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Comparing the Characteristics Strength of Hollow Sandcrete Blocks Produced Manually in Landmark University and Machine Compacted in Omu-Aran Metropolis

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ABSTRACT
This project work investigated and compared the strength of manual method of producing hollow sandcrete blocks with machine compaction method of producing hollow sandcrete blocks obtained from Omu-Aran, Kwara State, Nigeria. A total of sixty (60) was used for this project work. The block industries were visited and a total of Forty-eight (48) blocks were obtained, twelve (12) blocks for both 6″ and 9″ from four block industries and control sample of 1:7 mix design were produced, six (6) blocks each of 6″ and 9″. The blocks were subjected to various tests such as dimension check, bulk density, water absorption and compressive strength. The average density in these industries and control sample were within the minimum bulk density of 1,500 kg/m^3 specified by BS 2028 (BSI 1975). The water absorption rates for the block industries ranged between 8.826 to 13.363% compared to the average water absorption for the control sample which 10.1%. Only one block industry was able to meet the minimum requirement for water absorption, which is below 12%. The compressive strength for 6-inch blocks from the block industries ranged from 0.25-0.41N/mm^2 and for 9-inch ranged from 0.3-0.49N/mm^2 compared to the compressive strength of control samples for 6-inch and 9-inch produced were 0.31N/mm2 and 0.39N/mm^2 respectively, which are below required standards. It revealed that machine compacted blocks have a higher compressive strength than the manually compacted blocks, but all the samples of the sandcrete blocks were below the Nigeria Industrial standard (NIS 87:2000) specification.

Keywords: Comparing, Characteristics, Strength, Hollow Sandcrete Blocks, Produced Manually, Machine Compacted, Omu-Aran Metropolis.

INTRODUCTION
Sandcrete blocks are a special type of man-made structural component used in civil engineering projects. For example, in buildings, walls are built (using blocks) to offer shelter, protection, conveniently partition space, privacy, and security for man and his

property. The common sizes of sandcrete blocks available for use in Nigeria are 9 inch and 6 inch with dimensions 450mm x 225mm x 225mm and 450mm x 150mm x 225mm respectively (Rasheed & Akinleye, 2016). Sandcrete blocks are typically made from a set or prescribed mix ratio or amount of sand, water, and Portland cement. They should be made of a standard mix proportion of 1 part of cement to 6 parts of sharp sand; that is, 1:6 cement-sand ratio. However, the quality of the blocks produced varies depending on the industry, the location where they are produced, the methods of production, and the quality of the materials used (Rasheed & Akinleye, 2016). Because of the widespread use of sandcrete blocks for residential, institutional, agricultural, commercial, and health-care facilities, it is important in the construction industry, which is also an important aspect of Nigeria's economy.

The compressive strength of sandcrete blocks is influenced by the mix percentage, material quality, size, shape, and manufacturing method. The minimum compressive strength of the blocks after 28 days is 2.5N/mm2 as allowed by Nigerian Industrial Standard (N.I.S). It is expected that the compressive strength meets the specified strength after 28days because this is when its strengths is expected to be maximum according to British standard. Sandcrete blocks have been manufactured manually and mechanically to meet the need of building due to the discovery of cement. This has been done without putting into consideration the strength and durability of the blocks. These sandcrete blocks are manufactured in many parts of Nigeria without reference to any specifications either to suit local building requirements or for good quality work. The situation in Nigeria has since changed as Standards Organization of Nigeria (SON) now has specifications for both the manufacture and the use of blocks in Nigeria (Odeyemi et al., 2015). The quality of blocks produced however, differs from each industry due to different methods employed in the production and the properties of the constituent materials used respectively.

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The block's strength will influence the quality of the units employed in a structure. For example, walls constructed with low-quality blocks that fall short of the required strength are likely to break, causing significant structural damage and, in some cases, the loss of life and property. This demonstrates the importance of knowing a block's compressive strength. A standard information on the mix proportion and quality of materials to be used in achieving the desired strength of structure will undoubtedly be useful to block manufacturers, block users, and building designers in order to minimize the huge loss of money experienced by block users as a result of handling and transporting substandard blocks (Giamundo et al., 2014).

MATERIALS AND METHODS

Materials

Hollow sandcrete blocks in the sizes of six (6) inches and nine (9) inches were the materials used to carry out this project work. The apparatus/equipment used for this study were cement, water, fine aggregates, measuring tape, weighing balance, curing tank, wheelbarrow, compressive strength machine, 6″ and 9″ mould.

Methods

The localities were chosen because of accessibility and for the fact that they are the major block producing industries in the area. It is worth noting that the labels AKM, ROS, WAL and BAW of the industries do not necessarily have anything to do with the quality of the block concerned but are just mere labels for identifying the locality of the block samples. Below is an account of the investigation conducted for each industry.

Collection and Preparation of Materials

A total of forty-eight (48) blocks were collected from four block industries located around Omu-Aran. Kwara State, Nigeria. Twelve (12) blocks of both 6-inch and 9-inch from each industries where obtained and carried to the laboratory for performance evaluation of block strength. These blocks were produced using machine vibrator

method. The blocks were tested for compressive strength, water absorption, bulk density and dimension check.

Details of the block industries and their grade of cement used;

1. Akeem block industry (AKM), PLC42.5R
2. Rosofe block industry (ROS), PLC32.5R
3. Wale block industry (WAL), PLC42.5R
4. Baba Wasiu (BAW), PLC42.4R
5. Control sample (CS1:7), PLC42.5R

Figure 3.1- Hollow Sandcrete blocks from various Block industries.

Production of Control Sample

The control sample produced using hand ramming compaction method with 1:7 mix ratio design producing twelve (12) blocks for both 6-inch and 9-inch blocks. Portable borehole water was used for their production with Portland Limestone Cement (PLC) of grade 42.5R, the most suitable cement for higher strength.

Testing of Hollow Sandcrete Block Properties

Compressive strength, water absorption test, bulk density and are all tests that were performed on the hollow sandcrete blocks.

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Dimension Check

The dimensions of the blocks were measured and recorded in accordance with BS 6073. The requirement for blocks according to BS 6073 include:

I. Length and height of the block should not go above 3mm and go below 5mm of the standard length and length.
II. Thickness of the block should be between 2mm below and above the standard thickness.

The web thickness, cavity length and cavity weight were also measured because the blocks are hollow sandcrete blocks.

Figure 3.2-Taking dimension of 6-inch hollow sandcrete block.

Bulk Density

Each block samples were gathered for testing from various block industries. Each of the blocks were weighed in their dry form and their masses were recorded. Dimension check was used to measure and record measurements such as length, breath, and height of each block. Since we are dealing with hollow sandcrete blocks, the cavity length, cavity width and web thickness were obtained to get the volume and bulk density of the blocks.

The formular for bulk density is given as in equation 1.

$$Density = \frac{Mass\ of\ Block\ (kg)}{Dimenstonal\ Volume\ (m3)} \quad (3.1)$$

Figure 3.3 – Weighing of 6-inch hollow sandcrete block.

Water Absorption Test

Each block sample specimen were weighed in a dry state to obtain its dry mass (M1), then immersed in water for 24 hours to obtain its wet mass (M2). Once the samples were completely wetted, they were removed, and any remaining water was wiped away with a cloth before being weighed again to obtain the wet weight (M2) (M2). This technique was carried out on the remaining block samples, and the water absorption capacity was calculated using equation 2.

$$Water\ Absorption\ (\%) = \frac{M_2 - M_1}{M_1} \times 100 \qquad (3.2)$$

The average of the collected findings was used to determine the block's water absorption, which must not exceed 12 percent (NIS 583:2007).

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Figure 3.4 – 6-inch hollow sandcrete blocks immersed in water.

Compressive Strength

The compressive strength test was carried out in line with the NIS 87:2000 standard for making hollow sandcrete blocks, therefore the blocks' compressive strength was assessed through crushing. The blocks was weighed, and a wooden plank was placed beneath the sandcrete block and carefully placed between the center of the crushing machine's plates, with another wooden plank placed on top of the block to allow for uniform load transmission around the block surface. The machine's reading was taken and recorded, and the compressive strength of each block was estimated in N/mm2 using equation 3 (Anosike & Oyebade, 2012).

$$Compresssive\ Strength = \frac{Maximum\ load\ at\ failure\ (N)}{Cross\ sectional\ area\ (mm^2)} \qquad (3.3)$$

The average results obtained was taken as the crushing strength of the blocks and should not be less than 2.5 N/mm^2 for non-load bearing hollow sandcrete blocks and 3.45 N/mm^2 for load bearing hollow sandcrete blocks produced mechanically.

Figure 3.5 – Compressive strength test on hollow sandcrete block.

RESULTS AND DISCUSSION

Dimension Check

Tables 4.1 and 4.2 shows the dimensions of the blocks from the various hollow sandcrete block industries and the control samples produced.

Table 4.1- Average Dimension of 6" Blocks from Block Industries and Control Samples Produced

Block Industry	Length (mm)	Height (mm)	Width (mm)	Cavity Length (mm)	Cavity Width (mm)	Web Thickness (mm)
AKM	451	223	155	166	74	40
KOS	454	216	152	155	74	48
WAL	460	226	158	155	74	50
BAW	452	229	156	151	75	50
CS1:7	452	223	151	158	76	45

Table 4.2- Average Dimension of 9" Blocks from Block Industries and Control Samples Produced

Block Industry	Length (mm)	Height (mm)	Width (mm)	Cavity Length (mm)	Cavity Width (mm)	Web Thickness (mm)
AKM	451	222	232	163	135	42
KOS	453	225	232	154	137	48
WAL	451	226	227	149	134	51
BAW	452	230	217	152	137	49
CS1:7	453	225	226	158	153	46

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The average hollow sandcrete block's dimension from the block industries and the control samples both surpassed the BS 6073: Part 1 (1981) maximum dimensional deviation for masonry units, this can be traced from wrongly used mix ratio and the mould being poorly fabricated.

Bulk Density

The average density for the various sizes of hollow sandcrete blocks obtained from various industries in Omu-Aran, as well as the production of control samples, are shown in Table 4.3 below. Comparison between the density of various sizes of hollow sandcrete blocks from various block businesses and the control samples are shown in Figures 4.12 below.

Table 4.3- Average Density of 9" and 6" Blocks from Block Industries and Control Samples Produced.

Block Industry	Average density for 6"(Kg/m^3)	Average density for 9"(Kg/m^3)
AKM	1657.6	1763.33
ROS	1813.96	1768.46
WAL	1639.21	1689.23
BAW	1582.89	1941.82
CS1:7	2055.42	1921.41

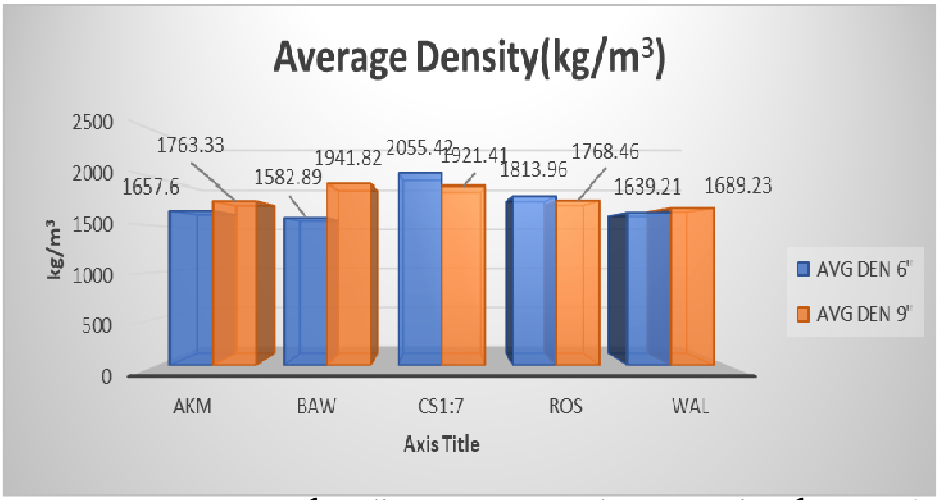

Fig. 4.12: Average Density of Hollow Sandcrete Block Samples from each Industry.

From Table 4.3 and Figure 4.12, the lowest average density of 6-inch hollow sandcrete blocks from the selected block industries was 1582.89 kg/m^3 from BAW and for 9-inch it was 1763.33 kg/m^3 from AKM and both are above the recommended minimum density of 1500 kg/m^3. The highest average density of 6-inch hollow sandcrete blocks from the selected block industries was 1657.6 kg/m^3 from AKM and for 9-inch it was 1941.82 kg/m^3 from BAW. This simply shows that the density of the blocks produced in Omu-Aran are all above recommended minimum density and are suitable. For the control samples produced, CS1:7 has the lower average density of 2055.42 kg/m^3 and 1921.41 kg/m^3 for 6-inch and 9-inch hollow sandcrete blocks respectively and they are both above the recommended minimum density of 1500 kg/m^3.

Water Absorption

The water absorption rate for the various sizes of hollow sandcrete blocks received from the various block Industries in Omu-Aran is shown in Table 4.4 below, along with the production of control samples. In a similar manner, Figure 4.13 illustrates the relationship between the water absorption rate of various sizes of hollow sandcrete

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blocks from the various block industries and the control samples produced.

Table 4.4 – Water Absorption Test Results for All Samples

Block Industry	Average Water Absorption for 6″ (%)	Average Water Absorption for 9″(%)
AKM	13.363	11.723
ROS	15.43	8.826
WAL	11.279	9.765
BAW	12.683	11.246
CS1:7	11.582	8.624

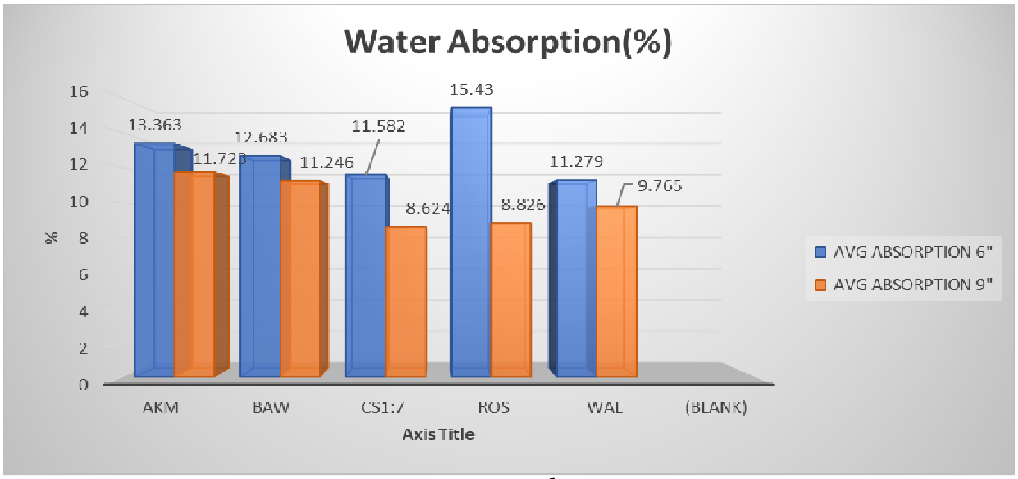

Fig. 4.13: Average Water Absorption Rate of Hollow Sandcrete Block Samples

According to the results, the water absorption rate for the 6″ block from AKM, ROS and BAW was higher than the maximum water absorption requirement of 12%, which could be traced from wrong mix ratio and deficient curing method. The control sample

Compressive Strength

Table 4.5 below shows the average compressive strength for the different sizes of the hollow sandcrete blocks obtained from the various industries in Omu-Aran and the control samples produced. Similarly, Figure 4.14 shows the relationship between the compressive of different sizes of hollow sandcrete blocks from the different block

industries, Figure 4.15 shows the relationship between the compressive strength of different sizes of the control samples produced.

Table 4.5- Average Compressive Strength of Hollow Sandcrete Block Sample.

Block Industry	Compressive Strength for 6″(N/mm²)	Compressive Strength for 9″ (N/mm²)
AKM	0.25	0.35
ROS	0.36	0.37
WAL	0.41	0.49
BAW	0.37	0.3

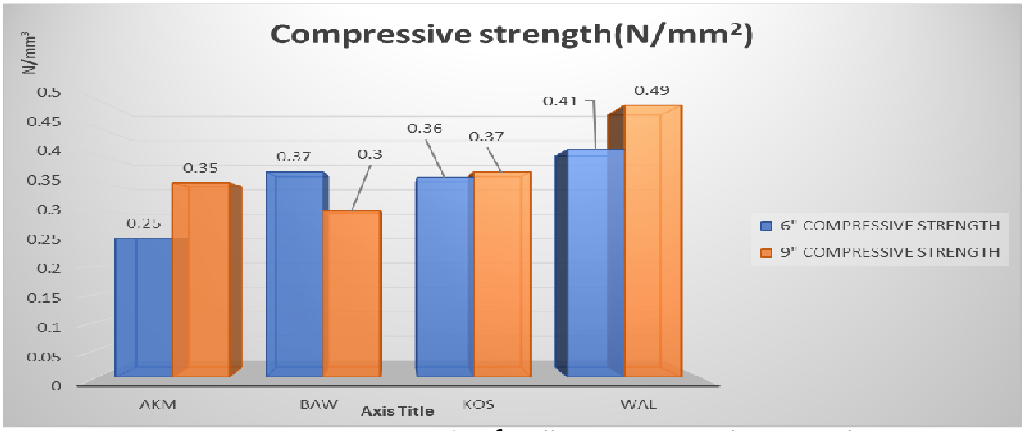

Fig. 4.14: Average Compressive Strength of Hollow Sandcrete Block Samples Produced.

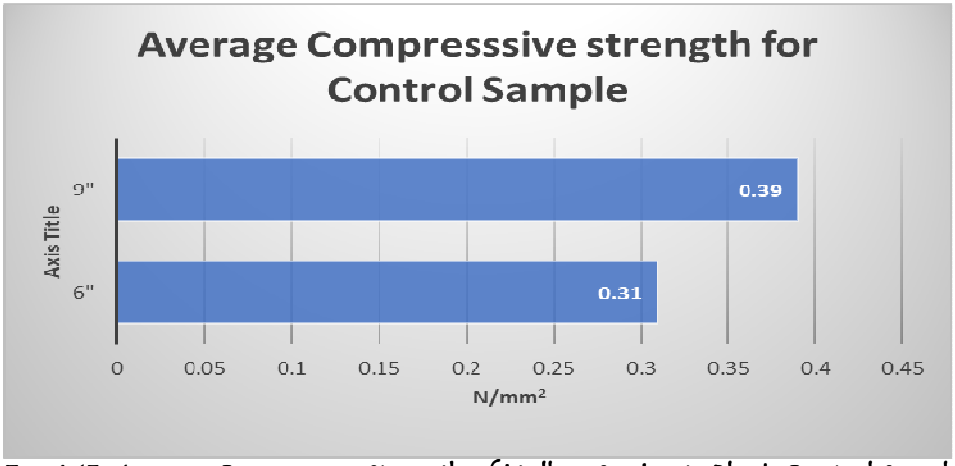

Fig. 4.15: Average Compressive Strength of Hollow Sandcrete Block Control Samples.

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From Figure 4.16, the average compressive strength for 6-inch hollow sandcrete blocks from selected block industries ranged from 0.25-0.41N/mm^2 and for 9-inch is ranged from 0.3-0.49N/mm^2. The lowest average compressive strength for the 6-inch hollow sandcrete blocks from selected block industries was 0.25 N/mm^2 from AKM and for the 9- inch hollow sandcrete blocks it was 0.3 N/mm^2 from BAW while the highest average compressive strength for the 6-inch hollow sandcrete blocks from selected block industries was 0.41 N/mm^2 from WAL and for 9-inch hollow sandcrete blocks it was 0.49 N/mm^2 from WAL. The highest compressive strength was 0.49 N/mm^2 from 9-inch hollow sandcrete block. The control samples produced which averaged 0.39N/mm^2 for 9-inch and 0.31N/mm^2 for 6-inch which is below the strength compared to the block industries. These values are all below the minimum standard requirement of 2.5 N/mm2 for non-load bearing hollow sandcrete blocks and 3.45 N/mm2 for load bearing hollow sandcrete block showing that they are not suitable for use in building or construction. The result can be traced from wrongly used mix ratio from the block industries, using non-potable water, insufficient curing, and the use of lower grade of cement.

CONCLUSION

This project work assessed the strength characteristics of sandcrete blocks produced in Omu-Aran Kwara state. The following conclusions were drawn from the study:

1. The producers did not adhered to the standard specification for mix ratio as required for sandcrete blocks.
2. The block industries and the control samples produced did not comply with the dimension requirements necessary for moulding blocks for both 6-inch and 9-inch blocks. It can be indicated from the wrongly used mix ratio and poorly fabricated moulds.
3. Both the average bulk density of the blocks produced by the block industries and the control samples both met the requirements which the minimum required was 1500kg/m3

4. Some industries did not make up with the requirement for water absorption while the average of the control samples produced met the minimum requirements for water absorption, which is below 12%, and this could be traced from poorly compacted blocks from machine.
5. The compressive strength of the sandcrete blocks produced at various block industries in Oma-Aran using machine compacted sandcrete blocks are higher in strength compared to the control sample produced manually compacted sandcrete blocks but did not meet the minimum requirement of 2.5N/mm^2 for non-load bearing walls.
6. The average strength characteristics of hollow sandcrete produced at various block industries in Omu-Aran using machine compacted method has higher strength than the manually produced blocks.

RECOMMENDATION

Not only workshops and seminars should be held on a regular basis to educate sandcrete block manufacturers in Omu-Aran on the value of following standards but there should be also thorough investigations and monitor all equipments used to carry out various tasks. All these should be done by authorities like Council for the Regulation of Engineering in Nigeria (COREN) and Standard Organization of Nigeria (SON) and ensure severe penalties ought to erring manufacturers that fail to follow such standards. This will ensure the reduction of the massive failure and collapse of buildings and structures. The main contribution to knowledge this study has showed is sandcrete blocks produced using machine method of production has higher strength compared to sandcrete blocks produced manually. It is also important to assess the material strength before they are used for construction to prevent failure and collapse of structures.

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