Assessment of Compressive Strength of Hollow Sandcrete Block Produced in Akure Ondo State

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Abstract:
This study aimed at evaluating the properties of sandcrete hollow blocks produced by block industries in Ondo State. The study focused on assessing the compressive strength, water absorption, and dimensional properties of sandcrete blocks obtained from five different producers. The blocks samples were collected from each producer and subjected to compressive strength, water absorption, and dimensional analysis. Also, sieve analysis and specific gravity tests were conducted on the sand samples to determine their suitability for block production. The results of these tests indicated that the fine aggregates used were appropriate for making blocks. However, the study found that the compressive strength of the 450 x 150 x 225mm (6") sandcrete blocks was not sufficient. The minimum recorded unit compressive strength was 0.55 N/mm², while the average compressive strength was 0.80 N/mm². These values fell below the standard requirements for load-bearing sandcrete blocks. According to the Nigerian industrial standard, individual blocks should have a minimum compressive strength of 2.5 N/mm², and the average compressive strength of five blocks should not be less than 3.45 N/mm². To enhance the quality of sandcrete blocks manufactured by commercial block industries in the study area, the study recommends standardizing the block manufacturing processes and enforcing strict supervision during production. These measures will ensure that the blocks meet the required compressive strength standards and suitable for load-bearing purposes.

Keywords: Hollow Sandcrete Block, Cement, Mix ratio, Compressive strength, Curing age.

Introduction
The study Sandcrete blocks are produced from a mixture of cement and fine aggregate (sand), either manually compacted or mechanically compacted by a block molding machine. The cement and fine aggregate are mixed together in volumetric ratios (cement:sand) of 1:6, 1:7, 1:8, 1:9, etc. Sandcrete blocks have become an important building material for construction works, mostly in African countries, especially with regards to the development and rapid urbanization of their towns and city centers following commercial growth and industrialization. Due to the climatic conditions in the tropics, structural walls are designed to allow the movement of heat and air within and throughout the structure. A significant number of buildings are being built in Nigeria with sandcrete blocks and in other West African countries (Adese & Olajide, 2021). There are two major types of sandcrete blocks: the solid and hollow forms. According to Odeyemi et al.
solid sandcrete blocks have no openings in their mass, while hollow sandcrete blocks have major openings within the block mass running from top to bottom, which occupies about 35% of the total volume of the block. Sandcrete blocks also participate mainly in the task of transferring the actual load from the overlaying structural element to the foundation (Abdullahi, 2005). Sandcrete blocks are widely used in the construction of load-bearing and non-load-bearing building walls. The mechanical properties of sandcrete blocks are greatly influenced by: the type of cement used; the nature of the fine aggregate; the production method adopted; the curing method and the curing period; as well as the size and type (solid or hollow) of the blocks (Akpokodje et al., 2021). In Nigeria, sandcrete blocks are commercially produced in makeshift structures both in rural and urban areas without adequate attention given to the quality of the sandcrete blocks produced. Apart from when consumers place special orders, the block producers do not follow any internationally recognized standard for sandcrete block production. However, the customized blocks (special order blocks), which are more likely produced based on recommendations approved by the Nigeria Industrial Standard (NIS), are always more expensive than the ordinary (customized) blocks. Negligence on the part of the sandcrete block producers has led to the general poor quality of the commercially produced blocks in Nigeria. The Nigeria Industrial Standard recommends a minimum compressive strength of 2.5 N/mm² for sandcrete blocks to be used for the construction of non-load-bearing walls and 3.45 N/mm² for sandcrete blocks to be used in the construction of load-bearing walls (NIS 87:2000). Research has shown that the compressive strength of hollow sandcrete blocks produced for masonry walls is below the recommended standard of the Building Standard Code (BS Code). According to Akpokodje et al. (2021), poor-quality sandcrete blocks is one of the major factors that can lead to structural failures, which are recently on the increase in Nigeria. Even while being transported, some of these blocks can collapse from their own weight. Omorogie (2012) stated that it is not surprising, therefore, to see reoccurring cases of building collapse, most especially due to failures of load-bearing walls made from these blocks. According to Ewa and Ukpata (2013), in some cases, even though the building has totally collapsed, the aesthetic value is lost due to cracks and other defects. The poor quality of the sandcrete blocks utilized as walling units is a contributing factor to this issue. Many Nigerians often buy substandard blocks at lower prices rather than high-quality blocks sold at higher prices. To look at the failure of building with masonry units. The frequency of building collapse in some major places in Nigeria, especially Lagos, Ibadan, Abuja, and Port Harcourt, among others, is one of the causes of building collapse. Adebowale et al. (2016) carried out analysis and evaluation of the death rate involved in 47 reported cases of building collapses verified between 2000 and 2010, and over 300 death rates were recorded for Lagos, Abuja, and Port Harcourt, which are the three major areas with a high rate of casualties. Blocks have been an integral part of masonry wall systems for many years. Consequently, these studies intend to evaluate the quality (compressive strength) of commercially produced sandcrete blocks within the Akure metropolises of Ondo State, Nigeria. The results of this study will be useful to relevant authorities in monitoring the quality of sandcrete blocks produced within Akure and its environs. on the assessment of hollow sandcrete blocks produced in Akure, Ondo State, within a selected area in FUTA. It was found that none of the producers complied with the allowable mix ratio standard for sandcrete blocks or followed the appropriate method of curing. The compressive strengths of the blocks at 28 days were lower than the minimum value of 2.5 N/mm² specified by the Nigerian Industrial Standard and the average dry development strength value was 0.80 N/mm². The results of water absorption tests and dimensional tests showed that the hollow sandcrete blocks produced by the different producers were not compliant with NIS 87-2004. The specific gravity value obtained from the laboratory was within the range of Neville (1981).
Most of the block manufacturing industries did not use standard measures in batching the sand used, and water was arbitrarily added to the cement and sand mix. The number of 450 mm x 225mm x 150mm hollow sandcrete blocks produced per 50kg bag of ordinary Portland cement varied from one industry to the other.

Methodology
Five major sandcrete block production industries were visited in the study area under review for an on-the-spot assessment. Three sandcrete blocks (6 inches) were purchased randomly from each block industry that was visited in order to evaluate their compressive strength. Due to the focus of this research, only 28-day-old sandcrete blocks were purchased from each block industry. The blocks samples were coded as A, B, C, D, and E. The fine aggregate used in the production of the blocks was collected in order to determine their physical characteristics. Tests that were carried out on the samples include sieve analysis, specific gravity, compressive strength tests, water absorption tests, and dimensional tests, which were carried out in accordance with BS EN 933-1, BS EN 12620, and BS EN 1097-6, respectively. The equipment used included a weighing balance, a mechanical sieve of varying standard sizes, a compressive strength testing machine and measuring tape.

Results and Discussion
The findings and results of research on the assessment of the compressive strength of hollow sandcrete blocks produced in Akure, Ondo State, within the study area are presented as follows:

Specific Gravity
The true gravity of a soil is actually the weighted average of the specific gravities of all the mineral particles present in the soil. Neville (1981) confirms the fact that the majority of natural aggregates have a specific gravity ranging between 2.6 and 2.7. The results of the specific gravity test of the sand collected from the five-block industries is shown in Table 1

<table>
<thead>
<tr>
<th>S/N</th>
<th>Sample</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>2.93</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>2.95</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>2.79</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>2.74</td>
</tr>
<tr>
<td>5</td>
<td>E</td>
<td>2.54</td>
</tr>
</tbody>
</table>

![Figure 1: Specific Gravity](image)

Water Absorption
The table 2 showed the results of the water absorption of samples of blocks from chosen block producers A, B, C, D, and E after 28 days. The comparable block production water absorption for A, B, C, D, and E were 14.6%, 11.2%, 11.9%, 11.6%, and 12.4%, respectively. However, the highest water absorption attained by block producers A (14.6%) and E (12.4%) is greater than the NIS 87-2004 maximum requirement of 12%. 

Dimensional Test
The results showing the dimensional test of the hollow sandcrete block bought from different producers showed that the blocks were not compliant with the Nigeria Industrial Standard (NIS 87-2004). The blocks A and E were compliant with the NIS 87-2004 standard, while blocks B, C, and D's widths and heights were greater than the recommended standard, which may be due to the expansion of the mould.
Table 2. Water Absorption Test

<table>
<thead>
<tr>
<th>Samples</th>
<th>Initial Weight before absorption (kg)</th>
<th>Final Weight after absorption (kg)</th>
<th>Total initial weight before absorption (kg)</th>
<th>Average weight of Initial (w1) (kg)</th>
<th>Average Weight of final (w2) (kg)</th>
<th>Percentage of water absorbed (%) (w2-w1)/w1 x100</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.8 6.4 6.6 7.6 7.4 7.6 19.7</td>
<td>22.6</td>
<td>6.6 7.5</td>
<td>14.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>8.0 8.3 7.7 8.8 9.1 8.6 23.8</td>
<td>26.5</td>
<td>7.9 8.8</td>
<td>11.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>7.2 7.3 7.1 8.0 8.1 8.0 21.5</td>
<td>24.1</td>
<td>7.2 8.0</td>
<td>11.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>7.1 7.1 7.8 8.1 8.1 8.4 21.9</td>
<td>24.5</td>
<td>7.3 8.2</td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>6.9 6.5 7.2 7.8 7.4 8.0 20.5</td>
<td>23.1</td>
<td>6.8 7.7</td>
<td>12.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sieve Analysis

The table below presents the results of a sieve analysis performed on the five main grains of sand used for block molding in the study area. The percentage of the aggregate passing through sieves 4.75mm, 2.36mm, 1.70mm, 1.18mm, 600µm, 500µm, 425µm, 212µm, 150µm, 72µm, and pan. The analysis reveals that all of the samples A, B, C, D, and E, conform to the overall grade limit specified by BS 932 (1997). Additionally, all of the samples are graded as medium and fall within the specified range, indicating a balanced distribution of particle sizes, which is essential for good compaction and stability in construction. The weight of the sample used was 500g.

\[
\text{Fineness modulus (FM)} = \frac{\text{cumulative percentage retained on standard sieve}}{100}
\]

\[
FM = \frac{1.28 + 3.02 + 3.96 + 6.28 + 17.74 + 33.34 + 38.08 + 70.80 + 85.80 + 85.86 + 100.00}{100} = 4.46
\]

The higher the finest modulus, the higher the coarse particle present in the soil sample.
Fineness modulus (FM) = \frac{\text{cumulative percentage retained on standard sieve}}{100} \quad (1)

\[
FM = \frac{4.04 + 7.88 + 8.62 + 11.54 + 23.96 + 37.04 + 41.68 + 71.82 + 85.26 + 85.32 + 100.00}{100} = 4.77
\]

The higher the finest modulus, the higher the coarse particle present in the soil sample.

Figure 4. Particle Size Distribution Curve for Sample (B)

Fineness modulus (FM) = \frac{\text{cumulative percentage retained on standard sieve}}{100} \quad (1)

\[
FM = \frac{6.10 + 11.38 + 12.40 + 16.08 + 28.78 + 44.68 + 48.12 + 75.96 + 88.48 + 88.58 + 100.00}{100} = 4.77
\]

The higher the finest modulus, the higher the coarse particle present in the soil sample.

Figure 5. Particle Size Distribution Curve for Sample (C)
\[ FM = \frac{6.20 + 8.84 + 10.04 + 14.72 + 31.78 + 41.86 + 45.10 + 70.24 + 84.46 + 84.52 + 100.00}{100} = 4.96 \]

The higher the finest modulus, the higher the coarse particle present in the soil sample.

\[ FM = \frac{7.28 + 9.82 + 10.84 + 15.74 + 30.94 + 40.44 + 42.54 + 67.40 + 84.62 + 84.66 + 100.00}{100} = 4.94 \]

The higher the finest modulus, the higher the coarse particle present in the soil sample.

**Compressive Strength**

The findings of the hollow Sandcrete block compressive strength test revealed that the compressive strength of hollow concrete blocks manufactured in the study area. Twenty-four hours before the test, the blocks that had reached the required age of 28 days for the compressive strength test were brought to the
laboratory to normalize the temperature and make the block generally dry or moisture-free. The blocks were divided into quadrants so that the laboratory’s compressive machine could place a focused stress on the center of the blocks. Each block was weighed before being positioned between two metal plates on the compression testing machine. Using universal compression testing machine, the blocks purchased from various vendors were crushed to assess their compressive strength in compliance with NIS 87-2004. The crushing load and compressive strength were recorded.

\[ f_c = \frac{P}{A} \]  

(2)

Where the compressive strength is \( f_c \)

\( P \) is the crushing load

Table 2 shows the findings of the compressive strength of block samples from block manufacturers A, B, C, D, and E for the compressive strength of 28 days. According to test findings, the hollow sandcrete blocks’ least unit compressive strength was 0.55 N/mm\(^2\), while their average compressive strength was 0.80 N/mm\(^2\). These numbers fall short of the requirements set out for load-bearing sandcrete blocks. According to the Nigerian Industrial Standard, the average compressive strength of five blocks should not be less than 3.45 N/mm\(^2\), and the lowest compressive strength of a single block cannot be less than 2.5 N/mm\(^2\). The compressive strength test was carried out to ascertain the weight the blocks could support.

Table 3. Compressive Strength of the Blocks Samples

<table>
<thead>
<tr>
<th>Block Samples</th>
<th>Compressive Strength</th>
<th>Mean Compressive Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>0.71</td>
<td>0.40</td>
</tr>
<tr>
<td>B</td>
<td>1.41</td>
<td>0.68</td>
</tr>
<tr>
<td>C</td>
<td>0.84</td>
<td>0.94</td>
</tr>
<tr>
<td>D</td>
<td>0.68</td>
<td>0.73</td>
</tr>
<tr>
<td>E</td>
<td>0.95</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Figure 8. Compressive Strength of Different Block Samples

Conclusion

The study focused on the assessment of hollow sandcrete blocks produced in selected area of Akure, Ondo State. It was found that none of the producers complied with the allowable mix ratio standard for sandcrete blocks or followed the appropriate method of curing. The compressive strengths of the blocks at 28 days were lower than the minimum value of 2.5 N/mm\(^2\) specified by the Nigerian Industrial
Standard and the average dry development strength value was 0.80 N/mm². The results of water absorption tests and dimensional tests showed that the hollow sandcrete blocks produced by the different producers were not compliant with NIS 87-2004. The specific gravity value obtained from the laboratory was within the range of Neville (1981). Most of the block manufacturing industries did not use standard measures in batching the sand used, and water was arbitrarily added to the cement and sand mix. The number of 450 mm x 225mm x 150mm hollow sandcrete blocks produced per 50kg bag of ordinary Portland cement varied from one industry to other.

**Recommendation**

Workshops or seminars be held on a regular basis to educate sandcrete block manufacturers on the significance of adhering to standard specifications and that the Nigeria Industrial Organization, as well as Professional organizations like Council of Registered Builders of Nigeria (CORBON), the Council of Regulation of Engineering, (COREN), and governmental agencies, should impose strict penalties on manufacturers that compromise the required standard.

**References**


Raheem, O., & Bamiloye, E. (2013). About 0.4 grams of water per gram of cement are needed to completely hydrate. American Concrete Institute (ACI).