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Compressive Strength of Marketed Hollow Blocks Produced in Sokoto, Nigeria

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ABSTRACT: This paper investigates the strength characteristics of hollow blocks in the Sokoto State metropolis. Five commercial block industries were selected, and soil samples were obtained from each manufacturer and transported to the Civil Engineering Laboratory at Umaru Ali Shinkafi Polytechnic, Sokoto. Compressive strength tests were conducted on the blocks, and particle size distribution tests were conducted on the soil samples. The test results show that the aggregates used are good for block making. The blocks produced were found to be unsuitable for use as either load-bearing or non-load-bearing walls as their strength ranges fall below the minimum values of between 2.5 N/mm^2 and 3.45 N/mm^2 as recommended by NIS 87:2000. Proper selection of constituent materials and curing were suggested to improve the quality of hollow blocks.

Keywords: Compressive strength, blocks, aggregates, particle size distribution, load-bearing walls, non-load bearing walls
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INTRODUCTION

Sandcrete blocks are produced and widely used in Nigeria as a construction material. They are cementitious composite materials produced from a mixture of cement, fine aggregates, and water, with or without special additives. This mixture can either be manually or mechanically compacted using a block moulding machine (Akpokodje et al., 2021; NIS 87:2000). The materials and the production methods differ for each manufacturer, which also makes the quality of the blocks produced different (Abdullahi, 2005). Manufacturers in Nigeria employ different mix ratios of binder to fine aggregates, which include 1:6, 1:7, 1:8 and 1:9 (Akpokodje et al., 2021).

According to BS 6073:1981, a block is a masonry unit whose length, width, or height, when employed in its usual aspect, is greater than that of a comparable brick. Similarly, according to the standard, a brick is any masonry unit that is not more than 112.5 mm in height, 225 mm in thickness, or 337.5 mm in length.

Baiden and Tuuli, (2004) maintained that sandcrete blocks are used in the construction of the majority of structural infrastructure in Nigeria, thus making them an important building material. Sandcrete blocks can either be solid or hollow. The solid blocks are voidless, whereas the hollow ones have voids that run from top to bottom, covering about one-third of the volume of the blocks (Akpokodje et al., 2021; Odeyemi et al., 2015).In Nigeria, hollow blocks are frequently used and come in the following sizes: 225 mm, 150 mm, 125 mm, and 100 mm mm (Alejo, 2020). These blocks can be formed into many shapes and sizes and are made of cement, fine aggregate (sand), and water (Odeyemi et al., 2018). Partitions and load-bearing walls are the main applications for hollow blocks (Agbi et al, 2020; Omoregie, 2012).

Yusuf and Hamza, (2011, as cited in (Agbi et al.,2020; Akpokodje and Uguru, 2019), maintained that the factors that influence the compressive strength of sandcrete blocks include the type of cement, nature of the fine aggregates, cement to sand ratio, shape of the block, production method, curing method, and water quality. However, water-cement ratio and water quality are the two most important factors that should be considered in order to get the desired final strength of the blocks (Akpokodje and Uguru, 2019). Cement relies on the presence of water to hydrate, forming an interlocking skeleton of calcium silicate hydrate that gives the material its strength. Complete hydration will not take place if the block is dried prematurely. (Akpokodje and Uguru, 2019; Hijab et al., 2010).

Table 1: Particle size distribution of soil samples.

Sieve size (mm)	Percentage passing %				
	Sample A	Sample B	Sample C	Sample D	Sample E
1.18	91.3	90.7	92.3	89.2	93.3
0.600	71.0	71.0	74.0	68.9	74.1
0.425	48.6	50.5	52.6	47.2	54.1
0.300	27.6	28.4	32.6	27.4	34.2
0.212	12.4	13.7	16.4	9.3	20.0
0.150	6.3	5.9	8.2	4.2	10.9
0.075	3.3	2.8	4.2	1.2	5.2
0.063	1.2	0.4	1.0	0.2	2.0

Source: Laboratory Work, 2023

The best curing practice is not followed because either the manufacturers are not aware of the significance of good curing or they feel that the effort spent in providing curing conditions is not worth the possibility of an increase in quality. A majority of manufacturers carry out watering of the blocks for a period of three consecutive days only. The production of blocks with maximum water content results in blocks with the highest strength. The manufacturers are generally not fully aware of this requirement, and consequently, different moisture contents are used at moulding (Hijab et al., 2010).

For some time now, most of the hollow blocks used in developing countries, especially in Africa, have frequently fallen short of local and global specification standards. The reason behind this trend is not unconnected with the increase in the price of cement, which is the most important constituent in the manufacture of sandcrete blocks. As such, low-income earners tend to resort to cheaper ways of accessing the necessary materials for their buildings (Omopariola, 2014). In the Nigerian building industry, for example, due to the aforementioned reasons, most of the hollow blocks in use do not meet the standards recommended by the Nigerian Industrial Standards. (Akpokodje et al., 2021)

It is not unexpected that buildings and structures do not withstand the test of time because one cannot be certain of the quality of blocks manufactured by small-scale, frequently roadside companies (Akpokodje and Uguru, 2019). Previous investigations in Nigeria found that these blocks function atrociously since their compressive strength is well below the required values (Omoregie, 2013). Even when transported, some of the blocks frequently collapse under their own weight. In light of this, it is not surprising to observe frequent instances of building collapse, particularly in walls constructed from these materials (Hijab et al., 2010; Omoregie and Alutu, 2006). Numerous studies have also revealed that the main causes of the frequent collapse of building structures in Nigeria are poor quality control and the use of non-standard building materials (Ayedun et al., 2010). This paper assesses the quality of hollow blocks produced in Sokoto State. It involves the sampling of the blocks from commercial industries; the compressive strength of the blocks will be tested at 28 days, and the results will be compared with those recommended by the standards.

MATERIALS AND METHODS

In this study, five commercial hollow block industries were visited twice a month. On the first visit, the blocks produced were noted and booked. After 27 days, five blocks of sizes 450 mm x 225 mm x 225 mm were randomly selected as per NIS 87:2000.The blocks were taken to the laboratory for testing on the 28th day. Samples of soil used for production were also collected. The blocks were weighed and tested for compressive strength using the compression testing machine, according to BS 6073 Part 1, (1981). A particle size distribution test was carried out on the soil samples to ascertain their suitability for block making, as per BS 1377 (1990). This paper assesses the quality of hollow blocks produced in Sokoto State. It involves the sampling of the blocks from commercial industries; the compressive strength of the blocks was tested at 28 days, and the results were compared with those recommended by the standards.

RESULTS AND DISCUSSION

Sieve analysis

The results for the particle size distribution of soil samples sources in the area are shown in (Table 1). The samples A, B, C, D, and E satisfy the overall grading limit per BS 882 (1992). The soil samples fall within the range and are of medium grading; the soil samples are suitable for construction work.

Compressive strength

The result of the compressive strength of blocks is shown in (Tables 2, 3, 4, 5, and 6). Test results indicate that the compressive strength of individual hollow blocks ranges from 0.4 N/mm^2 to 1.2 N/mm2. The average compressive strength of the five blocks ranges from 0.52 N/mm^2 to 0.96 N/mm2. The values fall below the standard prescribed for load-bearing hollow blocks.

Table 2: Compressive Strength Results for Sand-Crete Blocks; Industry A.

S/N	Age (days)	Size (mm)	Weight (kg)	Average weight (kg)	Crushing Load (KN)	Strength (N/mm^2)	Average strength (N/mm^2)
1	28	450x225x225	25.03		70.87	0.7	
2	28	450x225x225	25.76		121.5	1.2	
3	28	450x225x225	25.47	25.16	91.3	0.9	0.84
4	28	450x225x225	25.03		70.87	0.7	
5	28	450x225x225	24.52		70.87	0.7	

Source: Laboratory Work, 2023

Table 3: Compressive Strength Results for Sand-Crete Blocks; Industry B.

S/N	Age (days)	Size (mm)	Weight (kg)	Average weight (kg)	Crushing Load (KN)	Strength (N/mm^2)	Average strength (N/mm^2)
1	28	450x225x225	26.60		70.87	0.7	
2	28	450x225x225	28.10		60.75	0.6	
3	28	450x225x225	27.25	27.31	60.75	0.6	0.64
4	28	450x225x225	26.79		60.75	0.6	
5	28	450x225x225	27.83		70.87	0.7	

Source: Laboratory Work, 2023

Table 4: Compressive Strength Results for Sand-Crete Blocks; Industry C.

S/N	Age (days)	Size (mm)	Weight (kg)	Average weight (kg)	Crushing Load (KN)	Strength (N/mm^2)	Average strength (N/mm^2)
1	28	450x225x225	26.46		101.25	1.0	
2	28	450x225x225	26.27		111.25	1.1	
3	28	450x225x225	26.83	26.71	81.0	0.8	0.96
4	28	450x225x225	26.76		101.25	1.0	
5	28	450x225x225	27.23		81.0	0.9	

Source: Laboratory Work, 2023

Table 5: Compressive Strength Results for Sand-Crete Blocks; Industry D.

S/N	Age (days)	Size (mm)	Weight (kg)	Average weight (kg)	Crushing Load (KN)	Strength (N/mm^2)	Average strength (N/mm^2)
1	28	450x225x225	27.05		40.50	0.4	
2	28	450x225x225	26.18		50.63	0.5	
3	28	450x225x225	26.43	26.55	60.75	0.6	0.52
4	28	450x225x225	26.42		50.63	0.5	
5	28	450x225x225	26.67		60.75	0.5	

Source: Laboratory Work, 2023

Table 6: Compressive Strength Results for Sand-Crete Blocks; Industry E.

S/N	Age (days)	Size (mm)	Weight (kg)	Average weight (kg)	Crushing Load (KN)	Strength (N/mm^2)	Average strength (N/mm^2)
1	28	450x225x225	26.07		81.00	0.8	
2	28	450x225x225	25.89		81.00	0.8	
3	28	450x225x225	26.14	26.17	81.00	0.8	0.84
4	28	450x225x225	26.37		91.12	0.9	
5	28	450x225x225	26.36		91.12	0.9	

Source: Laboratory Work, 2023

NIS 87:2000 specified that the lowest compressive strength of individual load-bearing blocks should not be less than 2.5 N/mm^2 and the average compressive strength of five blocks should not be less than 3.45 N/mm^2. The result also indicates poor quality control because the strength result shows a wide range within the same lot. The particle size distribution result indicates that the soil particles are suitable for construction purposes. The entire block industry sites visited used potable drinking water from the tap, which is recommended for construction work as per BS 3148 (1980). Nonetheless, to obtain good-quality hollow blocks, it is essential that the constituent materials be selected with care; otherwise, segregation of materials occurs and eventually results in low compressive strength of the blocks. It was noted that curing was not done properly by manufacturers of hollow blocks. Blocks are produced and left in the open air. The water sprinkled on them was also not adequate. Most blocks sold have not reached 28 days as a result of high demand, resulting in low compressive strength.

Conclusion

The aggregates grading of the soils used for the manufacturing of hollow blocks are within the limit specified by BS 882 (1992) and are therefore suitable for block making. Hollow block industries do not adequately cure their blocks before selling them to clients or customers, and they do not carry out any form of testing

on the hollow blocks either before or at the end of production. The compressive strength of the hollow blocks was found to be below standard. The compressive strength of a single block tested was between 0.4 N/mm^2 and 1.2 N/mm^2, although the average compressive strength of five blocks selected randomly was between 0.52 N/mm^2 and 0.96 N/mm^2. These values fall below those recommended by NIS 87:2000. This study suggests improvements in the selection of materials, proper curing, and quality control on the hollow blocks

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