ABUAD Journal of Engineering Research and Development (AJERD)

ISSN: 2645-2685

Volume 3, Issue 2, 43-53

Assessment of Selected Engineering Properties of Sandcrete Blocks from Akinyele Local Government Area, Oyo State

Ajibola Ibrahim QUADRI[1], Mubaarak ABDULHAMEED[1]

[1]*Department of Civil Engineering, The Federal University of Technology, Akure, Nigeria*

aiquadri@futa.edu.ng/abdulhameedcve129390@futa.edu.ng

Corresponding Author: aiquadri@futa.edu.ng

Date Submitted: 03/07/2020
Date Accepted: 01/10/2020
Date Published: 31/12/2020

Abstract: *Previous works of research have indicated that quality standards are being ignored by actors in Nigerian Construction industry. This paper investigated and reported the strength properties of sandcrete blocks produced in Akinyele Local Government Area of Oyo State, Nigeria. A total of 30 blocks were acquired, three (3) blocks each of 6" (450 mm × 150 mm × 225 mm) and 9" (450 mm × 225 mm × 225 mm) were collected from five (5) industries randomly. Soil samples were also collected and tested. The tests carried out were, sieve analysis, specific gravity, compressive strength, and water absorption rate. The compressive strength of all the blocks was below standard requirement as their values range between 0.22 N/mm² and 0.46 N/mm² for the (9") blocks, 0.3 N/mm², and 0.6 N/mm² for the (6") blocks. It could be concluded that sandcrete blocks from the selected industries in the Local Government Area did not meet 2.1 N/mm², the minimum strength required for non-load bearing walls. Therefore, they should not be used as non-load bearing units. It is recommended that professional bodies and government agencies responsible for quality assurance of building units should enforce compliance of block industries with the minimum required specifications.*

Keywords: *Sandcrete, compressive strength, sieve analysis, water absorption rate, density.*

1. INTRODUCTION

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 [1,2]. The global concerns for cases of the sudden collapse of buildings across the world, and in Nigeria in particular demand that materials used for the construction of buildings meet minimum requirements [3]. In some cases, even though the building has not totally collapsed, the aesthetics value is lost to cracks and other defects.

In Nigeria, the common causes of building collapse have been attributed to the rampant use of sub-standard building materials, bad design; faulty construction; foundation failure; extraordinary loads, use of unqualified contractors and poor project monitoring and above all, lack of enforcement of building codes by the relevant Town Planning Officials [4-7]. Part of this problem is due to the poor quality of sandcrete blocks used as walling units. For a long time in Nigeria, sandcrete blocks are manufactured in many parts of the country without any reference to suit local building requirements or good quality work [8-9].

It is in this light that this study aims to investigate the quality of sandcrete blocks produced in Akinyele Local Government Area of Oyo State. Akinyele local government area as shown in Figure 1 lies between latitude 7°29' to 7°40' while its longitude ranges between 3°45' to 4°04'. The total land area is about 219.2 km². It is located along the northern area of Ibadan city. Further, the area is bounded in the North by Afijio Local Government Area, in the west by Ido Local Government Area, in the south by Ibadan-North Local Government Area and in the east by Lagelu Local Government Area and Osun State.

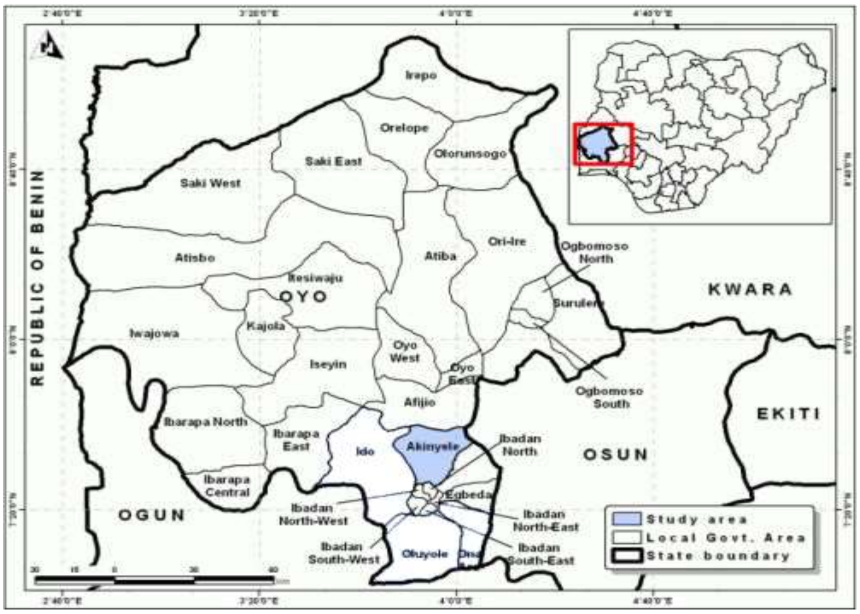

Figure 1: Map of Akinyele Local Government Area (www.open-science-repository.com)

2. -METHODOLOGY

The study evaluated some selected mechanical properties of commercially produced sandcrete hollow blocks for construction in Akinyele. Six inches (6") of 450 mm × 225 mm × 150 mm and nine inches (9") of 450 mm × 225 mm × 225mm are generally produced in Nigeria, these were obtained from the selected block producing industries and tested in accordance to NIS: 87:2004 and 2007 [11]. They are either made manually or by vibrating machine with controlled mix and quality materials. The sandcrete blocks were made from a mixture of cement, fine aggregate, and water. The cement commonly used is the ordinary Portland (limestone) cement of grade 42.5R while the fine aggregate is mostly sourced from river sharp sand, and the source of water is majorly from water boreholes and wells. Six (6) pieces (three 6" and three 9") of sandcrete blocks were sampled randomly from each of the selected block industries. 30 pieces of blocks were collected in total and were taken to the laboratory for quality assurance tests in terms of water absorption and strength requirement. Compressive strength, water absorption capacity, density, and elastic modulus tests were the properties tested on the block samples collected. The reason is that water absorption percentage and compressive strength are the two major characteristic requirements specified for testing and verifying the quality of sandcrete block apart from appearance and dimension [10]. Particle size distribution tests (sieve analysis) were also conducted on the soil samples collected from each of the selected block industries.

2.1. Sieve Analysis

Sieve analysis is a process of dividing into fractions soils that contain the same sizes of aggregates. This is important in the determination of the suitability of the aggregate pile for the mix. The grading of aggregates affects the workability of mortar. The aggregate of interest is thrown into series of sieves nested in order, the sieve with the smallest pore size is placed at the bottom and the sieve with the largest pore size is placed at the top. After vigorous shaking, the mass of aggregate retained in each sieve was weighed and percentages were calculated.

Part of the samples taken from each industry was kept in the oven for 24 hours to dry. Five hundred grams (500 g) of the oven-dried sample was taken using a digital weighing apparatus, poured in the set of sieves, and then shaken gently for ten (10) minutes. The mass retained in each sieve was weighed and recorded. Thereafter, the percentage mass retained on each sieve number was calculated as given in Eq.1.

$$\text{Percentage retained} = \frac{\text{mass retained}}{\text{total mass}} \times 100\% \quad (1)$$

Since the knowledge of fines is essential to appreciate how soil can be adopted for construction materials or as a foundation for structures [12], hence the selection of soil for specific use can depend on the assortments of particles embedded. Two coefficients, uniformity, Cu, and curvature, Cc, have been numerically measured to give information on the gradations. Eqs. 2 and 3 describe the two coefficients.

$$C_u = \frac{D_{60}}{D_{10}} \quad (2)$$

$$C_c = \frac{(D_{30})^2}{D_{10}\, D_{60}} \quad (3)$$

D_{60}, D_{30}, D_{10}, are the diameter of the soil particles for which 60%, 30%, and 10% of the particles respectively are finer. The criteria for classifying the limits of uniformity and that of concavity are described in Table 1. This is strictly applied to coarse sand and fine gravel.

Table 1: Criteria for classifying coefficient of uniformity and curvature

Grading	Remark	Criteria
Well graded	Gravel content > Sand content	$C_u \geq 4; 1 \leq C_c \leq 3$
	Sand content > Gravel content	$C_u \geq 6; 1 \leq C_c \leq 3$
Poorly Graded	Gravel content > Sand content	$C_u < 4;\ C_c < 1 \text{or}\ C_c > 3$
	Sand content > Gravel content	$C_u < 6;\ C_c < 1 \text{or}\ C_c > 3$

2.2. Compressive Strength Test (C_s)

This test was conducted in accordance with the specification given in the NIS 87:2000 standard [11] for producing sandcrete blocks. The compressive strength of the sandcrete blocks was determined through crushing. This was carried out on all the Thirty (30) samples of label blocks produced from different industries. The blocks were weighed, and a wooden plank was placed underneath the block and carefully placed between the center of the plates of the crushing machine, another wooden plank was placed on top of the block to enable the uniform transfer of the load around the surface of the block. During crushing, the indicator (digital) rose gradually until it drops indicating failure. The reading at this point was noted and recorded. The compressive strength in N/mm^2 of each block was then calculated as given in Eq.4.

$$C_s = \frac{\text{Crushing Load (N)}}{\text{Net area of the block (mm}^2\text{)}} \quad (4)$$

The average results obtained was taken as the crushing strength of the blocks and shall not be less than 3.45 N/mm^2 for load-bearing hollow sandcrete blocks and 2.1 N/mm^2 for non-load bearing hollow sandcrete blocks produced mechanically [11].

2.3. Water Absorption Rate (W_b)

Each specimen of the deployed sandcrete block sample was first weigh in a dry state to obtain its dry Mass (M_1) and then fully immersed in water for 24 hours when the samples were completely wetted, they were removed and the trace of water were wipe off with a damp cloth and then weigh again to obtain wet weight (M_2). This procedure was repeated on other samples and the water absorption capacity was computed from Eq. 5. The average of the results obtained was regarded as the water absorption of the block and shall not exceed 12% as specified by (NIS 583:2007) [13].

$$W_b\ (\%) = \frac{M_2 - M_1}{M_1} \times 100 \quad (5)$$

2.4. Specific Gravity

The weight of each soil sample relative to the weight of water was examined using specific gravity bottles. 50 g (Ws) of each oven-dried sample was put into a jar, water was added, and it was allowed to stay for 24 hours. The weight of the jar only, the weight of jar filled to the brim with water only, W1, and weight of jar filled with 50g soil sample and water to the brim (W2) were recorded and computed to get the specific gravity of the sample. The mass of the water displaced by the soil sample was measured as, W1+Ws-W2. The specific gravity was then expressed as given in Eq. 6.

$$G_s = \frac{W_s}{W_1 + W_s - W_2} \quad (6)$$

3. RESULTS AND DISCUSSION

3.1. Sieve Analysis

The result of the particle size distribution test carried out on the soil samples (collected from the block industries) are presented in Table 2 to 6 and Figures 2 to 6. From the Tables, the percentage finer than 0.075 mm is very low. The highest being 3.52%. This shows that the silt/clay content of the samples is insignificant. However, on examine Figures 2 to 6, the soil samples were not evenly graded, even though there is no presence of silt/clay, Fine gravels contributed a high percentage of the soils in all the samples. This could increase the rapid absorption of water and therefore can leave more pores upon drying if not thoroughly mixed.

Table 2: Sieve Analysis for Industry A

Sieve Size (mm)	Mass Retained (g)	% Mass Retained	% Cumulative	% Passing
4.76	27.4	5.48	5.48	94.52
2.36	42	8.4	13.88	86.12
1.7	6.9	1.38	15.26	84.74
1.18	34	6.8	22.06	77.94
0.6	81.4	16.28	38.34	61.66
0.5	90	18	56.34	43.66
0.425	2.1	0.42	56.76	43.24
0.212	159.9	31.98	88.74	11.26
0.15	29	5.8	94.54	5.46
0.075	23.6	4.72	99.26	0.74
Pan	3.7	0.74	100	0
Total	500	100		

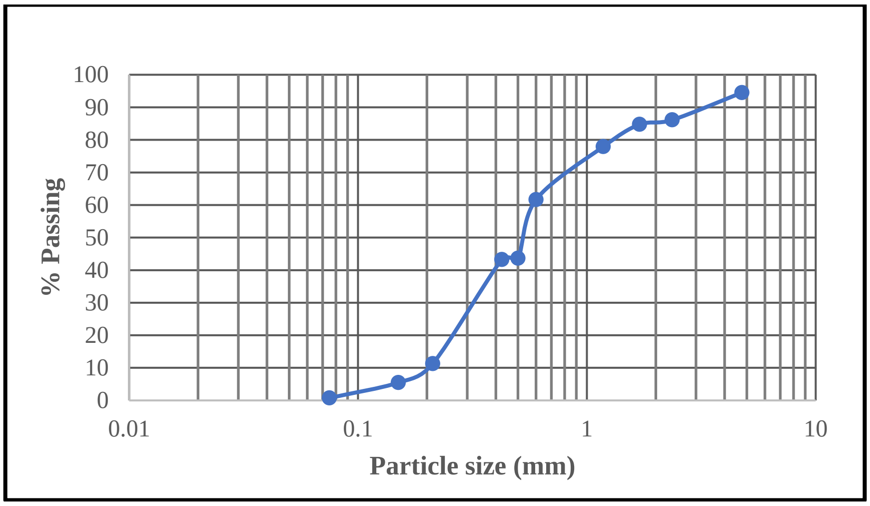

Figure 2: Particle Size Distribution Chart; Industry A

Table 3: Sieve Analysis for Industry B

Sieve Size (mm)	Mass Retained (g)	% Mass Retained	% Cumulative	% Passing
4.76	45.2	9.04	9.04	90.96
2.36	60.7	12.14	21.18	78.82
1.7	19.8	3.96	25.14	74.86
1.18	74.3	14.86	40	60
0.6	124.5	24.9	64.9	35.1
0.5	63.4	12.68	77.58	22.42
0.425	2.6	0.52	78.1	21.9
0.212	64	12.8	90.9	9.1
0.15	12.2	2.44	93.34	6.66
0.075	18.4	3.68	97.02	2.98
Pan	14.9	2.98	100	0
Total	500	100		

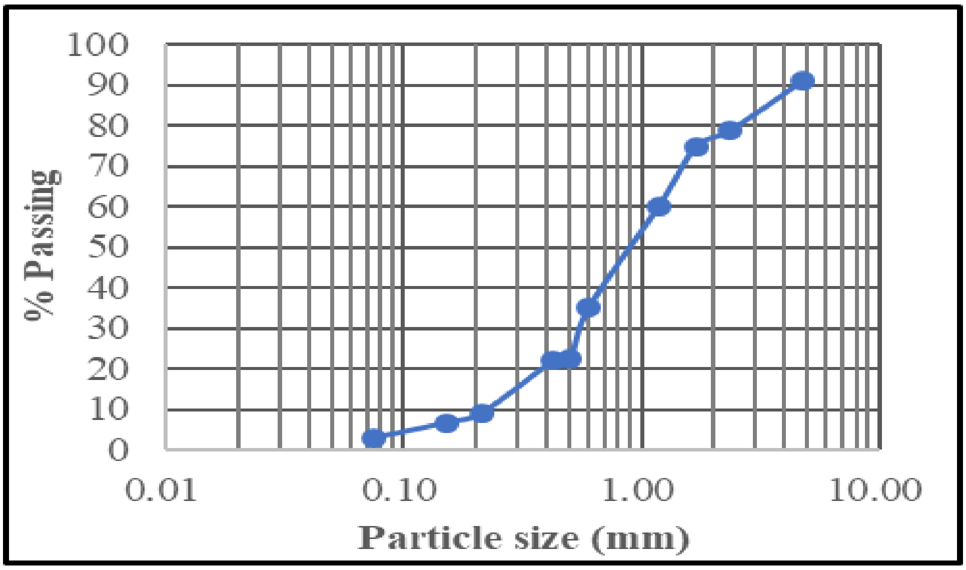

Figure 3: Particle Size Distribution Chart; Industry B

Table 4: Sieve Analysis for Industry C

Sieve Size (mm)	Mass Retained (g)	% Mass Retained	% Cumulative	% Passing
4.76	63	12.6	12.6	87.4
2.36	92	18.4	31	69
1.7	7.9	1.58	32.58	67.42
1.18	41.7	8.34	40.92	59.08
0.6	82.4	16.48	57.4	42.6
0.5	70.9	14.18	71.58	28.42
0.425	1.8	0.36	71.94	28.06
0.212	98.7	19.74	91.68	8.32
0.15	17.8	3.56	95.24	4.76
0.075	14.3	2.86	98.1	1.9
Pan	9.5	1.9	100	0
Total	500	100		

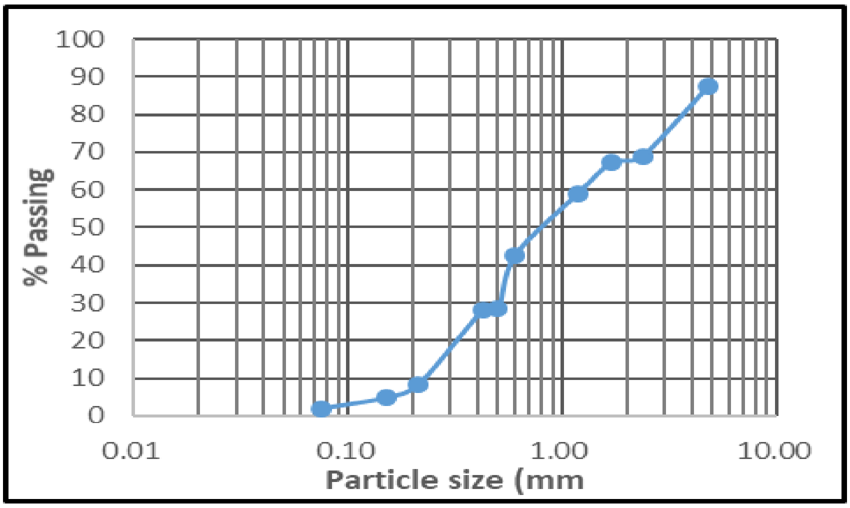

Figure 4: Particle Size Distribution Chart; Industry C

Table 5: Sieve Analysis for Industry D

Sieve Size (mm)	Mass Retained (g)	% Mass Retained	% Cumulative	% Passing
4.76	123.4	24.68	24.68	75.32
2.36	60.1	12.02	36.7	63.3
1.7	4.5	0.9	37.6	62.4
1.18	25.6	5.12	42.72	57.28
0.6	47.1	9.42	52.14	47.86
0.5	64.1	12.82	64.96	35.04
0.425	0.6	0.12	65.08	34.92
0.212	118.4	23.68	88.76	11.24
0.15	24	4.8	93.56	6.44
0.075	14.6	2.92	96.48	3.52
Pan	17.6	3.52	100	0
Total	500	100		

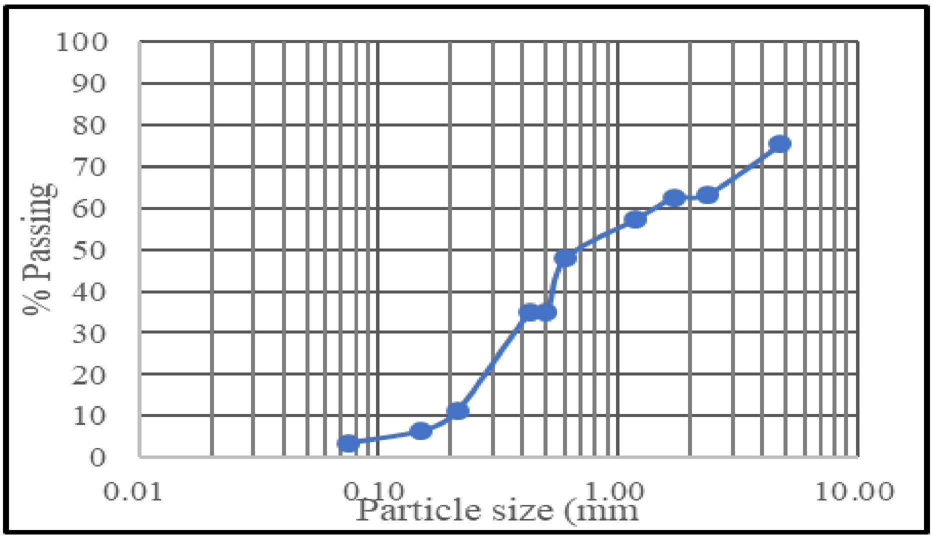

Figure 5: Particle Size Distribution Chart; Industry D

Table 6: Sieve Analysis for Industry E

Sieve Size (mm)	Mass Retained (g)	% Mass Retained	% Cumulative	% Passing
4.76	73.9	14.78	14.78	85.22
2.36	50.1	10.02	24.8	75.2
1.7	5.2	1.04	25.84	74.16
1.18	28.8	5.76	31.6	68.4
0.6	64.3	12.86	44.46	55.54
0.5	77.1	15.42	59.88	40.12
0.425	0.9	0.18	60.06	39.94
0.212	139.2	27.84	87.9	12.1
0.15	26.5	5.3	93.2	6.8
0.075	17.6	3.52	96.72	3.28
Pan	16.4	3.28	100	0
Total	500	100		

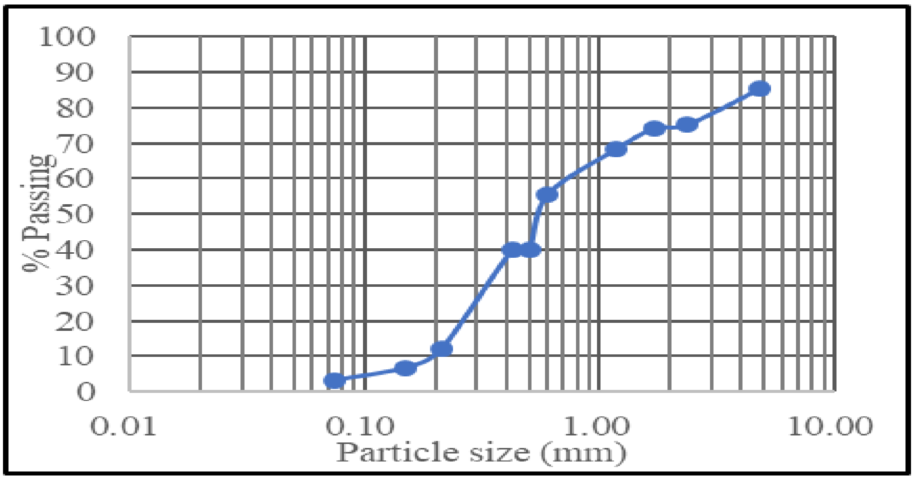

Figure 6: Particle Size Distribution Chart; Industry E

The textural classification of the samples as presented in Table 7 in terms of the coefficient of uniformity and curvature was done. Samples A, C, and E are poorly graded due to the presence of finer gravels contents than the sand contents, and samples A and D are well graded. because of more sand contents than the fine gravel. The initial and final setting time of the block sample can greatly be affected and in the long run, the strength of the block can seriously be affected.

Table 7: Textural Classification of the Industrial Specimens

Specimen	C_u	C_c	Remarks	Grading
A	3	0.8	Fine gravel content is higher than sand content	Poorly graded
B	6.5	1.2	Sand content is higher than fine gravel content	Well graded
C	5.9	0.9	Sand content is higher than fine gravel content	Poorly graded
D	7.5	0.4	Sand content is higher than fine gravel content	Well graded
E	3.8	0.7	Fine gravel content is higher than sand content	Poorly graded

Figure 7 shows the comparison of the particle distribution chart of samples A-E, samples A has the highest fine gravel contents follow by Samples B and E while sample D has the lowest fine gravel content. The distribution of the sample along fine sand are evenly closed. Sample D thus contains more sand than the rest of them and could affect its strength.

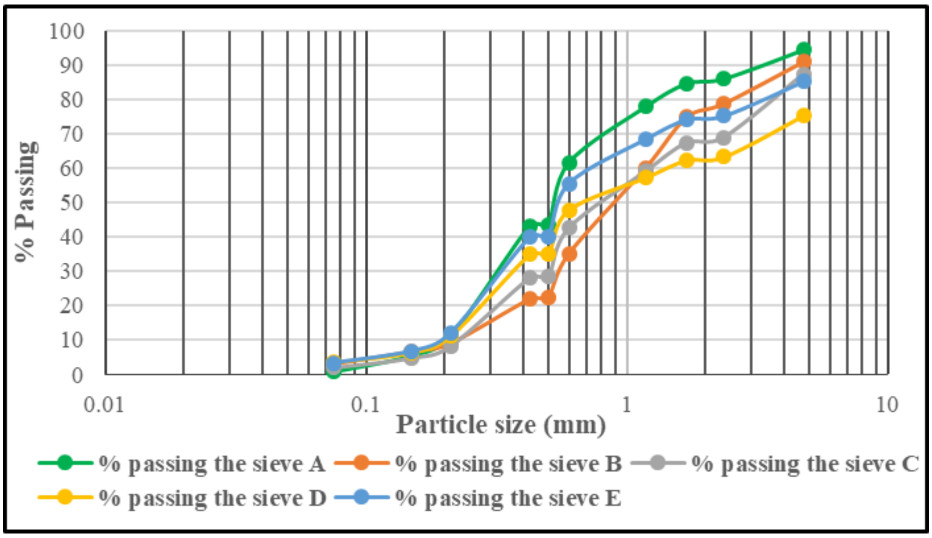

Figure 7: Particle Size Distribution Comparison Chart; Industries A-E

The specific gravity of aggregates has a great influence on the resulting compressive strength of concretes. This, is same for the strength of sandcrete blocks [14]. The results of the average specific gravity tests carried out on the aggregates from each block industry are presented in Figure 8. Sample B has the highest specific gravity follow by samples E and A, while samples D and C have very low specific gravity. From this group, only sample A met the minimum standard specific gravity of 2.63 as given by NIS 87:2000 [13]. It is clear that some contents of organic materials are present in the rest of the soil samples, especially samples C and D which can absorb water and become porous. Consequently, it results in the reduction of the strength of the sandcrete block.

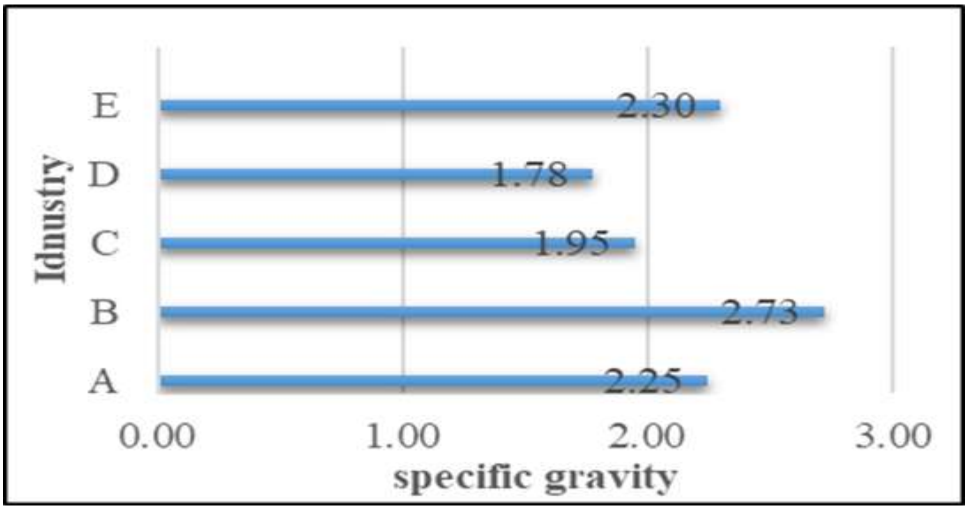

Figure 8: Specific Gravity Distribution of Fine Aggregates Across Industries.

3.3 Water Absorption Rate

The rate of absorption of the sandcrete blocks was measured after immersion in water for 24 hours. The results obtained for the average water absorption for 6- and 9-inches blocks from industry A-E are presented in Figure 9. Block industry A has the highest percentage of water absorption among the 9-inches blocks follow by industry C, the values of A and C exceed the absorption rate of 12% recommended by [13]. Block industry B has the lowest value in the group. Furthermore, the values of water absorption rate for all the block industries except industry D are below the recommended standard for the 6-inches block. Industry B with the lowest absorption rate could have the highest performance strength among the block industries. The implication of a high percentage of water absorption rate than the recommended standard of 12% is that, when exposed to inundation, the rate of permeability will be high, therefore become weakened and eventually fail.

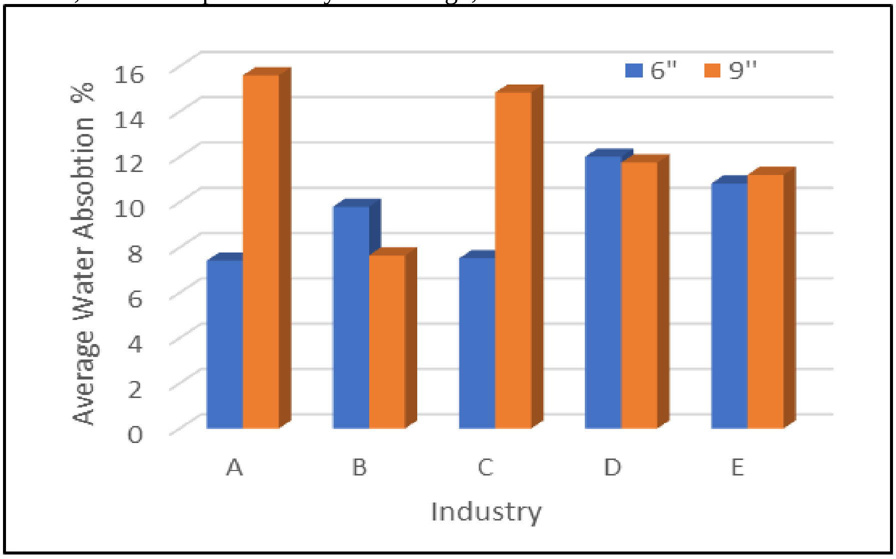

Figure 9: Water absorption rate for 6- and 9-Inches Blocks Across the Industries.

3.4 Density

The test results, for the determination of the dry densities of the sandcrete blocks from respective industries, show that they are within the recommended standard [15] of 1500 kg/m^3 for the dry density of average sandcrete blocks as presented in Figure 10. Block industry A has the highest density for the 6-inches block while all the block industries have almost the same values of dry density for the 9-inches block.

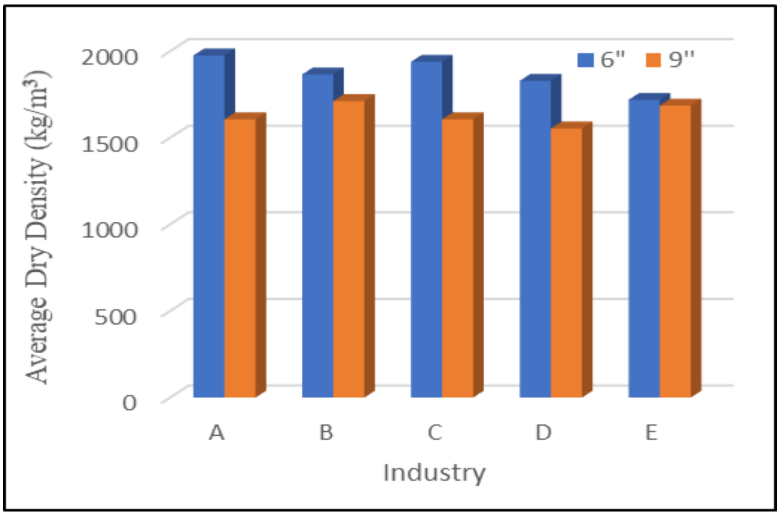

Figure 10: Average Dry Density for 6- and 9-Inches Blocks Across the Industry.

3.5. Compressive Strength of Samples

The results of the average compressive strength tests carried out on the 6 and 9-inches sandcrete blocks are presented in Figures 11 and 12 respectively. The results of the tests indicate that the average compressive strength ranges between 0.3 and 0.6 N/mm^2 for the 6-inches, and between 0.22 and 0.45N/mm^2 for the 9-inches block. The compressive strengths fall below the recommended standards [17, 15]. The Nigeria organization standards [15] recommends that for the non-load bearing wall, the compressive strength of the sandcrete blocks must not less than 2.1N/mm^2. The inferior quality of the blocks can be attributed to poor mix ratio and inadequate curing of the sandcrete blocks. While the [15] standard recommends the use of 1:8 mix ratio cement-sand proportion to achieve the minimum specified compressive strength of 2.1N/mm^2, and 0.45 water-cement ratio with the maximum water absorption rate of 12%, the industries do not adequately measure out the aggregates and quantity of water being used. They resort to approximation thereby undermining the quality of blocks so produced.

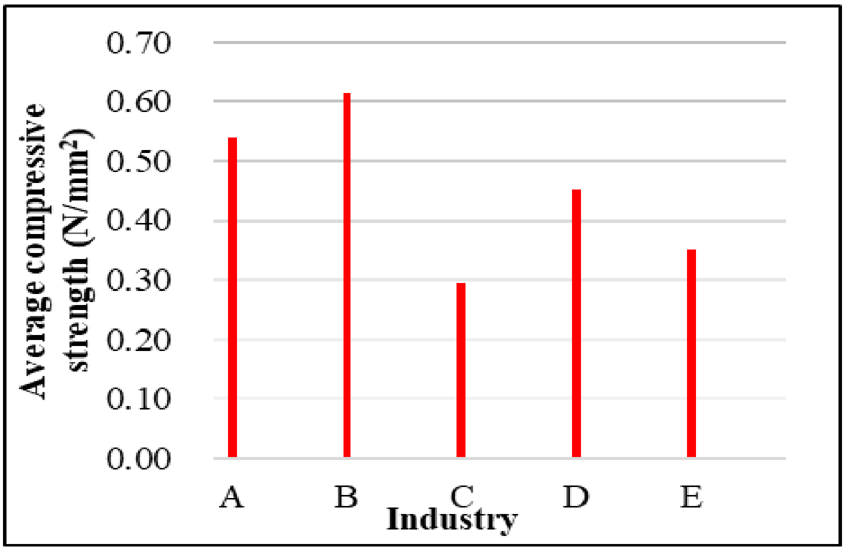

Figure 11: Average Compressive Strength of 6-inches Sandcrete blocks Across the Industries

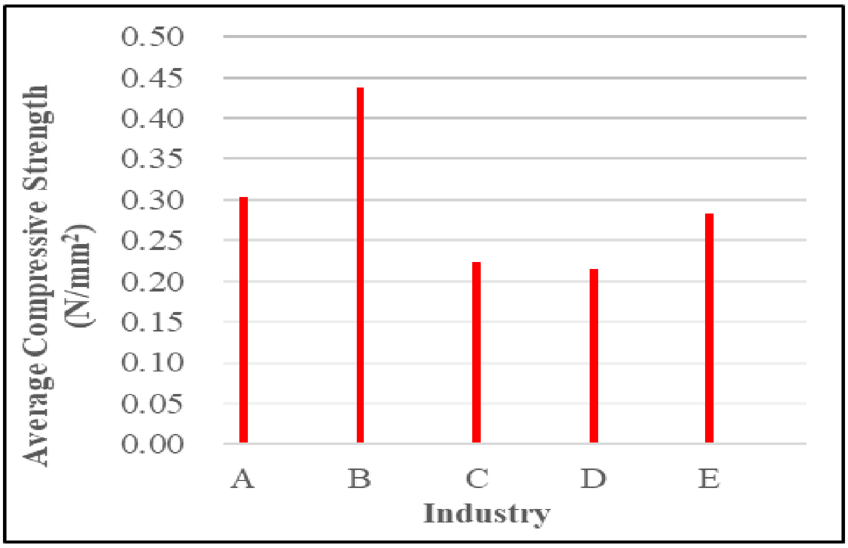

Figure 12: Average Compressive Strength of 9-inches Sandcrete blocks Across the Industries

4. CONCLUSION AND RECOMMENDATION

This study has assessed the quality of sandcrete blocks produced by industries in Akinyele Local Government Area of Oyo State, Nigeria. The quality was assessed based on some selected engineering properties which include compressive strength, water absorption rate, dry density, and the aggregate grading of the coarse aggregate used for production. This study shows that the quality of blocks produced in this area falls below acceptable national and international standards.

The compressive strength of all the blocks tested was below the standard of 2.8 N/mm^2 as specified by BS 6073 [17] and even 2.1 N/mm^2 specified by Committee for the Review of Decisions in Nigeria. The compressive strength of individual 9 inches blocks tested was between 0.220 N/mm^2 and 0.46 N/mm^2 while the compressive strength of individual 6 inches blocks was between 0.3 N/mm^2 and 0.6 N/mm^2.

Thirteen (13) of the fifteen (15) 450 mm × 150 mm × 225 mm (6 inches) blocks tested had a water absorption rates within the maximum specified value of 12% by NIS: 87:2007 [11] while eight (8) of the fifteen (15) 450 mm × 225 mm × 225 mm (9 inches) exceeded 12%.

The above suggests strongly that one of the important causes of failure of buildings, especially for the single-storey and 2-storey failure cases, in Nigeria is the low quality of commercially available sandcrete blocks. It is recommended that professional bodies such as the Nigerian Society of Engineers, Nigerian Institution of Civil Engineers, Nigerian Institution of Builders, and government agencies responsible for quality assurance of building units should enforce compliance of block industries with the minimum required specifications. Owners of block industries should be trained by professional or government bodies and also train their staff on attaining quality products.

REFERENCES

[1] Oyekan G. L. & Kamiyo O. M. (2008). Effect of Nigeria Rice Husk-Ash on some Engineering properties of Sandcrete Blocks, *Research Journal of Applied Sciences*, 3 (5), 345-351.
[2] Lateef H. T.and Quadri, A. I. (2018) Human Error Uncertainties for Structural Detailings In Reinforced Concrete Buildings, *Proceeding of School of Engineering and Engineering Technology, FUTA*. 2018 15.
[3] Ukpata, J. (2006) Structural Design as A Panacea for Building Failures in Nigeria. Nigerian Society of Engineers, Calabar.
[4] Quadri, A. (2019). Reliability Appraisal of Nominal Eccentricity of Short Reinforced Concrete Column Designed to BS 8110 and Eurocode (EN:2)-Ultimate Limit State on Fatigue, *Journal of Reliability Engineering and Resilience.* 1(2):10, doi:10.22115/rer.2019.197264.1013, https://www.rengrj.com/article_92758.html
[5] Quadri A.I. (2019) Reliability Assessment of Reinforced Concrete Column Designed to Eurocode (2)-Ultimate Limit State on Fatigue in *4th International Conference Proceedings of School of Engineering and Engineering Technology FUTA*. 2019. 1102-1128.
[6] Aderinola, O. S. Omolola, O. E. & Quadri, A. I. (2018). Effect of Calcium Carbide Waste Powder on Some Engineering Properties of Bamboo Leaf Ash Concrete, *OALib*, 5(11), 1–15. doi: 10.4236/oalib.1104990.
[7] Badejo, E. "Engineers, Others Urge Multi-Disciplinary Approach to Curb Building Collapse". The Guardian Newspapers [Online] Available: http://www.naijaproperties.com/news_95php. (2009, July 13).
[8] Quadri A. I. & Ijesoh, L. I. (2017). Assessment of the Mechanical Properties of Some Selected Sandcrete Hollow Blocks in Kogi State, *EJERS*, 2(11), 43. doi: 10.24018/ejers.2017.2.11.526.

[9] Bamidele, O.T. (2000, Feb.,18). "Building Collapse: Stakeholders Proffer Solutions on Way Forward". Daily Sun Newspapers, Retrieved from http://www.dailysunngr.com

[10] Oyekan G. L. and Kamiyo O. M. (2008) Effect of Nigeria Rice Husk-Ash on some Engineering properties of Sandcrete Blocks, *Research Journal of Applied Sciences*, 3 (5), 345-351.

[11] NIS (2000) NIS 87:2000. *Nigerian Industrial Standard. Standard for sandcrete blocks*. Standards Organisation of Nigeria (SON), Lagos.

[12] Aderinola, O.S., Oguntoyinbo, E. And Quadri, A.I. (2017). Correlation of California Bearing Ratio Value of Clays with Soil Index and Compaction Characteristics. *International Journal of Scientific Research and Innovative Technology* . ISSN: 2313-3759,12-22.

[13] NIS (2007) NIS 583:2007. Nigerian Industrial Standard. S*pecification for Standard Sand for Mortar Prism Test of Cement.* Standards Organisation of Nigeria (SON), Lagos.

[14] Afolayan, J.O., Arum C. and Daramola C.M. (2008) Characterisation of the Compressive Strength of Sandcrete Blocks in Ondo state, Nigeria, *Journal of Civil Engineering Research and Practice*, 5 (1), pp. 15-28.

[15] British Standards Institution. (1970) BS 2028. Pre-cast concrete blocks. Her Majesty Stationery Office, London.

[16] Ajagbe W.O., Ganiyu A.A. and Adeniji A.A. (2013) Quality Assesment of Sandcrete Blocks in Ibadan - A Review., *Epistemics in Science, Engineering and Technology*., 3 (2), pp 272-277.

[17] British Standards Institution. (1981) BS 6073-1., *Precast Concrete Masonry Units*., Her Majesty Stationery Office, London.