CHARACTERIZATION OF SANDCRETE BLOCKS IN OGUN STATE, NIGERIA

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ABSTRACT
Frequent building failure experience in Nigeria and many other countries necessitates the quality assurance of all building materials in circulation including sandcrete blocks. This study investigates the compressive strength and quality of sandcrete blocks produced in Ogun State, Nigeria. Sandcrete blocks, widely used in construction, are made from a mixture of sand, cement, and water. Laboratory tests conducted include sieve analysis, moisture content, silt/clay content, specific gravity, bulk density, organic matter content, compressive strength, water absorption, and microstructural analysis using X-ray fluorescence (XRF) and X-ray diffraction (XRD). The results revealed significant variations in the quality of sandcrete blocks across different locations in Ogun State, with many blocks failing to meet the minimum compressive strength requirements. The results reveal variations in block quality, with compressive strength tests showing the highest values in Obafemi Owode LGA (1.93 N/mm^2 for 225 × 225 × 450 blocks and 1.40 N/mm^2 for 150 × 150 × 450 blocks), while the lowest strengths were recorded in Ado-Odo/Ota LGA (0.17 N/mm^2 for 6-inch blocks) and Ifo LGA (0.40 N/mm^2 for both block sizes). Similar differences were seen in water absorption tests, where Likosi Simawa Sagamu LGA performed the highest (7.64-11.29% absorption) and Ado-Odo/Ota LGA performed the poorest (9.44-18.07% absorption). Sample X5, which showed the maximum compressive strength (1.93 N/mm^2), benefited from an ideal chemical composition, especially its high CaO (35.01%) and FeO_3 (11.53%) content, according to microstructural investigation using XRF and XRD. The elements present encouraged strong cement hydration and the development of ferrite phase which is known to increase strength. Sample A1 recorded the lowest compressive strength of 0.4 N/mm2 and it was observed to have high concentration of muscovite which is a mineral that is known to negatively affect the compressive strength of Sandcrete blocks. Sample K3 recorded a moderate strength of 0.9 N/mm2 with the silica oxide (SiO_2) and calcium oxide (CaO) percentage of 52% and 23.13% respectively. It can be deduced that the lower percentage of iron oxide reduced the potential strength gain from ferrite-related reactions. The result showed that 68% of the tested blocks failed to meet the NIS 87:2007 minimum recommendation of 1.2 N/mm2 while 72% exceeded the 12% minimum recommendation for water absorption. To solve these quality issues and avoid future building disasters in the area, the report suggests swift regulatory action, including regulated mix ratios (1:6 cement-sand), required curing times (minimum 28 days), and mechanized production techniques.

Keywords: Block quality, Building failure, Compressive strength, Sandcrete block, Structural integrity.

1. | Introduction

Sandcrete blocks are a popular building material in various parts of the world, particularly in West Africa. They are made from a mixture of sand, cement and water. Sandcrete block walls are typically not designed to support loads beyond their own weight (Awolusi *et al.,* 2021). Recent structural collapses in Nigeria and elsewhere have raised significant concerns, highlighting the need for more in-depth and intensified studies on the resistance mechanisms of all structural components.

In Nigeria, sandcrete blocks have an appeal to the Construction Industry due mainly to their ease of manufacture and the availability of sand, which is the main component (Ikumapayi and Afolayan, 2014). They are widely used in Nigeria and virtually all African Countries as walling units or partition and sometimes as load bearing walls. The Compressive strength of these blocks is a critical property that determines their load-bearing capacity and overall structural integrity. The quality of blocks produced however, differs from each industry due to the different methods employed in the production and the properties of the constituent materials. The frequent failure of buildings in Nigeria is a concern to all stakeholders. In the past, incessant building failures have been reported resulting in the loss of lives and properties in Nigeria (Adeosun and Adejumo, 2020). The global concerns for sudden collapses of building across the world, and in Nigeria particularly demand that materials used for construction of buildings meet minimum requirement.

Sandcrete blocks are small precast masonry units assembled and bound together using a cementitious material to form walls. These walls can serve as load-bearing walls, enclosure walls, or backup walls. Block units are manufactured as either solid (with a minimum of 75% solid material and a maximum of 25% hollow space) or hollow units (with less than 75% solid material) (Afolayan *et al.,* 2008).

The rapid shift from bricks to blocks in Nigeria has led to more elaborate investigations into the use of sandcrete blocks (Olubajo, 2024). The widespread adoption of sandcrete blocks has increased demand and necessitated high production volumes. This should attract the interest of various stakeholders and players in the construction industry to standardize the production and use of sandcrete blocks, ensuring their efficient application as major building materials (Awolusi *et al.,* 2021). The Committee on Review of Decision in Nigeria (1985) specifies 2.1 N/mm^2 as the minimum 28 days average compressive strength (based on gross area 450 × 225 mm^2) of at least 3 blocks, for load bearing walls of 2 to 3 story height. In addition, the document recommends that no individual block should have a compressive strength less than 1.75 N/mm^2. Other documents intended for the regulation of the quality of sandcrete blocks used for buildings in Nigeria include National Building Code (2006) and Nigerian Industrial Standards (2004).

Large scale structural failure is a nightmare that haunts Construction industry. The financial devastation, the damaged reputations and the loss of life that could result from a collapse have troubled the sleep of every architect, engineer, contractor or developer at some time.

Afolayan *et al.* (2008) wrote that although poor quality of sandcrete blocks is not the only cause of building failures it is however one of the frequently adduced major causes for one-and two-storey buildings failure cases in Nigeria and it is known that in this class of buildings the use of sandcrete blocks for load-bearing walls is very widespread.

Previous investigation on the compressive strength of sandcrete blocks in places like Calabar, Ondo State, showed the compressive strength to be in the range between 0.23 N/mm^2. These values are below the minimum requirements of 1.75 N/mm^2 by the Nigerian National Building Code (2006) for individual block, and 2.0 N/mm^2 by the British

Standard for non-load bearing walls. Therefore, lack of information on the quality assurance of existing sandcrete blocks is a threat to the building industry.

This research addresses a critical gap by generating comprehensive data on sandcrete blocks produced in Ogun State, Nigeria. Poor quality sandcrete blocks are often identified as a major factor to structural collapses, especially in one- and two-story buildings where they serve as load-bearing walls. The high frequency of building failures has been strongly associated with defective building materials. The compressive strength of commercially produced sandcrete blocks in different parts of Nigeria has been the subject of numerous investigations, all of which have consistently produced subpar findings. The average compressive strength for 150 mm block samples from Ondo State was 0.55 N/mm^2 while 225 mm block samples have 0.45 N/mm^2 as reported by Afolyan *et al.,* (2008). The study of Ogunbayo *et al.,* (2021) reported that the average strength of block in calabar is between 0.23 to 0.58 N/mm^{2}.. The study of Olaniyi and Abiodun (2024) reported that the average compressive strength of blocks in Akure is 0.80 N/mm^2 while the minimum compressive strength is 0.55 N/mm^2. The samples are well below the Nigerian National Building Code (2006) and Nigerian Industrial Standards recommendation of 1.75 N/mm^2 for individual blocks and 2.5 N/mm^2 for load-bearing blocks. Public safety is seriously threatened by this pervasive quality shortfall. Nigeria's quick switch from brick to block construction calls for further in-depth research into the characteristics of sandcrete blocks because there has not been enough done to control producers of inferior blocks, which are frequently offered for significantly less than what high-quality materials would cost.

This study created a scientific basis for quality improvement in the block manufacturing sector by meticulous testing of compressive strength, water absorption characteristics, and microstructural analysis. The results offered practical suggestions for improving production procedures and facilitating efficient standardization of sandcrete blocks in Ogun State and across Nigeria, hence assisting in the avoidance of structural failures that cause monetary losses and fatalities.

2. | Materials and Methods

2.1 | Materials and their Locations

Sandcrete blocks were gathered from five (5) distinct Ogun State local government regions, encompassing both urban and rural areas where the production of sandcrete blocks was common. Three (3) samples of sandcrete blocks were collected from each selected site. The map of Ogun State shows the study area presented in Figure 1. The list of the block industries where samples are collected is presented in Table 1.

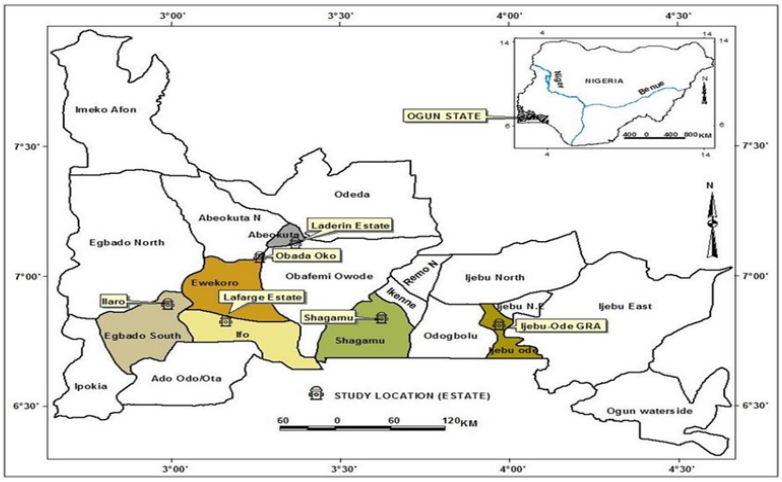

Figure 1 | Map of Ogun State (Source: Amujo *et al.,* 2022)

Table 1 | Locations where samples were selected

Location Number	Local Government Area	Code Name
1	Ado Odo Ota	A B C D E
2	Ifo (Alagbole)	F G H I J
3	Ishere Local Government (OPIC Kara Axis)	K L M N O
4	Likosi Simawa Sagamu	P Q R S T
5	Obafemi Owode (Redeemption City)	U V W X Y

2.2 | Methods

2.2.1 | Moisture Content

The fine aggregate samples were subjected to the test in compliance with ASTM C566 (2019). The test found the percentage of moisture in the sand samples used in Ogun State's sandcrete block manufacturing. Samples were weighed both before and after a 24-hour oven drying period at 105 ± 5°C. The moisture content was represented by the mass differential, which had an immediate impact on the water-to-cement ratio and, in turn, the sandcrete blocks' compressive strength.

2.2.2 | Silt/Clay Content

To ascertain the proportion of harmful elements (clay and silt) in sand samples, the test adhered to ASTM C117 (2017). The material was washed through a 75µm filter, and the mass loss was measured. High amounts of silt are known to negatively affect the strength of block samples.

2.2.3 | Sieve Analysis

The test was conducted in accordance with BS 882 (1992) and ASTM C136 (2019). The samples were dried in the oven and were passed through a set of sieves having different sizes and were arranged in ascending order. A sieve shaker was used to sieve the soil samples. Well graded aggregates are known to produce blocks of high strength.

2.2.4 | Specific gravity

The specific gravity test was conducted in accordance with ASTM C127 (2015). The specific gravity test is useful in getting information about the quality of the materials being used.

2.2.5 | Bulk density

The bulk density test was conducted in accordance with BS EN 772-13:2000. The weight of the block samples was taken, and the volume was also determined. The Bulk density relates the weight of samples to the volume.

2.2.6 | Organic Content of Fine Aggregate

Sand samples were mixed with a sodium hydroxide solution, and color changes were recorded. Higher organic content was indicated by darker hues, which may impede cement hydration and weaken sandcrete blocks. The test was conducted in compliance with ASTM C40 (2020) to use the colorimetric method to determine whether the sand samples contained hazardous organic chemicals.

2.2.7 | Compressive Strength Test

The test was conducted in accordance with BS EN 772-1:2011. Universal testing machine was used to access the maximum force needed to fail the samples. The area of the sandcrete blocks were recorded as well to estimate the strength. The compressive strength is determined by dividing the maximum force at failure with the area of the samples.

2.2.8 | Water Absorption

This test was done based on BS 1881-122 (2011) where it was aimed to establish the percentage of water that the blocks absorbed after twenty four (24) hours in water. Weights of the samples were determined before and after immersion and the difference was reported as a percentage of the dry weight. An important factor to adopt during the evaluation of the durability of the blocks was its ability to absorb water, especially when it is in a wet environment or rain-prone areas.

2.2.9 | Microstructural Analysis of the Samples

In line with ASTM C114 (2018), X-Ray Fluorescence (XRF) analysis was employed to establish the elemental composition of cement samples applied in the production of blocks. In accordance with ASTM C1365 (2018), x-ray diffraction (XRD) analysis was performed to determine the presence of crystalline phases in samples of cement. These state-of-the-art analytical methods, by providing extensive data on the chemical composition and mineralogical framework of the cement, helped in creating links between cement properties and the strength properties of sandcrete block manufactured in Ogun State.

3. | Results and Discussion

3.1 | Moisture Content, Specific Gravity and Bulk Density of the Soil Samples

Table 2 indicates that the moisture content of the brownish soil was 2.41, the sand had a moisture content of 4.90 and the stone dust had the lowest level of moisture content, which was 1.35. The moisture content of the sand (4.90) is slightly higher than the suggested range of 3-4% recommended by the BS 5628-1:2005, but with the necessary adjustments to the mix it still can be worked. Oti et al. (2009) assert that these amount of moisture can be dealt with successfully in the production without affecting the quality of the block. The low moisture (1.35) of the stone dust offers the self evident benefits of use in wet climate or when the manufacture entails the need to control the moisture content of the product accurately. The moderate moisture content (2.41%) in the brownish soil will make it easier to control the moisture in production.

The specific gravity of all the materials used is within the expected range of a material used in the manufacturing of sandcrete blocks. The specific

Table 2 | Properties of Materials Used in Block Production

S/N	Parameter	Brownish Soil	Sand	Stone Dust
1	Moisture Content (%)	2.41	4.90	1.35
2	Bulk Density (kg/m³)	2650	1610	1650
3	Specific Gravity (G_s)	2.54	2.70	2.68

gravity of the brownish soil was 2.54, sand was 2.70 and the stone dust had specific gravity of 2.68 (Table 2). The concrete aggregate requirement of the specific gravity of stone dust (2.68) is consistent with the ASTM C33 standard; the latter is particularly significant since it influences directly the density of the cement-sand mixture at the particle packing, which may enhance the density of blocks in the appropriate mixtures (Neville, 2011).

Based on the ASTM C29/C29M (2017) guidelines, bulk density tests were conducted and the findings revealed that the materials had a high difference between them. The densities of the sand, stone dust and brownish soil were 1610 kg/m³, 1650 kg/m³ and 2650 kg/m³, respectively (Table 1). The sand bulk density (1610 kg/m³) falls within the acceptable range of 1600-1800 kg/m³ in the production of sandcrete blocks as in the research conducted by Ogunribido (2012). This medium density is used during the block molding to have a reasonable balance between structural integrity and workability of the final product. In the same manner, the stone dust (1650 kg/m³) has a high density, which means that it can be used as an additional ingredient. Nevertheless, the brownish soil has a very high density (2650 kg/m³), which implies that it would be necessary to mix it very carefully to incorporate it successfully into the process of blocks production. All these test outcomes indicate that although the three materials can be used in producing sandcrete blocks, all possess their own strengths and weaknesses: sand has the key characteristics as a primary constituent material; stone dust is an excellent material that could be potentially used to reinforce some properties; and brownish soil, as it is very dense, would have to be carefully considered and mixed with other materials.

3.2 | Sieve Analysis / Particle Size Distribution

Based on the test results, all three materials could be used in the development of sandcrete blocks, although each of them has its own strengths and weaknesses: sand suits all the basic requirements as the primary constituent material; stone dust has a great potential as the added material to enhance some of its properties; and brownish soil has to be taken into a serious consideration and mixed as it has gradation properties. The results give viable recommendations on how to optimise sandcrete block production without compromising the quality of the product with the available resources in the region. The data of particle size distribution of each material have a characteristic pattern of gradation which has significant impact on the behaviour of each material during the manufacturing of blocks (Figure 2). The sand exhibited a superior distribution characteristic of well-graded construction sand and met the ASTM C33 (2018) criteria of concrete aggregates with 48 percent passing through the 0.212 mm filter and 18 percent passing the 0.075mm screen. This distribution is especially important because it guarantees correct packing of particles in the cement -sand matrix, which influences the ultimate strength and workability of the blocks when they are moulded. The more subtle-grade of the stone dust (23% retained at 0.212 mm and 24% passed 0.075 mm) suggests that the particle can be used to increase block density when employed in part of sand.

The analysis of the Ogunribido (2012) research revealed the balance of gradation of the sand was within the allowable level of manufacturing sandcrete blocks. Through this even distribution, there is a good compromise between the block molding workability and structural integrity of the end product. The bimodality of the stone dust, which is a potential supplemental material, is due to the fact that the brownish soil has undergone continuous gradation with 49.5 as the percentage held at 0.212 mm, which may need mixing to achieve the best outcome. Findings of the block manufacturing in the fines content investigation were very remarkable. Even the fact that the sand contains 18 per cent of less than 0.075 mm in the sieve is manageable with the necessary adjustments to the mix, though it is substantially higher than the typical 15 per cent suggested by BS 882:1992. According to Oti *et al.,* (2009), manufacturing fines can be controlled without deteriorating the quality of blocks. The more fines the stone dust (24 percent) obviously allows the making of denser blocks, however, it is also necessary to pay attention to moisture regulation.

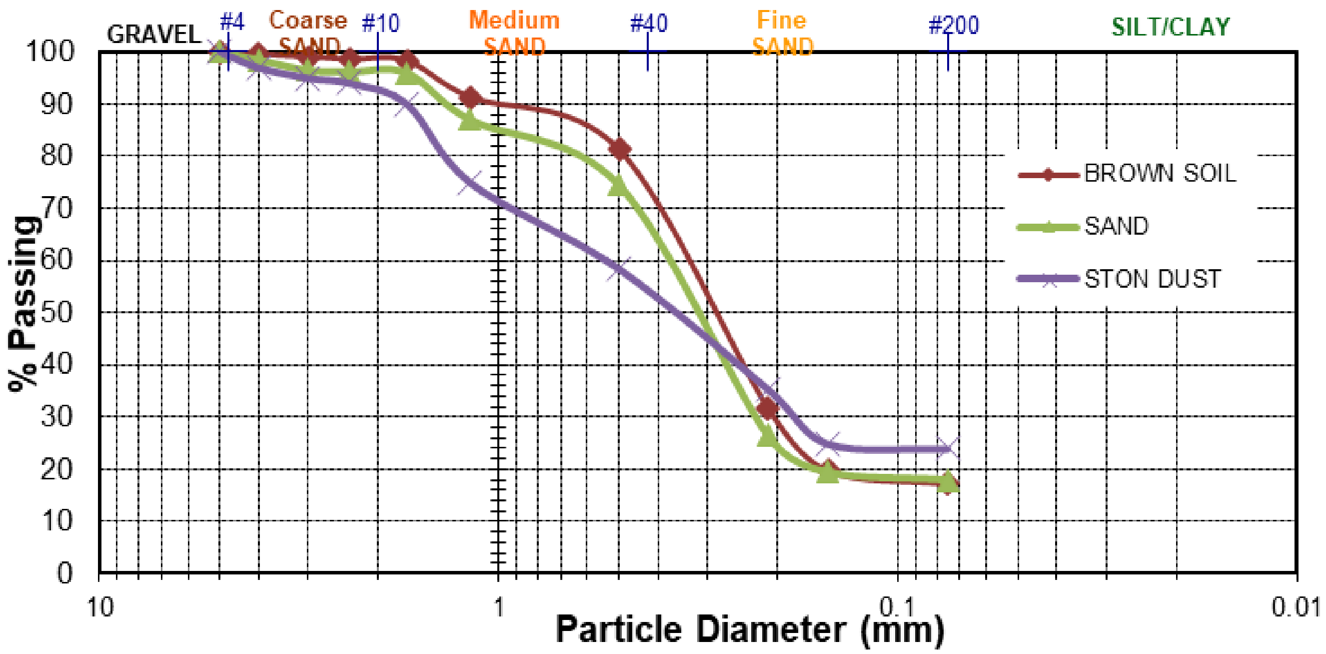

Figure 2 | Particle size distribution of soil samples

3.3 | Compressive Strength

Investigation on compressive strength of sandcrete blocks in five Local Government Areas in Ogun State (Ado Odo Ota, Ifo, Likosi Simawa Sagamu, and Obafemi Owode) produced disturbing results as compared to the 1.2 N/mm² required standard of non-load bearing walls as stipulated by the NIS 87:2007. The research determined that noncompliance was prevalent with Ado Odo Ota and Ifo LGAs recording the worst scores with all the samples tested recording below the required strength levels. Likosi Simawa Sagamu LGA also performed poorly in compliance and 6-inch blocks performed a bit better. The compressive strengths of both 9-inch blocks and 6-inch blocks at these places are quite low between 0.17 and 1.00 N/mm². The outcomes of Obafemi Owode LGA were mixed; there were blocks that fulfilled the requirements and blocks that failed to do the same. The results have been summarized in Figure 3. The so-called defects are probably due to the constellation of different factors such as improper mix ratios, low quality materials and improper curing methods. This has led to a general

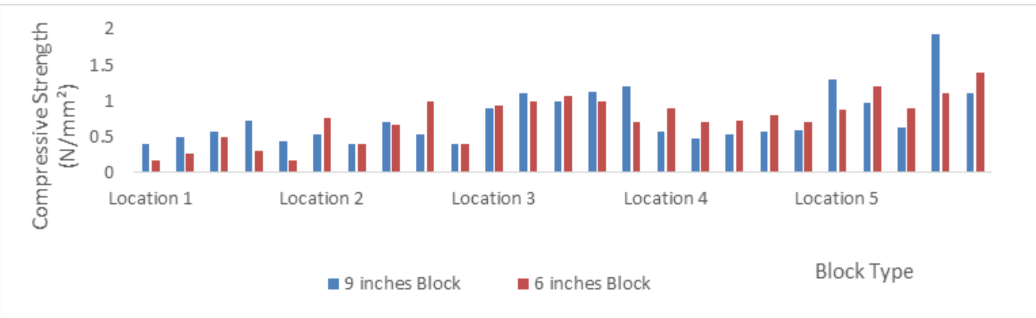

Figure 3 | Summary of findings of the compressive strength

concern on integrity of buildings and structural safety due to these discoveries. The solutions found in quick fixes involve tougher enforcement of the standards, block maker training, better production processes and quality control mechanisms.

3.4 | Water Absorption of Block Samples

3.4.1 | Water absorption of samples from Location 1 (Ado Odo Ota LGA)

The water absorption test of the sandcrete blocks of Location 1 (Ado Odo Ota LGA) displays a major and profound violation of the NIS 87 (2007) criteria. Test results indicated that 4 of 5 9-inch blocks and 100% of the 6-inch block did not reach the 12 per cent water absorbance limit, which implies they have a serious problem with quality control across production facilities.

Group A recorded 9.44% absorption for 9-inch blocks and 17.58% for 6-inch blocks, according to the study. Group B's measurements for 9-inch and 6-inch blocks were 16.18% and 17.18%, respectively. Group C displayed 14.62% for 6-inch blocks and 13.27% for 9-inch blocks (Table 3). Group D's 6-inch block had the maximum absorption rate of 18.07%, while their 9-inch block complied at 10.38%. Group E registered 17.45% for 9 inches blocks and 15.52% for 6 inches blocks. These results reveal several critical findings. First, all the 6 inches blocks failed, with absorption rates ranging from 14.62% (Group C) to 18.07% (Group D), representing 22% to 51% above the permissible limit. Second, only one 9 inches block sample (Group D) met the standard, while others exceeded it by up to 45% (Group E at 17.45%). Third, Group D had inconsistent performance for both 9 inches blocks with the worst-performing 6 inches blocks (Figure 4.8). These findings have serious structural implications. The high absorption rates will likely can reduce compressive strength by 30-50% when wet, and shorten building lifespan by 40-60% (Garbalińska *et al.,* 2020). This widespread non-compliance among producers points to a crisis in the business that requires quick action.

Table 3 | Water Absorption for Location 1 (Ado Odo Ota LGA)

Group	9 inches Block			6 inches Block		
	Absorption (%)	% Compliance (≤12%)	Meets NIS 87:2007	Absorption (%)	% Compliance (≤12%)	Meets NIS 87:2007
A	9.44	79% (Non-compliant)	No	17.58	147% (Non-compliant)	No
B	16.18	135% (Non-compliant)	No	17.18	143% (Non-compliant)	No
C	13.27	111% (Non-compliant)	No	14.62	122% (Non-compliant)	No
D	10.38	87% (Compliant)	Yes	18.07	151% (Non-compliant)	No
E	17.45	145% (Non-compliant)	No	15.52	129% (Non-compliant)	No

3.4.2 | Water absorption of block samples from Location 2 (Ifo LGA - Alagbole/Akute)

In the evaluation of the water absorption of sandcrete blocks from Location 2 (Ifo LGA-Alagbole/Akute), Group F recorded 9.55% absorption for 9-inch blocks and 14.24% for 6-inch blocks. Group G measured 13.11% for 9 inches blocks and 15.98% for 6 inches blocks. Group H showed 13.03% for 9 inches blocks and 11.47% for 6 inches blocks. Group J recorded 11.52% for 9-inch blocks and

16.98% for 6-inch blocks, whereas Group I recorded 13.38% for 9-inch blocks and 12.43% for 6-inch blocks (Table 4). Significant non-compliance with the NIS 87 (2007) criterion is also revealed by this evaluation. According to test results, four out of five 6-inch blocks and three out of five 9-inch blocks did not exceed the maximum 12% water absorption standard, showing widespread problems with quality control throughout production facilities (Figure 4.9).

Additionally, these data show several important conclusions. First, absorption rates ranged from 12.43% (Group I) to 16.98% (Group J), or 4% to 42% above the allowable limit, and 80% of 6-inch blocks failed. Second, 60% of 9-inch block samples performed better than expected, with Group I, which performed the lowest at 13.38%, exhibiting 12% over-absorption. Third, variable production quality was evident as only Group H showed compliance for 6-inch blocks (11.47%) and failed for 9-inch blocks (13.03%).

There are significant structural ramifications to these discoveries. The increased absorption rates could shorten a building's lifespan by 30–50% by reducing wet compressive strength by 25–40% and accelerating weathering effects (Garbalińska *et al.,* 2020). Numerous firms' extensive non-compliance points to structural problems with the local construction materials industry' quality control

Table 4 | Water Absorption for Location 2 (Ifo LGA - Alagbole/Akute)

Group	9 inches Block			6 inches Block		
	Absorption (%)	**% Compliance (≤12%)**	**Meets NIS 87:2007**	**Absorption (%)**	**% Compliance (≤12%)**	**Meets NIS 87:2007**
F	9.55	(Compliant)	Yes	14.24	(Non-compliant)	No
G	13.11	(Non-compliant)	No	15.98	(Non-compliant)	No
H	13.03	(Non-compliant)	No	11.47	(Compliant)	Yes
I	13.38	(Non-compliant)	No	12.43	(Non-compliant)	No
J	11.52	(Compliant)	Yes	16.98	(Non-compliant)	No

3.4.3 | Water absorption of block samples from Location 3 (Isheri LGA - OPIC/Kara Axis)

The water absorption analysis of sandcrete blocks from Location 3 (Isheri LGA-OPIC/Kara Axis) reveals unsettling patterns of noncompliance with the NIS 87 (2007) norm. The test results showed that four out of five 6-inch blocks and three out of five 9-inch blocks failed to reach the 12% maximum water absorption limit, and thus, there is still a problem of quality control in the production factories. The findings indicated that the absorption rate of Group K was 14.26% with 6-inch blocks, and 12.04% with 9-inch blocks. Group L recorded 12.02% for 9-inch blocks and 15.41% for 6-inch blocks, according to Table 5. Group M displayed 12.73% for 9-inch bricks and 10.50% for 6-inch blocks. Group N reported 8.82% for 9-inch blocks and 16.94% for 6-inch blocks, whereas Group O recorded 10.08% for 9-inch blocks and 12.62% for 6-inch blocks. These studies highlight several significant conclusions. First, 80% of 6-inch blocks showed absorption rates between 12.62% (Group O) and 16.94% (Group N), which were 5% to 41% higher than the allowed maximum. Second, Group M (12.73%) had the lowest performance and 6% overabsorption, with 60% of 9-inch block samples failing to comply. Third, Groups K and L reported low noncompliance (12.04% and 12.02%, respectively) for 9-inch blocks,indicating that they were nearly in compliance.

Many production problems are probably the cause of the high absorption properties. Such results have significant structural implications. Garbalinska *et al.,* (2020) argue that the high absorption rates may lead to a 20-35 percent decrease in the wet compressive strength and, at the same time, a 25-45 percent drop in the durability of the structure. The consistent trends of non compliance in different block sizes are indicators of fundamental manufacturing problems that must be eliminated immediately.

Table 5 | Water Absorption for Location 3 (Isheri LGA - OPIC/Kara Axis)

Group	9 inches Block			6 inches Block		
	Absorption (%)	**% Compliance (≤12%)**	**Meets NIS 87:2007**	**Absorption (%)**	**% Compliance (≤12%)**	**Meets NIS 87:2007**
K	12.04	100% (Marginal)	No	14.26	119% (Non-compliant)	No
L	12.02	100% (Marginal)	No	15.41	128% (Non-compliant)	No
M	12.73	106% (Non-compliant)	No	10.50	88% (Compliant)	Yes
N	8.82	74% (Compliant)	Yes	16.94	141% (Non-compliant)	No
O	10.08	84% (Compliant)	Yes	12.62	105% (Non-compliant)	No

3.4.4 Water absorption of block samples from Location 4 (Likosi/Simawa - Sagamu Axis)

The water absorption assessment of sandcrete blocks from Location 4 (Likosi/Simawa-Sagamu Axis) shows significantly greater compliance with the NIS 87(2007) norm than the other locations. Results of the test indicated that these production facilities were having satisfactory quality control procedures as four out of five 6-inch blocks and all five 9-inch blocks were within the 12 percent water absorption maximum. The test reveals that Group P takes 11.29 percent of 9- inch brick and 11.66 percent of 6- inch block. The performance of the Group Q was quite improved scoring 7.64% and 7.79% respectively on 9 and 6 inch block respectively. Group R had excellent results with a score of 8.22% on 9-inch blocks and 7.79% on 6-inch blocks. Table 6 indicates that Group S got 9.15 percent on 9-inch blocks and 12.74 percent on 6-inch blocks as contrasted to Group T with 10.08 percent on 9-inch blocks and 10.00 percent on 6-inch blocks.

These results have some interesting observations. To start with, all the 9-inch blocks proved to be completely compliant with the highest and the lowest absorption rates of 7.64% (Group Q) and 11.29% (Group P), respectively, fitting the acceptable framework with a significant margin. Second, 80% of 6-inch blocks exceed the criterion and thus Group S only slightly exceeds the threshold by 12.74, or by almost 6%. Third, Groups Q and R were remarkably high in production standards with the absorption level being less than 8.5% when using both block sizes (Table 6). These positive results have significant structural benefits. The long-term low absorption rate guarantees higher retention of compressive strength (85-95% of dry strength when wet) and a substantial extension of construction time (50+ years in the construction of buildings) as indicated by Panagiotou et al. (2021). The slight non-conformity of the Group S 6 inch block must be corrected, although this does not take away the excellent performance of this place.

Table 6 | Water Absorption of location 4 (Likosi/Simawa - Sagamu Axis).

Group	9 inches Block			6 inches Block		
	Absorption (%)	% Compliance (≤12%)	Meets NIS 87:2007	Absorption (%)	% Compliance (≤12%)	Meets NIS 87:2007
P	11.29	94% (Compliant)	Yes	11.66	97% (Compliant)	Yes
Q	7.64	64% (Compliant)	Yes	7.79	65% (Compliant)	Yes
R	8.22	69% (Compliant)	Yes	7.79	65% (Compliant)	Yes
S	9.15	76% (Compliant)	Yes	12.74	106% (Non-compliant)	No
T	9.43	79% (Compliant)	Yes	10.00	83% (Compliant)	Yes

3.4.5 Water absorption of block samples from Location 5 (Obafemi Owode - Redemption City)

The water absorption assessment of sandcrete blocks from Location 5 (Obafemi Owode, Redemption City) shows a distinct pattern of compliance with the NIS 87 (2007) norm. Significant production differences between block sizes are indicated by test findings, which demonstrate 100% compliance for all 6-inch blocks and significant non-compliance for 9-inch blocks. According to the evaluation, Group U achieved 10.53% absorption for 6-inch blocks and 13.89% absorption for 9-inch blocks. For 9-inch blocks, Group V measured 10.27%, and for 6-inch blocks, 10.32%. With 9.71% for 9-inch blocks and 10.53% for 6-inch blocks, Group W performed quite well. With 13.19% for 9-inch blocks and an outstanding 6.73% for 6-inch blocks, Group X showed the biggest difference. Group Y recorded 8.22% for 6-inch blocks and 13.57% for 9-inch blocks (Table 7).

These results draw attention to several important conclusions. First, all the 6-inch blocks that were tested met the requirements, with absorption rates ranging from 6.73% to 10.53%. Group X's 6-inch blocks performed very well at 6.73%. Second, with absorption rates ranging from 13.19% to 13.89%, or 10–16% above the allowable limit, three out of five nine-inch blocks did not comply. Third, major process control problems unique to larger block production are shown by the notable performance difference between block sizes within the same production groups, especially in Group X where

Table 7 | Water Absorption for Location 5 (Obafemi Owode - Redemption City)

Group	9 inches Block			6 inches Block		
	Absorption (%)	% Compliance (≤12%)	Meets NIS 87:2007	Absorption (%)	% Compliance (≤12%)	Meets NIS 87:2007
U	13.89	116% (Non-compliant)	No	10.53	88% (Compliant)	Yes
V	10.27	86% (Compliant)	Yes	10.32	86% (Compliant)	Yes
W	9.71	81% (Compliant)	Yes	10.53	88% (Compliant)	Yes
X	13.19	110% (Non-compliant)	No	6.73	56% (Compliant)	Yes
Y	13.57	113% (Non-compliant)	No	8.22	69% (Compliant)	Yes

6-inch blocks achieved 6.73% while 9-inch blocks reached 13.19%. Better complication characterises the compliant 6-inch blocks which retain 85-90% of their compressive strength under wet conditions. Panagiotou *et al.,* (2021) expect that it will deliver over 50-year service lives in structural applications. It seems that the 9-inch blocks which fail, instead, may not last 30 to 40 years in wet climate, when wet gain 25 to 35 percent of their strength, and become more vulnerable to weathering and efflorescence.

4. | Conclusion and Recommendations

4.1 | Conclusion

The following conclusions are drawn from the study:

a. The lowest score was on ado odo ota, Ifo, and Lakosi Simawa LGAs on compressive strength; all the tested blocks were below the NIS standard. On the contrary, the compliance was uneven in Obafemi Owode LGA: some blocks were at or beyond the standard, whereas others were not.

b. The performance of the 6-inch blocks was usually poor compared to the 9-inch blocks indicating that there were some inconsistencies in the production methods. This means that varying block sizes might have varying production methods and this might result in variation in strength.

c. The values of compressive strength, which were ranging between extremely low (ex. 0.17 N/mm²) and quite high (ex. 1.93 N/mm 2) indicated the great differences in the quality of production of the LGAs.

d. Ifo, Isheri and Ado Odo Ota LGAs blocks were above the 12 percent limit of water absorption which shows their low durability and prone to water damage. Conversely, Likosi Simawa Sagamu LGA had most of its blocks with water absorption limit indicating superior manufacturing management and choice of materials.

e. The block quality depends on the gradient in the bulk density, the specific gravity as well as the moisture content of the soil at which the blocks are made.

4.2 | Recommendations

The following recommendations are suggested from the study:

a. The use of 1:6 or 1:8 mix-ratio of cement and sand and well graded aggregates should be embraced by the block producers so as to improve compaction and minimize void thus making blocks of sufficient strengths.

b. The compliance with NIS 87:2007 and the imposition of serious penalty to the violators of the standard by the regulatory bodies in block making industry should be enforced. Along with that, awareness systems and campaigns should be created.

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