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Characterization of Strength of Sandcrete Blocks in Omu-Aran Metropolis

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Abstract: This research work aimed at investigating the strength characteristics of commercially produced sandcrete blocks in Omu-aran, Nigeria where Landmark University is located. It involved visiting and collecting blocks from selected block making industries, determining their physical and mechanical properties (bulk density, moisture content, water absorption capacity and compressive strength) and highlighting the levels of compliance of the various industries with the relevant standards. The results of the physical and mechanical tests (bulk density, moisture content, water absorption capacity and compressive strength) revealed that none of the commercially produced blocks in the study had a compressive strength that was up to the minimum recommended standard 2.5 N/mm^2 for individual blocks and 3.45 N/mm^2 for 5 blocks as recommended by the Nigeria Industrial Standards (NIS 87: 2000). The overall average compressive strength for 6-inch blocks was 0.44 and 0.28 N/mm^2 for 9-inch blocks. The average location compressive strength ranged from 0.24-0.65 N/mm^2 for 6-inch and 0.12 -0.64 N/mm^2 for 9-inch blocks which was far below recommended standards. The bulk density was found to be over the minimum recommended limit of 1500 kg/m^3 for Type A: dense aggregate blocks with individual bulk densities for 6-inch blocks ranging from 1510.62-2124 kg/m^3 and 1399.7-1751.1 kg/m^3 for 9-inch blocks. The overall average bulk density for 6-inch blocks was 16954.4-1597.8 kg/m^3 for 9-inch blocks. The water absorption capacity for individual 6-inch blocks ranged from 151.6-339.9 kg/m^3 and 130.92-434.79 kg/m^3 or 9-inch blocks. Location average water absorption capacity ranged from 169.09-271.79 kg/m^3 for 6-inch blocks and 160.87-340.4 kg/m^3 for 9-inch blocks while the averages were 236.37-226.33 kg/m^3, respectively. The maximum recommended limit was pegged at 240 kg/m^3 from ASTM C140. Half of the locations did not meet up with standard for both 6 and 9-inch blocks.

Key words: Sandcrete block, compressive strength, absorption capacity, bulk density, moisture content, properties, moisture

INTRODUCTION

The quest of man for centuries has been to find better ways, better materials, better methods and better practices of doing things. This is evident in how far the world has come technologically. Life is easier with the invention of things like aircrafts, vehicles, trains and trams to assist man in transportation over a distance in the shortest period of time with maximum comfort, convenience and safety at minimum cost. It is now possible to communicate to someone thousands of miles away in the convenience of your home. Many construction methods and practices have been improved together with the materials used materials have been developed such as carbon fibre cables, fibre glass and super strength concrete and different types of cement. All these are to improve the methods (practices and materials) that are inefficient, counter-productive, restrictive, susceptible to failure and outright expensive. But in the building industry particularly in Nigeria, some practices have developed over a number of years now that are not only counter-productive but can also be tagged as anti-developmental. These practices are responsible for failure of buildings, loss of lives, damage of property and outright loss of property and money. Ayininuola and Olalusi (2004) reported that a great number of buildings collapse weekly in the country but did not receive public or official notice and some of those collapsed building showed that their load bearing walls were not of adequate strength to withstand the applied load on them (Oloyede *et al.,* 2010). The quality of blocks produced differs from each manufacturer depending on the production method and constituent materials (Aiyewalehinmi and Tanimola, 2013). The reasons behind the failure of buildings are both common and unique to certain situations. There are many reasons that underline the recent and frequent failure of buildings and other building materials of sub-standard 2 qualities are being

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produced as well but for the purpose of this study, sandcrete blocks will be our only focus. These practices can be easily seen in the block making industry of Nigeria which has as a way of saving money and maximizing profits, been producing sub-standard sandcrete blocks and distributing the same. The quality of blocks produced differs from each manufacturer depending on the production method and constituent materials.

MATERIALS AND METHODS

Dimension check: The dimensions of the blocks were checked for conformity to the recommended dimensions. All the necessary dimensions were measured and recorded then checked against BS 6073 (BSI., 1981). This is to make sure that the moulds being used to give the blocks their characteristic dimensions are within standard. The dimensions recorded included; length (mm), height (mm), width (mm), cavity length (mm) and cavity width (mm). Under this process the blocks will be weighed and weight of the blocks will be documented. Any special features on the blocks will be documented.

Bulk density: Each sample of the blocks acquired from the different block production industries for testing was labeled and numbered and each of them was weighed in their dry states during which their masses was recorded. The mass scale used was of 30 kg capacity, BS2028 (BSI., 1968). The earlier measured and recorded dimensions such as the length, breadth and height of each block was taken from dimension check, the volume and there after, the bulk densities were calculated.

Water absorption: Each sample of the blocks whose weights were taken in the dry state during the dimension check were then oven-dried for 48 h after which they were weighed. The samples were then immersed in water for 24 h after which they were weighed again. Cold immersion method was used in determining the total water absorption of the block samples. The time at which the blocks were fully immersed was noted and period of 24 h was allowed to elapse. After the 24 h the wet block samples were removed and weighed. The difference between the dry and wet weights of each block was then calculated by subtracting the dry weight after oven drying from the wet weight. From this, the water absorption capacity was then expressed as a percentage (Anonymous, 2006).

Compressive strength: For the compressive strength test, the compression testing machine was used. The labeled samples (24; 9 and 24; 6-inch blocks) of the blocks produced from the different block industries were crushed in order to obtain the crushing loads. The compressive strength was determined according to BS 2028. The crushing load was indicated by the monitor on the compressive strength machine while the cross sectional area of the blocks were calculated from the data in the dimension check the compressive strength of each block was then calculated, recorded and then tabulated. The blocks were place in between pieces of plywood before being placed on the compressive strength, so as to ensure a uniform distribution of the applied load across the whole face of the block. Before the compressive strength test was carried out, the weight of the block and area (mm^2) was obtained from the dimension check tests initially carried out. During the actual compressive strength test the machine gradually loaded the block until it failed. The failed load was noted and recorded. Two pieces of plywood were placed at the bottom and the top of the block, so as to evenly distribute the load across the surface area of the block. The resulting compressive strength was determined using the equation below. It was expressed as Newton per millimeter squared (N/mm^2) (Abdullahi, 2005; Hijab *et al*., 2010).

Sieve analysis: The sieve analysis test is used to determine the distribution of the coarse, larger-sized particles it is widely used in the classification of soil. The distribution of different grain sizes affects the engineering properties of soil. This analysis will be carried out on all the materials that will be used except for cement. A dry sample of mass 1000 g of the soil is measured using the weighing balance and also the weight of each sieve is taken and recorded. The sieves will be arranged in ascending order (sieve size of 2 mm at the top and 63 μm at the bottom with the pan it). The soil sample will be carefully poured into the top sieve. The sieve stack is then placed in the mechanical shaker and allowed to shake for 10 min. The stack of sieve is then removed from the shaker and then each sieve with the sample retained on it was weighed and recorded.

Silt/clay content: The silt/clay content of the fine aggregates is the volume of silt/clay present in fines. Fine aggregates with larger volume of clay required washing before use in construction as silts clay and organic matters are not suitable for construction.

Consistency test: Consistency test of cement was carried out in order to determine the percentage of water requiredfor preparing cement pastes for other tests. This was carried out on the bua, elephant and dangote cements used during the project.

Initial and final setting time test: This was carried out to determine the beginning of noticeable stiffening in the cement paste (initial setting) and the time at which the final hardening occur (Final setting). The time from the beginning of hydration to the final set is the setting time of the cement. Checks were also made on the cements for false and flash sets. Setting time is the term used to describe the stiffening of the cement paste. The period of setting is divided into (2) parts, initial and final setting.

Time of initial set: The time at which the sample can no longer be properly mixed, finished or compacted (represented by a vicat needle penetration of 5 mm).

Time of final set: The time required for the cement to harden to a point where it can sustain load (represented by no penetration of vicat needle).

Soundness test: Soundness means the ability of cement to resist volume expansion. In the soundness test, specimen of hardened cement paste was boiled for a fixed time, so that, any tendency to expand is speeded up and detected. Soundness test was carried out using the "Le Chatelier apparatus? which consist of a small brass cylinder split along its generate. In this apparatus, two indicators with pointed ends are attached to the cylinder on either side of the split. In this manner, the widening of the split, caused by the expansion of cement is greatly magnified and can be easily measured.

Fineness test: The degree of grinding of the cement powder which is the fineness of cement determines the rate of hydration, the finer the cement, the faster the strength development fineness of cement was measured by sieving it on standard sieve. The proportion of cement of which the grain sizes are larger than the specified mesh size is thus determined. The sieve method which is one of the methods for testing cement fineness was used for this project this involves sieving some cement samples for 15 min with the sieve BS No. 170 (0.09 mm). The percentage weight retained on the sieve was noted and recorded. Fineness of cement is determined by dry sieving method. The principle of this is to determine the proportion of cement whose grain sizes is larger than specified mesh size.

RESULTS AND DISCUSSION

Grain size analysis results: The result i presented in Table 1. From the plots of percentage passing agsindt grain size, the following were obtained: for LOC 1 using the Unified Soil Classification System (USCS) to classify this soil sample, since, Cu (= 4) is (<6), the sample (sharp sand) is not well graded it can be classified as SP soil i.e., a poorly graded sand. For LOC 2, using the Unified Soil Classification System (USCS) to classify this soil sample, since, Cu (= 4) is (<6), the sample (sharp sand) is not well graded it can be classified as SP soil, i.e., a poorly graded sand. For LOC 3, using the Unified Soil Classification System (USCS) to classify this soil sample, since, Cu (= 12.5) is (>6), the sample (quarry dust) is well graded, it can be classified as SW soil, i.e., a well graded sand. For LOC 4, using the Unified Soil Classification System (USCS) to classify this soil sample, since, Cu (= 11) is (>6), the sample (laterite) is well graded it can be classified as SW soil, i.e., a well graded sand. For LOC 5, using the Unified Soil Classification System (USCS) to classify this soil sample, since, Cu (= 14) is (>6), the sample (laterite) is well graded, it can be classified as SW soil, i.e., a well graded sand.

Bulk density: The results are presented in Table 2. The lowest bulk density recorded for the 6-inch blocks was 1625.2 kg/m^3 from RBI and1495.3 kg/m^3 from EBI for the 9-inch blocks while the highest was 1942.8 kg/m^3 from OBI for the 6-inch blocks and 1682.0 kg/m^3 from OMBI for the 9-inch blocks. RBI and EBI had the lowest location average bulk densities of 1625.2 and 1495.3 kg/m^3, respectively for the 6 and 9-inch blocks, respectively. OBI and OMBI had the highest location average bulk density of 1942.8 and 1682.0 kg/m^3, respectively for the 6 and 9 -inch blocks, respectively. The average bulk density was 1730.8 kg/m^3 for the 6-inch blocks and 1592.9 kg/m^3 for the 9-inch blocks as can be seen in Table 3 and 4.

According to BS 2028 (1975), the average bulk density of both the 6 and 9-inch blocks can be classified as Type A: dense aggregate blocks with a density not <1500 kg/m^3 except for the 9-inch blocks from EBI whose average bulk density is below 1500 kg/m^3 and can be classified as Type B: light aggregate blocks for load bearing walls. Therefore, based on the provision in BS2028 (1975) the blocks in Omu-Aran can generally be used for load bearing walls.

Table 1: Result for sieve analysis for all locations

	Location of block industry									
Sieve size	2.00	1.18	0.6	0.425	0.3	0.212	0.15	0.075	0.063	Pa
LOC 1	85.40	79.05	61.65	47.85	32.45	19.45	9.45	3.35	2	0
LOC 2	85.40	79.05	61.65	47.85	32.45	19.45	9.45	3.35	2	0
LOC 3	67.00	56.45	42.60	34.60	25.75	18.05	11.75	3.30	2.2	0
LOC 4	33.85	25.90	17.10	13.20	9.55	6.65	4.15	1.35	1.05	0
LOC 5	69.70	57.55	41.50	30.90	25.45	20.90	13.80	5.50	1.5	0

Table 2 : Time and penetration values of cement

Time (min)	Penetration (mm)	Remark
0	40	Initial setting time
5	10	
10	40	
15	40	
20	40	
25	40	
30	40	
35	40	
40	38	
45	**34**	
50	LP	
180	LP	
240	LP	
300	LP	
360	LP	
420	LP	
480	LP	
540	LP	
600	LP	
625	NP	

LP: Low Penetration; NP: No Penetration

Water absorption capacity: The results are presented in Table 4. The lowest water absorption capacity for the 6-inch blocks was 165.6 kg/m^3 from OMBI and 176.6 kg/m^3 from OBI for the 9-inch blocks while the highest water absorption capacity for the 6-inch blocks was 339.4 kg/m^3 from EBI and 428.5 kg/m^3 from RBI for the 9-inch blocks. OMBI and OBI had the lowest location average water absorption capacities of 175.4 kg/m^3 and 184.2 kg/m^3, respectively for the 6 and 9-inch blocks, respectively. EBI and RBI had the highest location average water absorption capacity of 271.4 and 338.3 kg/m^3 for the 6 and 9-inch, respectively. The average water absorption capacity for the 6-inch blocks was 234.8 and 262.6 kg/m^3 for the 9-inch blocks.

The water absorption capacities for all the 6-inch blocks revealed that 6-inch sandcrete blocks from most of the block industries were lower than the maximum limit recommended by Anonymous (2014) ASTM C140 of 240 kg/m^3 except for blocks from OBI, EBI and RBI whose blocks had water absorption capacities above maximum limit recommended. For the 9-inch blocks, water absorption capacities for the 9-inch sandcrete blocks revealed that only product from OBI block making industry has absorption capacity lower than the maximum limit recommended as above while blocks from OMBI, BBI, EBI and RBI has water absorption capacities higher than the recommended value as it can be seen in Table 3. The overall average of the blocks in 6-inch blocks falls below the maximum limit of 240 kg/m^3 as recommended by ASTM C140 while that of 9-inch is higher. Therefore, blocks from locations whose average water absorption capacity is above 240 kg/m^3 are not fit for use. This can be attributed to high percentage of fines.

Silt/clay content test result: Based on the relevant calculations, the ratio of fine aggregate is 18.5% whereas the maximum percentage for silt/clay content of concrete must not be more than 6% (Cho, 2013) and this has violated this as the value gotten is very high. It shows that the silt/clay content of these blocks are high and make them of low strength.

Compressive strength: The compressive strength of the individual 6-inch blocks ranged from 0.50 N/mm^2 from RBI -1.49 N/mm^2 from OMBI and that of the 9-inch blocks ranged from 0.39 N/mm^2 from OBI-0.93 N/mm^2 from EBI. Blocks from OMBI had the highest mean compressive strength for the 6-inch blocks (1.40 N/mm^2) and blocks from EBI for the 9-inch blocks (0.90 N/mm^2). The lowest mean compressive strength was recorded for the 6-inch blocks were 0.50 N/mm^2 from RBI and 0.50 N/mm^2 from OBI for the 9-inch blocks. The mean compressive strength for all the 6-inch blocks was 0.80 and 0.60 N/mm^2 for the 9-inch blocks. These compressive strengths fall far below the recommended minimum value of 2.5 N/mm^2 for individual blocks as recommended by the Nigerian Industrial Standards (NIS 87: 2000). According to the Nigeria Industrial Standards (NIS 87: 2000) the average compressive strength of 5 sandcrete blocks shall not be 3.45 N/mm^2 while the British Standard BS 2028 (1975) recommends the average compressive strength of 5 commercial sandcrete blocks should not be <3.25 N/mm^2. The 3-blocks average compressive strengths of the various block industries falls far below the

Table 3: Average water absorption capacities of blocks from selected block industries

	150 mm blocks		225 mm blocks	
Location	Water absorption N (kg/m^3)	Average water absorption N (kg/m^3)	Water absorption N (kg/m^3)	Average water absorption N (kg/m^3)
OMBI	165.6	175.4	257.8	**254.7**
	177.8		245.5	
	182.9		260.6	
BBI	207.8	221.6	283.0	**272.8**
	218.6		270.3	
	238.5		265.0	
OBI	200.5	249.7	184.8	**184.2**
	255.6		191.3	
	292.9		176.6	
EBI	246.5	271.4	214.8	**263.1**
	228.3		302.7	
	339.4		271.9	
RBI	245.5	255.9	270.5	**338.3**
	246.2		315.9	
	276.0		428.5	
Average water consumption for all blocks	234.8	234.8	262.6	**262.6**

Table 4: Compressive strength of blocks from selected block industries

	150 mm blocks		225 mm blocks	
Location	Average compressive	Strength (N/mm^2)	Average compressive	Strength (N/mm^2)
OMBI	1.40	1.4	0.64	**0.6**
	1.49		0.49	
	1.29		0.55	
BBI	0.53	0.6	0.70	**0.7**
	0.64		0.68	
	0.00	0.6	0.76	
OBI	0.62	0.6	0.48	**0.5**
	0.59		0.54	
	0.49		0.39	
EBI	0.79	0.8	0.85	**0.9**
	0.78		0.93	
	0.82		0.77	
RBI	0.47	0.5	0.55	**0.6**
	0.00		0.51	
	0.57		0.65	
Average compressive strength (N/mm^2) for all blocks	0.80	0.8	0.60	**0.6**

Bold values are significant values

recommended minimum limits in both standards. The low values and variation of compressive strengths indicate poor quality control in the production of these blocks.

CONCLUSION

The study has shown that the sandcrete blocks which are in circulation in Omu-Aran, Nigeria have an average bulk density of 1730.8 kg/m^3 for the 6-inch blocks and 1592.9 kg/m^3 for the 9-inch blocks which is above the 1500 kg/m3 minimum limit for Type A: dense aggregate blocks. In terms of bulk density they qualify to be used in load bearing walls. Further, the study has shown that the sandcrete blocks in circulation in Omu-Aran, Nigeria have an average water absorption capacity of 234.8 kg/m^3 for the 6-inch blocks which falls below the maximum recommended limit of 240 kg/m^3. Hence, the 6-inch blocks in Omu-Aran are of standard water absorption capacity but the value of 262.6 kg/m^3 for the 9-inch blocks are higher than the maximum recommended limit hence, not fit for use.

Finally the study has shown that the compressive strength of commercially produced sandcrete blocks in circulation in Omu-Aran is far below the recommended minimum limits both for individual block and average of 3-blocks per block industry. The values for individual 6-inch blocks ranging from 0.50-1.49 N/mm^2 and for individual 9-inch blocks ranging from 0.39-0.90 N/mm^2. The mean compressive strengths from the selected block making industries ranged from 0.50-1.40 N/mm^2 for the 6-inch blocks and 0.50-0.90 N/mm^2. These values fall below the Nigeria Industrial Standards (NIS 87: 2000) recommended value of 2.5 N/mm^2 for individual sandcrete blocks and 3.45 N/mm^2 for 5 sandcrete blocks.

RECOMMENDATIONS

From the conclusions, it is recommended that; commercially produced blocks in Omu-Aran should not be used in load bearing walls but may be used in external and partitioning walls in framed structures. Compliance to improved curing practices, reasonable batching practices and use of recommended materials should be strongly enforced by Council for the Regulation of Engineering in Nigeria (COREN) and Nigeria Society of Engineers (NSE) on blocks producers to ensure production of quality blocks. Stakeholders should be enlightened on the current state of the quality of blocks being commercially produced in Omu-Aran, Nigeria and the dangers of compromising safety over cost.

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