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Structural Characteristics of Sandcrete Blocks Produced in South-East Nigeria

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Abstract: Blocks are indispensable materials predominantly used as walling units in the construction of shelter (which is one of the basic needs of man) and other infrastructures. Some of the problems faced in construction can be linked to this masonry unit, which is a major construction material. A survey was conducted of the various block moulding firms within south east Nigeria to determine the mode of production of blocks, mix ratios nature/quality of sand and the structural characteristics of the blocks. In this paper, the results obtained were compared with standard specifications. It was found out that most of the blocks produced are generally substandard. Block production practices in Nigeria should be looked into by the government. Quality control should be introduced to assist block producers to produce strong and durable blocks at minimal cost.

Key Words: Blocks, Structural characteristics, South-East, Nigeria.

INTRODUCTION

Sandcrete blocks are masonary units manufactured from a mixture of cement, sand and water. They are predominantly used as walling materials in construction of shelter (which is one of the basic needs of man) and other infrastructures. The percentage of walling materials made of sandcrete blocks account for over 95% of all walling materials. Sandcrete has been in use throughout West Africa for over 50years as a popular building material for preparation of building blocks. Block moulding or sandcrete technology is becoming the backbone of infrastructural development of every country.

At present, numerous block making firms have sprung up in south east Nigeria to meet with the requirements of construction and infrastructural development. These block making firms include both small scale and large scale producers. Small scale producers use manual method of mixing and moulding while large scale producers use mixers and block moulding machine.

Several researchers (Acquah and Danso, 2003; Amiri, Krause, Tadros, 1994; Andam, 2002; Baiden, and Tuuli, 2004; deVerkey, 2001; deVerkey and West, 1980; Emesiobi, 2004) have worked on sandcrete blocks using different methods of production, mix ratios, different cement materials, different aggregate materials and admixtures to produce good quality blocks. However, there is need to look into the quality of blocks produced by commercial producers that are widely used in construction today.

Recently, some problems like structural failures have been recorded in the construction industry in Nigeria. This masonry unit which is major

construction material cannot be unconnected to some of these problems faced in construction. From experience in construction, the blocks produced show wide variations in their strength. In view of this, a survey was conducted of the various block moulding firms within south east Nigeria to determine the mode of production of blocks, mix ratios nature/quality of sand and the structural characteristics of the blocks. In this paper, the results obtained will be compared with standard specifications.

METHODOLOGY

Two types of investigations, namely field and laboratory were carried out in this work.

Field Investigation

About thirty block firms within south east Nigeria were visited. The survey was made in order to find out the block firms' mode of production, mix ratios, nature/quality of sand and other necessary information. Blocks were bought from different manufacturers and carried to the laboratory for the necessary tests.

Laboratory investigation

The blocks bought from different producers were crushed in universal compression testing machine to determine their compressive strength in accordance to BS 2028,1364 (1968). The crushing load was recorded and the compressive strength was obtained from the following equation:

$$f_c = \frac{P}{A} \qquad (1)$$

where f_c = the compressive strength
P = crushing load
A = cross-sectional area of the specimen

RESULTS AND DISCUSSION

The field result and the laboratory results of the tests conducted are presented as follows:

Field results

From the field survey made, the following information was gathered:

(a) Types and sizes

There are two main types of blocks moulded within south east Nigeria. They are solid and hollow blocks. The sizes in length x breath x height include

1. 450mm x 225mm x 225mm (hollow)
2. 450mm x 150mm x 225mm (hollow)
3. 450mm x 225mm x 225mm (solid)
4. 450mm x 150mm x 225mm (solid)
5. 450mm x 125mm x 225mm (solid)

(b) Constituent materials

These include cement, fine aggregate (sharp sand), and water.

1. Fine aggregate (sand): The two major types of sand used are white sand and coloured sand. The sands were not free from materials such as dust, silt, tree roots etc. Their sources of sand include pits, rivers and sea.
2. Cement: Ordinary Portland Cement (OPC) is widely used.
3. Water: They make use of any type of water available. This includes water from streams, rivers, boreholes.

(c) Mode of production/ Mix ratios

Batching by volume is adopted by block manufacturers. They use wheel barrows and paint buckets (for water). The mix ratio varies from 1 bag of cement to 3 to 7 wheel barrows of sand. The amount of water required is usually determined by trial and error. This ranges from 2 to 4 paint buckets of water or 3 to 5 wheel-barrows of water depending on the moisture content of the sand.

Small scale manufacturers use manual method of mixing while large scale manufacturers use mixers. The general procedure for mixing is as follows:

Measure sand and cement unto a concrete platform on the ground. Mix with shovel about three times. Add water the fourth time and then turn the whole mix about two times.

Most of the block producers use moulds. The equipment is prefabricated steel or wooden mould box of the requisite dimension with one end open and removable steel or wooden plate resting at the

bottom. Two perforated handles on either side of the device assist in the lifting and overturning the steel mould box. It is accompanied by a steel or wooden rod which is used for compaction. The procedure for moulding is as follows: Pour mixture into mould, vibrate, ram and demould immediately. Cure after 24 hours. The block moulding machine used by the large scale producers is the Rosacometta type which vibrates the block during filling and or compaction. One block is produced at a time. One bag of cement produces an average of fifty blocks.

The method generally adopted for curing is sprinkling the exposed blocks with water 24 hours after demoulding. They use long rubber hoses with nozzles. Ninety percent of the manufacturers spray their blocks once a day for a period of not more than three days. They do this because they are always in a haste to dispose of the blocks, cut cost and economise space.

Laboratory results

The results of compressive strength tests carried out on the blocks bought are presented on Tables 1 to 10. The variances and standard deviation were calculated. The result of the calculation of standard deviation of the compressive strength of the blocks from each block firm is presented on Table 11.

Table 1: Compressive strength test result for block firm A located at Nekede

Block sample no	Compressive strength (X) in N/mm^2	$(X - \bar{X})$	$(X - \bar{X})^2$
1	1.03	-0.012	0.00
2	1.15	0.108	0.012
3	0.92	-0.122	0.015
4	1.12	0.078	0.006
5	0.99	-0.052	0.003
	$\sum X = 5.21$		$\sum(X - \bar{X})^2$ = **0.036**

Total number of samples, $N = 5$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{5.21}{5} = 1.042 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.036}{5} = 0.0072$

Standard deviation, $\sigma = \sqrt{0.0072} = 0.08 N/mm^2$

Table 2: Compressive strength test result for block firm B located at Concord road

Block sample no	Compressive strength (X) in N/mm^2	$(X - \bar{X})$	$(X - \bar{X})^2$
1	0.60	0.032	0.001
2	0.66	0..028	0.0008
3	0.40	-0.232	0.054
4	0.70	0.068	0.005
5	0.80	0.016	0.028
	$\sum X$ = **3.16**		$\sum(X - \bar{X})^2$ = **0.0888**

Total number of samples, $N = 5$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{3.16}{5} = 0.632 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.0888}{5} = 0.018$

Standard deviation, $\sigma = \sqrt{0.018} = 0.134 N/mm^2$

Table 3: Compressive strength test result for block firm C located along Port Harcourt road

Block sample no	Compressive strength (X) in N/mm^2	$(X - \bar{X})$	$(X - \bar{X})^2$
1	1.16	0.008	0.00006
2	1.12	-0.032	0.0010
3	1.16	0.008	0.00006
4	1.14	-0.012	0.00014
5	1.18	0.028	0.0008
	$\sum X$ = 5.76		$\sum(X - \bar{X})^2$ = **0.00204**

Total number of samples, $N = 5$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{5.76}{5} = 1.152 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.00204}{5} = 0.0004$

Standard deviation, $\sigma = \sqrt{0.0004} = 0.02 N/mm^2$

Table 4: Compressive strength test result for block firm D located along Chukwuma Nwaoha street

Block sample no	Compressive strength (X) in N/mm^2	$(X - \bar{X})$	$(X - \bar{X})^2$
1	1.02	-0.022	0.0005
2	1.12	0.078	0.006
3	1.10	0.058	0.0033
4	0.99	-0.052	0.0027
5	0.98	-0.062	0.0038
	$\sum X$ = 5.21		$\sum(X - \bar{X})^2$ = **0.0163**

Total number of samples, $N = 5$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{5.21}{5} = 1.042 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.0163}{5} = 0.003$

Standard deviation, $\sigma = \sqrt{0.003} = 0.055 N/mm^2$

Table 5: Compressive strength test result for block firm E located at Nekede

Block sample no	Compressive strength (X) in N/mm^2	$(X - \bar{X})$	$(X - \bar{X})^2$
1	1.50	0.068	0.0046
2	1.40	-0.032	0.0010
3	1.46	0.028	0.00078
4	1.38	-0.052	0.0027
5	1.42	-0.012	0.00014
	$\sum X$ = 7.16		$\sum(X - \bar{X})^2$ = **0.00922**

Total number of samples, $N = 5$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{7.16}{5} = 1.432 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.00922}{5} = 0.0018$

Standard deviation, $\sigma = \sqrt{0.0018} = 0.043 N/mm^2$

Table 6: Compressive strength test result for block firm F located along Okigwe Road

Block sample no	**Compressive strength (X) in N/mm^2**	$(X - \bar{X})$	$(X - \bar{X})^2$
1	1.08	0.207	0.0428
2	0.81	-0.063	0.0039
3	0.54	-0.333	0.1109
4	0.81	-0.063	0.0039
5	0.90	0.027	0.0007
6	0.99	0.117	0.0136
7	0.90	0.027	0.0007
8	0.81	-0.063	0.0039
9	0.99	0.117	0.0136
10	0.90	0.027	0.0007
	$\sum X$ = **8.73**		$\sum(X - \bar{X})^2$ = **0.1811**

Total number of samples, $N = 10$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{8.73}{10} = 0.873 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.1811}{10} = 0.018$

Standard deviation, $\sigma = \sqrt{0.018} = 0.134 N/mm^2$

Table 7: Compressive strength test result for block firm G located along Okigwe Road

Block sample no	**Compressive strength (X) in N/mm^2**	$(X - \bar{X})$	$(X - \bar{X})^2$
1	0.90	0.027	0.0007
2	0.81	-0.063	0.0039
3	0.81	-0.063	0.0040
4	0.90	0.027	0.0007
5	0.99	0.117	0.0137
6	0.90	0.027	0.0007
7	0.63	-0.243	0.0590
8	1.08	0.207	0.0428
9	0.72	-0.153	0.0234
10	0.99	0.117	0.0137
	$\sum X$ = **8.73**		$\sum(X - \bar{X})^2$ = **0.1626**

Total number of samples, $N = 10$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{8.73}{10} = 0.873 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.1626}{10} = 0.01626$

Standard deviation, $\sigma = \sqrt{0.01626} = 0.1275 N/mm^2$

Table 8: Compressive strength test result for block firm H located along Orlu Road

Block sample no	**Compressive strength (X) in N/mm^2**	$(X - \bar{X})$	$(X - \bar{X})^2$
1	0.90	0.054	0.0029
2	0.72	-0.126	0.0159
3	0.81	-0.036	0.0013
4	0.81	-0.036	0.0013

5	0.90	0.054	0.0029
6	0.99	0.144	0.0207
7	0.54	-0.306	0.0936
8	0.99	0.144	0.0207
9	0.72	-0.126	0.015
10	1.08	0.234	0.0548
	$\sum X$ = **8.46**		$\sum(X - \bar{X})^2$ = **0.23**

Total number of samples, $N = 10$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{8.46}{10} = 0.846 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.23}{10} = 0.023$

Standard deviation, $\sigma = \sqrt{0.023} = 0.152 N/mm^2$

Table 9: Compressive strength test result for block firm I located along Orlu Road

Block sample no	**Compressive strength (X) in N/mm^2**	$(X - \bar{X})$	$(X - \bar{X})^2$
1	0.81	-0.045	0.0020
2	0.90	0.045	0.0020
3	0.90	0.045	0.0020
4	0.81	-0.045	0.0020
5	0.99	-0.135	0.0182
6	0.54	-0.315	0.0992
7	0.99	0.135	0.0182
8	1.08	0.225	0.0506
9	0.72	-0.135	0.0182
10	0.81	-0.045	0.0020
	$\sum X$ = **8.55**		$\sum(X - \bar{X})^2$ = **0.2144**

Total number of samples, $N = 10$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{8.55}{10} = 0.855 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.2144}{10} = 0.02144$

Standard deviation, $\sigma = \sqrt{0.02144} = 0.146 N/mm^2$

Table 10: Compressive strength test result for block firm J located at Amakohia

Block sample no	**Compressive strength (X) in N/mm^2**	$(X - \bar{X})$	$(X - \bar{X})^2$
1	0.90	0.041	0.00168
2	1.01	0.151	0.0228
3	0.81	-0.049	0.0024
4	0.90	0.041	0.00168
5	0.72	-0.139	0.0193
6	0.81	-0.049	0.0024
7	0.63	-0.229	0.0524
8	1.08	0.221	0.0488
9	0.72	-0.139	0.0193
10	1.01	0.151	0.0228
	$\sum X$ = 8.59		$\sum(X - \bar{X})^2$ = 0.19356

Total number of samples, $N = 10$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{8.59}{10} = 0.859 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.19356}{10} = 0.019356$

Standard deviation, $\sigma = \sqrt{0.019356} = 0.139 N/mm^2$

Calculation of standard deviation of the compressive strength of the blocks from each block firm

Table 11: Average compressive strength test result for all the block firms and the standard deviation

Block firm	**Average compressive strength (X) in N/mm^2**	$(\boldsymbol{X - \bar{X}})$	$(\boldsymbol{X - \bar{X}})^2$
A	1.042	0.0814	0.0066
B	0.632	-0.3286	0.1080
C	1.152	0.1914	0.0366
D	1.042	0.0814	0.0066
E	1.432	0.4714	0.2222
F	0.873	-0.0876	0.0077
G	0.873	-0.0876	0.0077
H	0.846	-0.1146	0.0131
I	0.855	-0.1056	0.0112
J	0.859	-0.1016	0.0103
	$\boldsymbol{\sum X}$ **= 9.606**		$\sum(X - \bar{X})^2$ **= 0.43**

Total number of samples, $N = 10$

Mean compressive strength, $\bar{X} = \frac{\sum X}{N} = \frac{9.606}{10} = 0.9606 N/mm^2$

Variance, $\sigma^2 = \sum(X - \bar{X})^2/N = \frac{0.43}{10} = 0.043$

Standard deviation, $\sigma = \sqrt{0.043} = 0.207 N/mm^2$

The standard deviation measures the variability or diversity. The value of the standard deviation is 0.207N/mm^2 which is low. This indicates that the data points tend to be very close to the mean. The maximum compressive strength obtained was 1.5N/mm^2 from a large scale industry and 1.15N/mm^2 from a small scale industry. However the mean compressive strength from all the block industries is 0.96N/mm^2. These values are not up to the values recommended by Nigerian Industrial Standard (NIS) (2004). NIS recommends that the lowest crushing strength of individual load bearing blocks shall not be less than 2.5N/mm^2 for machine compacted and 2.0N/mm^2 for hand compacted sandcrete blocks.

CONCLUSION

1. Current block production practises in south east Nigeria have been reviewed. The structural characteristics of the blocks produced by commercial producers were determined. The mean compressive strength from all the block industries is 0.96N/mm^2. The strengths of the blocks do not measure up to the recommended value by Nigerian Industrial Standard (NIS) (2004). NIS recommends that the lowest crushing strength of individual load bearing blocks shall not be less than 2.5N/mm^2 for machine compacted and 2.0N/mm^2 for hand compacted sandcrete blocks. The standard deviation of the compressive strength of the blocks from each block industry is 0.207N/mm^2 which is low. The standard deviation measures the variability or diversity. This indicates that the data points tend to be very close to the mean.

2. Block production practices in Nigeria should be looked into by the government. Quality control should be introduced to assist block producers to produce strong and durable blocks at minimum cost.

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