.21N/mm2 to 1.26N/mm2 for 225mm thick blocks and 0.28N/mm2 to 0.95N/mm2 for 150mm thick blocks. Ewa (2013) investigated the compressive strength properties of sandcrete blocks produced within the Calabar metropolis. The findings indicated a poor-quality sandcrete block.

The literature indicated that almost all of the sandcrete blocks examined in various settings were of poor quality and did not meet the standards included in the Nigerian Industrial Standard. The formation of cracks in structures is one of the potential outcomes that could result from employing substandard blocks in the building process. This is especially likely to occur when substandard blocks construct load-bearing units. When there is a significant amount of water present, the porosity of the blocks rises, and as a result, they become weakened and eventually fall apart. According to research, the rapid rise in the price of cement and the demand for cement has an uncountable effect on the price of building blocks. As a result, the bulk of commercial block manufacturers have lowered their production standards in order to maximize profits and produce affordable blocks.

Hollow sandcrete blocks constitute over 90% of residential building construction in developing countries, especially West Africa (Sojobi et al., 2021). Incorporating laterite in sandcrete block production is a standard commercial practice in Nigeria. However, proper calibrations per optimal mix proportions of these aggregates to produce blocks that meet minimum requirements by various standards are lacking (Ewa et al., 2022). Although disparate literature has indicated low-quality sandcrete block production in many locations in Nigeria, it is currently a lack of data-driven outcomes to suggest the same in Benin City Metropolis. Thus, the paper examines the quality of sandcrete blocks manufactured in different locations in Benin City of Edo State, Nigeria.

Materials and Methods

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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

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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%.

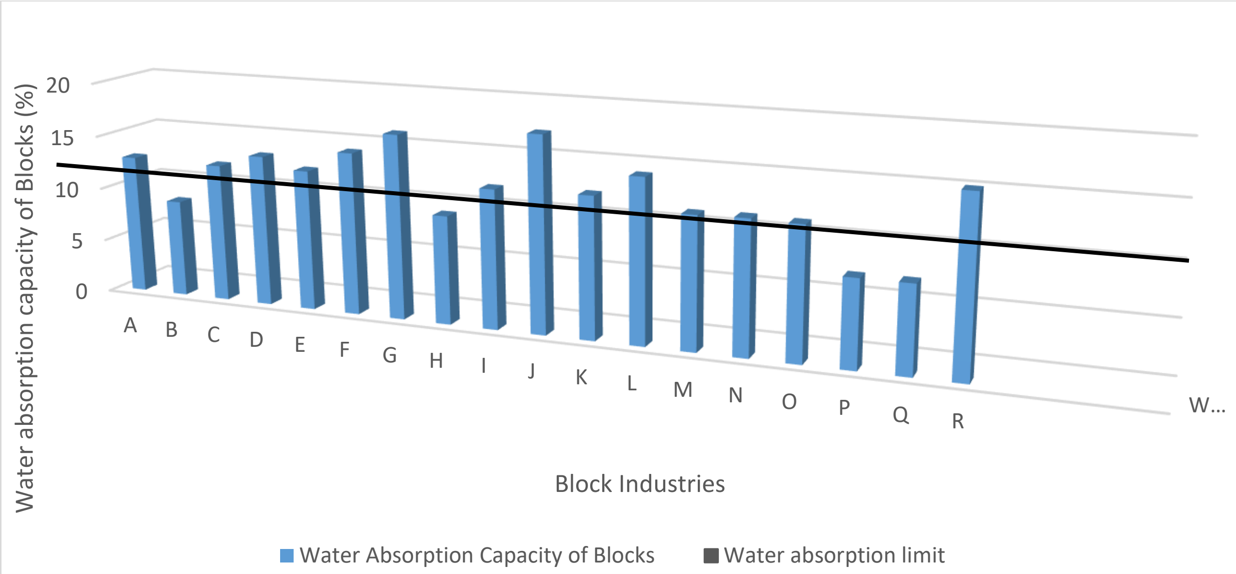

Fig. 2: Mean Water Absorption Capacity (%)

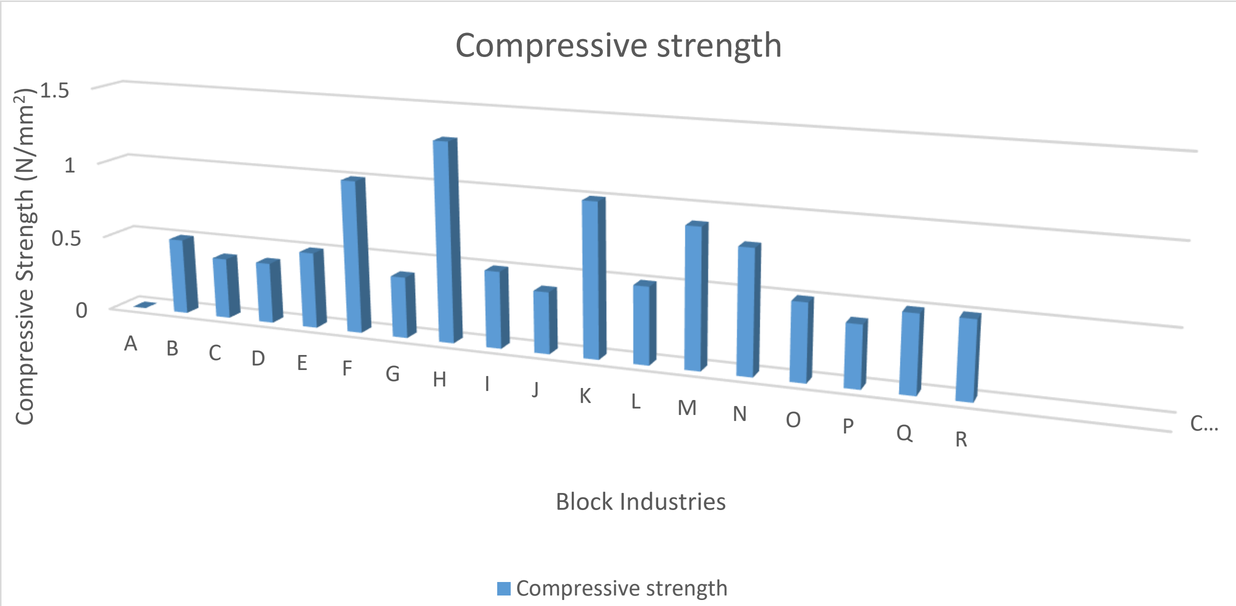

Fig. 3: Mean Compressive Strength (N/mm2)

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 of 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 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 compaction 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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