Assessment of Structural Strength of Commercial Sandcrete Blocks in Kano State

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ABSTRACT: This research was aimed at studying the strength properties of the commercial sandcrete blocks produced in Kano State. A total number of 250 block samples were randomly collected from five local government areas, fifty (50) from each of the local governments and cured for 3, 7, 14, 21 and 28 days. The blocks were subjected to various tests at wet and dry conditions as follow: wet compressive test, drying shrinkage, moisture movement and density all in accordance with established standards in the structural laboratory of Department of Civil Engineering, Ahmadu Bello University, Zaria, and the aggregates were subjected to sieve analysis and moisture content determination in the Geotechnical Laboratory of the department. The compressive strength was found to be between 0.25 N/mm^2 and 0.92 N/mm^2 which are far below the specified values (2.5 N/mm^2 to 3.45N/mm^2 respectively) in the Nigerian Industrial Standard (NIS 87, 2000). It is concluded that the commercially produced sandcrete blocks in Kano State are of lower standard than expected. It is recommended that workshop should be organised periodically to enlighten the producers of sandcrete blocks. The importance of adhering to standard specifications should be emphasised and strict penalties be meted out to erring producers by the Nigerian Industrial Standard Organisation.

KEYWORDS: sandcrete blocks, compressive strength, Kano State, British standard, mix ratio

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I. INTRODUCTION

Sandcrete blocks are the most prominent of the concrete masonry units in the building industry today especially in the construction of residential, industrial and commercial buildings (Ejeh, 1982). Sandcrete blocks are the most widely used walling unit in Nigeria, accounting for 90% of houses (Ewa and Ukpata 2013). They could be used as external walls (i.e. 460 mm thick blocks) or as partition walls (the 150 mm thick blocks.). The later (150 mm) is usually non-load bearing. They are made from a cement/sand mix usually 1 part of cement to 6 or 8 parts of sand (1:6 or 1:8) with a water/cement ratio of between 50 and 75% (B.S. 3921: 1969).

Historically, most concrete masonry units are manufactured on the local level and industry standards are not always adhered to (Ewa and Ukpata 2013, Aiyewalehinmi and Tanimola 2013, Mahmoud *et al* 2010, Abdullahi 2005). Variations in shape, size and surface texture are common features. There is no complete standardization of sizes in the industry for sandcrete blocks and sizes must be checked in each locality.

Cement stabilized laterite and cement stabilized sand (Sandcrete) increases in strength with cement content and that at high cement content, the granules of sandcrete blocks behave elastically (Adepegba, 1975). It was also observed that the most economic range of the use of cement stabilized sand lies between 0-10 percent cement content by weight (Ejeh 1982).

B.S. 2028 (1968) gives specification for precast concrete blocks which describes solid, hollow and cellular blocks: See Table 1.

Table 1: Specification for precast concrete blocks.

Type	Void percent of total volume
Solid	Up to 25 percent
Hollow; large holes or cavities pass through the block.	More than 25 percent but less than 50 percent
Cellular: Large holes or cavities with one bed, face closed (usually laid uppermost).	More than 25 percent but less than 50 percent

Source: B.S. 2028 (1968)

It further stated that the total width of cavities measured at right angles to the face of the blocks as laid in a wall must not exceed 65 percent of the block thickness. Table 2 gives the dimensions for the three types of blocks described in the British Standard.

Table 2: Dimensions for the three types of blocks in British Standard.

Type	To bond with B 7mm bricks size specified for manufacture (mm)	Sizes dimensionally conditioned on the nominal 102 mm basis. Size specified for manufacture (mm)
A Length	448	397 or 499
Height	143 or 219	194 or 295
Thickness	51,64,76,102,152 or 219	76,92,102,143,178 or 194
B Length	448	397,499 or 600
Height	219	194 or 295
Thickness	76,89,102,152,203 or 219	76,92,102,143,178 or 194
C Length	448	397,499 or 600
Height	219	194 or 295
Thickness	51 or 64	51 or 64

Source: B.S. 2028 (1968)

The standard (BS 2028) describes type A blocks as dense (having a density of not less than 1500 kg/m3) and include the

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strongest blocks the use of which is permitted in all positions. Types B and C blocks are lightweight concretes having densities less than 1500 kg/m^3 made with lightweight aggregate or aerated cement with or without fine aggregate, high pressure steam autoclaved.

The minimum level of performance of blocks and bricks which deals with solid blocks, cellular blocks and with a variety of aggregates including lightweight blocks and blocks made with autoclaved aerated concrete (NIS, 2004). This code also deals with solid bricks, hollow bricks and cellular bricks. It states that the minimum requirement for blocks (which are more than 75 mm thick) and for bricks are based on a sample of ten units for which the average crushing strength must be not less than $0.9Q + 0.62S$, where $Q = 2.8$ N/mm^2 as a minimum for concrete blocks and S is the standard deviation for the ten units.

Table 3: Compressive Strength for Sandcrete/Masonry.

Standard	Average Strength N/Mm^2	Lowest Strength N/Mm^2	Number of Blocks Tested N/Mm^2	Immersion Days	Contact Layer
NIS 74	2.50	Not specified	About 6 blocks	1&3	Plywood
FMW 1979	2.10	1.70	3 blocks	Not specified	Not specified
BS 2028/A	3.50	2.80	12 blocks	7 - 8	Cement mortar
BS 2028/B	2.80	2.25	12 blocks	7 - 8	Cement mortar

Source: BS 2028 (1968)

Compressive strength for sandcrete /masonry is presented in table 3 above. The Compressive strength often referred to for sandcrete /masonry is based on the gross area of the unit, that is, the total area including any core spaces. The primary factors influencing the compressive strength of cement are type and gradation of aggregate, degree of compaction, amount of water used, and moisture content and temperature of the units at test period.

II. FACTORS AFFECTING QUALITY OF SANDCRETE BLOCKS

Compressive strength of sandcrete blocks is widely accepted as the leading parameter for quality control and this quality is largely dependent upon the type and properties of the constituent materials (Murdock *et al*, 1991).

- Cement: The cement used by the industries is basically from Ashaka cement factory which is ordinary Portland cement. Poor quality of cement usually reflects in the strength of the end product.
- Sand: Neville (1997), describes sand as a natural aggregate that can be separated by such gentle mechanical means as agitation in water which implies that it is a cohesionless aggregate of rounded angular or sub angular fragments of more or less unaltered rocks or minerals. Particles with a size of up to 5 mm are referred to as sand.
- Mix Ratio: Mix ratio with respect to sandcrete blocks refers to the ratio of quantity of cement to the quantity sand. Standard mix ratio for sandcrete blocks should range between 1:6 to 1:8, or not more than twenty five (25) blocks are allowed to be produced for each bag of cement as a rule of thumb.
- Proper Curing: Curing is also one of the crucial factors that determine the attainment of the desired strength of sandcrete blocks. The method and the duration of curing must be given proper for attention for the blocks to have attained their designed strength, even if the materials are of the required quality and mix ratio is adequate.

III. MATERIALS AND METHOD

The localities were so 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 A,B,C,D and E 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.

A. Case Study Industries

Industry A is located along Bayero University new campus road in Ungogo local government. The producer claims that he produces about forty (40) blocks (225 mm thick) per each bag of cement instead of using a mix of 1 part cement to 4 parts coarse sand and 2 parts fine sand (1:6) or at worst 1:8 or twenty five (25) blocks per bag of cement as an acceptable rule of thumb. The detailed result of the sieve analysis on the soil sample obtained from the industry is presented in Table 7.

The blocks are produced by means of an automatic block making machine which compact and vibrate the mix in a steel moulds. A very dry mixture of cement, aggregate and water is used and the moulds are removed immediately after compaction. This machine produces four 460 mm x 225 mm blocks simultaneously. The machine has a production capacity of about one thousand five hundred (1,500) per day. The source of water in the industry is a tap located at the corner. The industry has staff strength of about ten (10) men. Fifty blocks were bought from the industry. The method of curing is by spraying the blocks with water in the morning and evening for minimum of three (3) days to maximum of seven (7) days.

Industry B block industry is located at the edge of Gezawa town in Gezawa Local Government. Here the producer said to have been producing between thirty five (35) to thirty nine (39) blocks (225 mm thick) per bag of cement. The method of curing is by spraying the blocks with water in the morning and evening for minimum of three (3) days to maximum of seven (7) days.

Industry C is located in Tudun Wada town in Tudun Wada Local Government, the cement used is also of Ashaka brand and the manager did not reveal his mix ratio. The method of curing is by spraying the blocks with water in the morning and evening for minimum of three (3) days to maximum of seven (7) days.

Industry D is located in Gwarzo town in Gwarzo Local Government. The type of cement used is also Ashaka type of ordinary Portland cement. The producer said to have been

producing between 40 blocks (225 mm thick) per bag of cement. The method of curing is by spraying the blocks with water in the morning and evening for minimum of three (3) days to maximum of seven (7) days.

Industry E is located in Wudil town in Wudil Local Government. The cement used by the producer is also the Ashaka brand of the ordinary Portland cement. The producer said to have been producing between 40 blocks (225 mm thick) per bag of cement. The method of curing is by spraying the blocks with water in the morning and evening for minimum of three (3) days to maximum of seven (7) days.

B. Data Collection and Preparation

A total of two hundred and fifty (250) block samples (225 mm thick) were collected from five local government areas, that is 50 block samples from each area. The block samples were subjected to various tests in the structural laboratory of the department of Civil Engineering, Ahmadu Bello Universty, Zaria. The tests carried out include dry development strength test, wet development test, wet compressive test, shrinkage, sieve analysis and moisture content.

Each specimen was immersed in water at a temperature of 20+/- 2°C for at least 16 hours and allowed to drain for about 30 minutes under damp sacking or similar material before capping with mortar in accordance with BS 2028 (1968).

C. Evaluation Procedure

Since tests for compressive strength are widely accepted as the most convenient means of quality control and this quality is largely dependent upon the type and properties of the constituent materials used, results for the compressive tests for the five locations are as shown in Table 4a. The Age (days) refers to the number of days with reference to the time of production.

Table 4a: Dry development strength values for Industry A.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	460	229	230	50.50	1045.83	0.48
7	459	230	228	76.20	1058.30	0.72
14	461	230	229	94.20	1109.69	0.89
21	458	230	230	96.30	1136.08	0.91
28	460	229	230	97.30	1170.83	0.92

Mean strength value = 0.79 N/mm^2, Standard deviation = 0.17 N/mm^2, covariance = 21.50%.

Table 4b: Dry development strength values for Industry B.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	459	227	230	40.20	1033.30	0.38
7	461	228	229	63.50	1048.61	0.60
14	460	230	229	77.20	1068.02	0.73
21	459	230	230	81.50	1099.97	0.77
28	460	230	230	82.50	1116.63	0.78

Mean strength value = 0.65 N/mm^2, Standard deviation = 0.15 N/mm^2, covariance = 23.08%.

Table 4c: Dry development strength values for Industry C.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	460	229	229	36.00	1012.47	0.34
7	459	230	229	44.50	1030.42	0.42
14	461	228	228	53.00	1033.60	0.50
21	461	229	227	56.00	1043.30	0.53
28	459	230	230	58.20	1064.58	0.55

Mean strength value = 0.47 N/mm^2, Standard deviation = 0.08 N/mm^2, covariance = 17.02%.

Table 4d: Dry development strength values for Industry D.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	459	229	230	26.50	1005.56	0.25
7	459	230	228	33.90	1019.44	0.32
14	460	228	229	42.30	1029.86	0.40
21	461	230	228	46.60	1043.02	0.44
28	460	229	229	48.70	1096.91	0.46

Mean strength value = 0.37 N/mm^2, Standard deviation = 0.08 N/mm^2, covariance = 21.62%.

Table 4e: Dry development strength values for Industry E.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	460	229	228	49.70	1019.41	0.47
7	460	230	229	67.70	1035.72	0.64
14	460	230	230	79.40	1062.08	0.75
21	459	229	230	87.80	1067.60	0.83
28	459	230	230	91.00	1090.97	0.86

Mean strength value = 0.72 N/mm^2, Standard deviation = 0.14 N/mm^2, covariance = 19.44%.

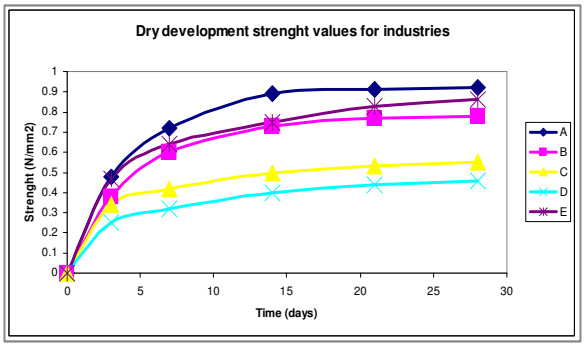

Figure 1: Graph showing the dry development strength values against days for the five industries.

Table 5a: Wet development strength values for Industry A.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	461	229	229	40.20	1229.17	0.38
7	460	230	230	46.55	1368.06	0.44
14	459	230	230	51.40	1448.61	0.58
21	460	229	230	62.40	1530.52	0.59
28	460	230	230	62.42	1362.50	0.59

Mean strength value = 0.52 N/mm^2, Standard deviation = 0.09 N/mm^2, covariance = 17.31%.

Table 5b: Wet development strength values for Industry B.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	460	229	230	27.50	1154.17	0.26
7	459	229	229	31.70	1334.72	0.30
14	459	230	230	42.32	1427.78	0.40
21	459	230	230	44.50	1458.33	0.42
28	461	230	230	45.50	1498.83	0.43

Mean strength value = 0.36 N/mm^2, Standard deviation = 0.07 N/mm^2, covariance = 19.44%.

Table 5c: Wet development strength values for Industry C.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	460	230	229	23.30	1095.83	0.22
7	461	230	230	29.60	1136.11	0.28
14	460	230	229	35.90	1188.89	0.34
21	460	229	230	38.00	1204.17	0.36
28	459	230	230	39.10	1270.83	0.37

Mean strength value = 0.31 N/mm^2, Standard deviation = 0.06 N/mm^2, covariance = 19.35%.

Table 5d: Wet development strength values for Industry D.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	461	229	229	19.00	1132.92	0.18
7	461	230	228	23.30	1197.22	0.22
14	460	230	230	29.60	1287.50	0.28
21	460	230	230	31.70	1327.77	0.30
28	459	229	229	31.72	1405.55	0.30

Mean strength value = 0.26 N/mm^2, Standard deviation = 0.05 N/mm^2, covariance = 19.23%.

Table 5e: Wet development strength values for Industry E.

Age (Days)	Avg Length (Mm)	Avg Width (Mm)	Avg Height (Mm)	Failure Load (Mm)	Avg Density Kg/M^3	Avg Strength N/Mm^2
3	460	228	230	39.20	1150.00	0.37
7	460	229	229	46.30	1194.45	0.44
14	459	229	229	56.00	1302.78	0.53
21	459	230	229	61.40	1437.50	0.58
28	451	230	229	63.50	1479.17	0.60

Mean strength value = 0.50 N/mm^2, Standard deviation = 0.09 N/mm^2, covariance = 18.00%.

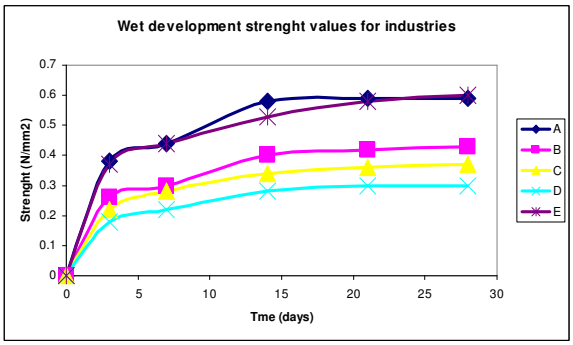

Figure 2: Graph showing the wet development strength values against days for the five industries.

IV. Discussion

From the information obtained above, we can clearly see that none of the producers complies with the allowable mix ratio standardized for sandcrete blocks. And it can also be seen that none of them follows the appropriate method of curing by immersing the blocks in curing tank for the design period but instead they spray the blocks with the water twice a day. And they start selling out the blocks from the third day of curing instead of minimum of one weak.

Considering the methods and procedure of the tests conducted and as can be seen from the graphs, it is important to make the following observations and conclusion on the nature and quality of the Sandcrete blocks produced in Kano and Jigawa States of Nigeria.

The strength of Sandcrete blocks produced in the industry A at 28 days is higher than that of other industries (B, C, D, E) in the dry development stages. However, this is much lower than the minimum value of 2.5 N/mm^2 specified by the Nigerian Industrial Standard.

The wet development strength has a maximum value of 0.59 N/mm^2 for the industry as compared with the minimum value of 2.50 N/mm^2.The overall average dry development strength value is 0.58 N/mm^{2}and that of the wet development strength is 0.39 N/mm^2 (i.e. about 67% of the dry development strength value).

The quality of the sandcrete blocks depend mainly on the quality of the constituent materials viz: cement, sand and water/cement ratio respectively. All the sand particles used by industries A, B, C, D and E fall within zone 1 of the grading curve of BS 882.

V. Conclusion

The paper has assessed the strength of commercial sandcrete blocks produced in Kano State of Nigeria. The following conclusions are drawn from the study:

i. The producers are not actually adhering to the standard specification for mix ratio as is required for sandcrete blocks.
ii. They do not conform to the standard method and duration for curing as they do it haphazardly by spraying water with a hose twice a day for a period of three days or more.
iii. Commercial sandcrete blocks produced in Kano State do not meet the standard required strength for commercial blocks.

It is therefore recommended that workshops/seminars should be organized periodically to enlighten the producers of sandcrete blocks on importance of adhering to standard specifications and strict penalties should be meted out to erring producers by the Nigerian Industrial Standard Organization.

References

Abdullahi, M. (2005). Compressive Strength of Sandcrete Blocks in Bosso and Shiroro Areas of Minna, Nigeria, A.U. J.T. 9(2): 126-132.

Adepegba, D. (1975). The structural properties of Latecrete and concrete. Presented at the seventh biennial

conference of the West African Science Association Journal of Testing and Evaluation (jteva), 6: 1975.

Aiyewalehinmi, E. O., Tanimola, M. O. (2013). Strength Properties of Commercially Produced Sandcreteblock In Akure: Ondo State, International Journal of Engineering Science Invention, 2(5): 22-33.

BS (British Standard) 2028 (1968). Specification for Precast Concrete Blocks. British Standard Institution, Gayland and Sons Ltd. London.

BS (British Standard) 3921 (1969). Specification for bricks and blocks of fired brick earth, clay or shale.

Ejeh, S. P. (1982). Comparative strength of Soilcrete blocks in Zaria, (Unpublished) Msc Thesis, Department of Civil Engineering, Ahmadu Bello University, Zaria.

Ewa, D. E., Ukpata, J. O. (2013). Investigation of the Compressive Strengths of Commercial Sandcrete Blocks in Calabar Nigeria. International Journal of Engineering and Technology, 3(4): 477 - 482.

Mahmoud, H., Hamma, H. A. and Abba, H. A. (2010). Compressive Strength of Marketed Sandcrete Blocks Produced in Yola, Nigeria, Journal of Engineering and Applied Sciences, 2: 74 – 81.

Neville, A. M. (1983). Properties of Concrete; 3rd ed. Longman Group, U.K.

NIS (Nigerian Industrial Standard) (2000). Standard for Sandcrete Blocks. The Standard organization of Nigeria.

NIS (Nigerian Industrial Standard) (2004). Characteristics of the Compressive Strength of Sandcrete blocks. The Nigerian Industrial Standard Organization of Nigeria.