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Sandcrete Blocks and Quality Management in Nigeria Building Industry

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Abstract: Over 90% of physical infrastructures in Nigeria are being constructed using sandcrete blocks making it a very important material in building construction. It is widely used in Nigeria, Ghana, and other African countries as load bearing and non-load bearing walling units. For a long time in Nigeria, sandcrete blocks are manufactured in many parts of the country without any reference to suit local building requirements or good quality work. The Standard Organization of Nigeria (SON) developed a reference document which prescribed the compressive strength and water absorption properties standard requirements for different kinds of sandcrete blocks. The objective of this research is to ensure that all block manufacturers meets a minimum specified standard. The study appraised this objective using field study, sampling and laboratory experimentation and results obtained revealed very low compliance with as low as 0.66N/mm2 compressive strength value and as much as 16.95% water absorption capacity. The study revealed that poor quality control, poor selection of constituent materials and inadequate curing period by the manufacturers contributed to the negative results obtained.

Keywords: compressive strength, fine aggregate, quality, quality management, sandcrete block.

1. Introduction

In developing countries, like Nigeria, the construction industry is a very important sector of the economy. It plays critical role in a nation's economy such as Nigeria because of the transient trend in national growth. The rapid growth in the country's economy and population requires additional physical infrastructures to accommodate additional various component of the Gross National Product (GDP). These physical infrastructures include residential and commercial buildings, agricultural and health facilities to mention a few on the other hand requires the integration of engineering, project, and production management techniques (Ko, 2011) to provide.

Over 90% of physical infrastructures in Nigeria are being constructed using sandcrete blocks (Baiden and Tuuli, 2004). This makes sandcrete blocks a very important material in building construction. It is widely used in Nigeria, Ghana, and other African countries as load bearing and non-load bearing walling units. British Standard 6073: 1981 Part 1 defines a block as a masonry unit of larger size in all dimensions than specified for bricks but no dimension should exceed 650mm nor should the height exceed either its length or six times its thickness.

For a long time in Nigeria, sandcrete blocks are manufactured in many parts of the country without any reference to suit local building requirements or good quality work (Oyekan and Kamiyo, 2008). In the year 2000, and in an attempt to enhance the best materials and manufacturing practice, the Standard Organization of Nigeria (SON) developed a reference document which prescribed the minimum requirements and uses of different kinds of sandcrete blocks (NIS 87:2000 series). Among the objectives of this NIS document are to ensure that all block manufacturers meets a minimum specified standard, as well as to control the quality of blocks produced by these manufacturers.

Years later after the introduction of the standards, variations in quality still exist in the quality of blocks being produced by these manufacturers. According to the NIS document chance and assignable variations are two factors known to cause variations in the quality of sandcrete blocks. Chance variations are variations in quality as a result of environmental influences such as temperature, radiation, noise etc. The effects of chance variations are usually unnoticed. Assignable variations on the other hand are the sources of variation that can be attributed to man, machine, raw materials and method. It is against these assignable causes of variations that this study assessed the quality of sandcrete blocks manufactured in parts of Nigeria. The objectives of this study are to investigate among block manufacturers the level of conformance to NIS standard specifications, evaluate the production process employed in the production of sandcrete blocks, and assess the level of quality of the materials used in the production of sandcrete blocks in comparison to NIS standards.

2. Theoretical Framework

Quality is defined as “fitness for purpose” or compliance with specification (Anosike, 2011, Taylor, 2002) the totality of features required by a product or service to satisfy stipulated and implied needs (Eze et al, 2005). ISO 8402-1986 standard defines quality as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs". Similarly, in manufacturing Business dictionary, defined quality as a measure of excellence or a state of being free from defects, deficiencies, and significant variations, brought about by the strict and consistent adherence to measurable and verifiable standards to achieve uniformity of output that satisfies specific customer or user requirements. In a similar development (Ogunsanmi et al, 2011) identified quality as one of the three key elements for developing risk classification model for design and build projects. This therefore follows that quality is a significant factor that cannot be undermined in the construction of projects. Quality management and quality assurance on the other hand have been adopted to include all aspects of producing and accepting a construction project which meets all required quality standards (Nunnally, 2007). He further asserts that quality management includes such activities as specification development, process control, product acceptance, laboratory and technician certification, training and communication. Consequently, (Nunnally, 2007) concluded that quality control, which is a part of the quality management process, is primarily concerned with the process control function. The SON established through Act 56 in 1971 is the sole statutory body that is vested with the responsibility of standardising and regulating the quality of all products in Nigeria including sandcrete blocks.

The Nigerian Industrial Standard (NIS) for sandcrete block is a standard reference document developed by the SON which prescribes the minimum requirement and uses of sandcrete blocks. These requirements include the quality of materials, the methods and procedure to employ for production and testing of the final products to ensure compliance to prescribed standard. The first standard for sandcrete block in Nigeria was developed in 2000 and known as NIS 87:2000; Standard for Sandcrete blocks. In 2004, the document was reviewed and NIS 87:2004; Standard for Sandcrete blocks became the country’s standard reference document for sandcrete block. The last review was done in 2007 from which NIS 87:2007; Standard for Sandcrete blocks emerged as the latest standard reference document for sandcrete block production in Nigeria.

2.1. Sandcrete Block

Block is a composition of usually (1:6) mix of cement and sharp sand with the barest minimum of water mixture, and in some cases admixture, moulded and dried naturally. NIS 87:2000 defines sandcrete block as a composite material made up of cement, sand and water, moulded into different sizes. According to them, they are masonry units which when used in its normal aspect exceeds the length or width or heights specified for bricks. The block can therefore be made either in solid and hollow rectangular types (for normal wall) or decorative and perforated in different designs, patterns, shapes, sizes and types (for screen wall or sunbreakers). The jointing of beddings and perpends are 25mm thick in both the normal and screen wall. Sandcrete blocks are widely used as walling units and over 90% of houses in Nigeria are being constructed of sandcrete blocks (Baiden and Tuuli, 2004). In the hardened state, sandcrete has a high compressive stress and this strength increase with density. The range of minimum strength specified in NIS 87:2007 is between 2.5N/mm2 to 3.45N/mm2. According to Abdullahi (2005) the quality of sandcrete blocks, however, is inconsistent due to the different production methods employed and the properties of constituent materials. Abdullahi (2005) studied the compressive strength of sandcrete blocks produced in some parts of Minna, Niger State, Nigeria and discovered that they were below the minimum NIS standard requirement. Uzoamaka (1977a) found that the crushing strength of sandcrete blocks increases with decreasing specific surface of sand and that curing of block by water sprinkling enhances their strength. Oyekan and Kamiyo (2011), Oyetola and Abdullahi (2006) and Rahman (1987) studied the possibility of using rice husk ash (RHA) in the production of sandcrete blocks and reported that the optimum water/cement + RHA ratio increases with rice husk ash contents and that up to 40% RHA could be added as partial replacement for cement without any significant change in compressive strength at 60 days and 28days respectively. Compressive strength being the maximum stress sustained by the specimen, that is the maximum load registered on the testing machine divided by the cross sectional area of the specimen. Compressive strength is influenced by the level of quality control employed (Afolayan, Arum and Daramola (2008) good selection of materials and adequate curing method (Abdullahi 2005) among others.

The NIS specified two types of blocks, types A (load bearing) and Type B (non–load bearing) and these blocks can also be solid or hollow. Approved sizes for sandcrete blocks specified by NIS are presented in Table 1.

Other types of sandcrete blocks are decorative and ventilating blocks which are sandcrete blocks without voids or webs normally used for non-load bearing wall construction. Hollow blocks are masonry units with core voided area greater than 25% of the gross area. Hollow sandcrete blocks are manufactured from light weight aggregate and are used for both load bearing and non-load bearing wall construction (Punmia, 1993). Originally, a decorative block was understood to be a solid block with decorative textured faces used to provide an attractive appearance and light, without need for burglar-proofing or any kind of louvers, shutters as well as to provide permanent ventilation without using ventilation blocks.

2.2. Materials Used in Making Sandcrete Blocks

2.2.1. Aggregate

According to UNESCO (2008) aggregates are mineral filler materials used in concrete. Materials like sand, gravel, crushed rock and other mineral fillers are used as aggregates. Aggregates which can be sourced from either natural or manufactured sources occupy about 75% of the volume of concrete (Taylor, 2002).

Table 1. Types of sandcrete blocks and their usage

Type	Work size (mm) Length x Height x Thickness	Web Thickness	Usage
Solid Blocks	450 x 225 x100	-	For non-load bearing and partition walls
Hollow	450 x 225 x 113	25	For non-load bearing and partition walls
Hollow	450 x 225 x 150	37.50	For load bearing walls
Hollow	450 x 225 x 225	50.00	For load bearing walls

Source: NIS 587: 2007

Aggregate are classified according to BS 812 and BS 882 standards as coarse and fine. Coarse aggregates are materials at least 5mm in size and passing through 75mm mesh sieve and retained on a 5mm sieve. Fine aggregates are materials not larger than 5mm in size and which pass through a 5mm mesh sieve but will be completely retained on a 0.07mm mesh sieve. Particles of aggregate smaller than 0.06mm are classified as silt and clays and are considered as harmful ingredients (Taylor, 2002).

2.2.2. Fine Aggregate (Sand)

Sand is the product of natural or artificial disintegration of rocks and minerals. Sand is an important constituent of most soil and is extremely abundant as a surface deposit along the course or rivers, on the shores of lakes and the seas and in arid regions. As the term is used by geologists, sand particles range in diameter from 0.0625 to 2 millimeters. An individual particle in this size range is termed 'sand grain'. The next smaller size class in geology is silt, particles smaller than 0.0625 mm down to 0.004 mm in diameter. Sand feels gritty when rubbed between fingers. Silt by comparison feels like flour or powder. Sand is commonly divided into five sub–categories based on size: (i) very fine sand (0.0625 mm to 0.125 mm), (ii) fine sand (0.125 mm to 0.25 mm), (iii) medium sand (0.25 mm to 0.5 mm), (iv) coarse sand (0.5 mm to 1 mm), and (v) very coarse sand (1 mm to 2 mm) (Wikipedia, 2007). River sand particles are fine, but likely to vary in size and it is most suitable for plastering work. Erosion sand is similar to river but coarser than river sand. It is cheaper than river sand and has higher crushing strength because of its coarse nature (Uzoamaka, 1977b). Common sand is the most widely used sand. It is close to erosion sand in terms of grain size and has a tint of reddish brown colour which is retained when used. Lasisi and Osunade (1984) posited that the most economic sandcrete blocks can be made with common sand where the red tints associated with common sand is not a detrimental factor. Marine sand is often grained and fairly uniform in size. Fine sand is mostly used for plastering work with the sand grains passing through No. 16 ASTM sieve. Medium sand is used for mortar in masonry work and the sand grains pass through the No. 8 ASTM sieve and Coarse sand is best for concrete work producing higher strength, its particles must pass through the No. 4 ASTM sieve. Sand is used basically as filler in concrete, in making plastering mortar and sandcrete as the principal component of aggregate used in their production.

2.2.3. Cement

For constructional purposes, cement is a term restricted to the bonding materials used with stones, bricks and sand. The principal constituents of this type of cement are compounds of lime. On adding water to cement a chemical reaction known as hydration takes place and a large quantity of heat is released. On hydration, gel is formed which binds the aggregate particles together and provides strength and water tightness to concrete on hardening. Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction work. American society for testing materials ASTM C150 has specified certain physical requirement for each type of cement. These properties include fineness, soundness and consistency, setting time, compressive strength, heat of hydration, specific gravity and loss of ignition. Each of these properties has influence on the performance of cement. The fineness of cement, for example, affects the rate of hydration and the degree of fineness of cement is the measure of the mean size of the grain in it (Duggal, 2003). Portland cement to be used for the production of sandcrete blocks must comply with all the prescribed requirements in BS 12 and NIS 444-1: 2003 respectively.

2.2.4. Water

The strength and workability of sandcrete depends greatly on the amount of water used in mixing. The purpose of using water is to cause the hydration of cement. Water to be used for the production of concrete or sandcrete must be free of suspended particles, inorganic salts, acids and alkalis, oil contamination and algae. In the production of sandcrete blocks is necessary for mixing cement and sand, to wash aggregates and in curing of blocks after manufacturing them. Potable water is recommended for use in the production of sandcrete blocks (NIS, 2007).

3. Test Methods

Laboratory experiments, work study and field survey were adopted to carry out this study. The field survey entailed collecting sandcrete blocks specimens from randomly selected block manufacturing factories in Abuja (FCT) representing the northern region of Nigeria, Ogun (Ota) representing the western region and Abia (Umuahia) representing eastern region respectively for laboratory tests. The Compressive strength tests and water absorption tests were the properties tested on the blocks sampled. The reason for this being that the compressive strength and the percentage water absorption are the two major characteristic requirements that the NIS specified for testing and verifying the quality of sandcrete block apart from the appearance and dimension (NIS 587: 2007. P8-9). Pilot laboratory produced blocks were used as control sample. Only 450 x 225 x 225mm size of blocks were obtained and utilized in evaluating the block samples. Five pieces of sandcrete blocks were sampled randomly per factory among selected manufacturers. In all, a total of eighty pieces of sandcrete blocks were obtained and deployed for each of the two evaluation parameters tested. Random sampling method was adopted among selected manufacturers comprising, twenty-five pieces from each of the three major regions or five pieces from each of the five factories from each region sampled in addition to the five pieces sampled from among Pilot laboratory specimens. The objective of sampling the blocks was to evaluate its quality and compare the results obtained with the NIS (87:2000 series) minimum standard specification for high quality and high performance sandcrete blocks.

Work study was carried out by direct observation of the techniques deployed among block manufacturers' at selected sampled factory sites in the production process. Site operations observed included the batching and mix ratios, placing, compaction, and curing. Structured interview was conducted at each factory on some of the factory staff to elicit further information on their operations in order to give credibility to some of the observations made during site visits.

The experimentation method involved the procurement of sandcrete block specimens from among manufacturers at different locations across the three selected states in Nigeria. These specimens were subjected to laboratory tests for compressive strength and water absorption properties. Pilot laboratory specimens manufactured and deployed in these experiments were prepared at the Department of Building Laboratory at Covenant University, Ota, Ogun State. The purpose of this pilot laboratory production was to compare the results obtained with that of the field along with the NIS specified standards.

- **Test No. 1 – Compressive Strength Test:**

For specimen prepared in the laboratory the test was carried out on attaining 7 days curing age while those that were procured from the various manufacturers were already above 7 days old before procurement and so were tested without further curing upon delivery. Smooth surface wood (serving as base plate) was placed at the bottom and top of each specimen block so as to ensure uniform distribution of load for accurate crushing. To obtain the compressive strength in N/mm2, the load recorded was divided by the effective surface area of the block. The effective surface area of the block = Total surface area – Area of hollow. This is given by [(450 x 225) – 2(180 x 155)] = 45,450mm2. All samples were tested using HFI compressive strength machine 1500KN capacity. The compressive strength values obtained from all tests specimens were derived from the crushing values obtained using compression test machine. The laboratory specimens were prepared using the Nigerian Industrial Standard (NIS 87: 2007) as guide. Fine aggregate was sieved with a 5mm mesh sieve; all particles retained above this sieve were discarded. The mix proportion used was 1:8 of cement and sand batched by volume. The composite materials were mixed with mixing machine and the water component used was obtained from the tap in the laboratory. The mixed materials were poured into the moulds and compacted by machine vibration. Excess materials were removed with a flat wooden plank. The blocks were then released onto a flat board laid under the machine. The moulding machine used has the capacity of three 450 x 225 x 225mm blocks at once. The blocks were left on the wooden boards for 24hrs to air–cure before spraying them with water twice daily for 7 days to cure.

- **Test No.2 – Water Absorption Test:**

All specimens were first subjected to 'Water Absorption' tests before compressive strength tests were conducted. According to (Neville, 2002) the rate of water absorption of aggregate influence the bond between aggregates and the cement paste, the resistance of concrete to freezing and thawing, chemical stability, resistance to abrasion and specific gravity. Water absorption is the ratio of the decrease in mass to mass of dry sample. This is determined by measuring the decrease in mass of saturated block and surface dry sample. This was computed using the formula (1):

$$\frac{M_2 - M_1}{M_1} \times 100\% \tag{1}$$

Where:

M1 = mass of dry sample and M2 = mass of wet sample (after 24hrs in water). The results obtained are presented in Table 5.

4. Results and Discussion

Test results obtained from specimens were analyzed and the quality assessed based on the observed variability as compared with NIS standard requirements. The data collected from interview and work study were analysed using the simple percentage method. The results from the interview, work study, and experiments are presented in the form of frequency tables, bar charts and pie charts.

4.1. Materials Utilized

4.1.1 Fine aggregates

Results presented in Table 2 indicated that all fifteen factories sampled utilized soft sand, sharp sand, clay and stone dust in producing their sandcrete blocks. However, in as much as this could enhance the bonding of the cement and sand grains in the green state, it could have a deleterious effect on the compressive strength of the blocks as highlighted in literature.

4.1.2. Cement

All factories within the scope of this study used Ordinary Portland Cement (OPC) Dangote, Elephant and Burham brands which conformed to NIS 444-1: 2003 as evidenced by the certification mark (NIS 444-1:2003; ISO 9001: 2008) on the product bags.

4.1.3. Water

All the factories used potable water as specified in NIS 87:2007 for mixing. 20% utilized tap water, 40% drilled well water and 40% a combination of tap and drilled well water. Sources of water are shown in Fig. 1.

4.1.4. Test on raw materials

All the factories do not perform any test on the fine aggregates used for production. Sieving of the fine aggregates supplied to their sites was alien to them.

Table 2. Proportion of Fine Aggregate used by the Various Factories

	Constituent of Fine Aggregate (%)			
Factories	Sharp Sand	Soft Sand	Clay	Stone Dust
FCT A	25	25	0	50
B	20	60	10	0
C	50	0	15	0
D	60	40	0	20
E	60	20	18	0
Umuahia F	20	50	30	0
G	30	35	35	0
H	44	18	38	0
I	35	25	40	0
J	50	25	25	0
Ota K	25	25	0	50
L	20	60	20	0
M	30	0	50	0
N	40	40	0	20
P	60	20	20	0

Source: Field Survey, 2011

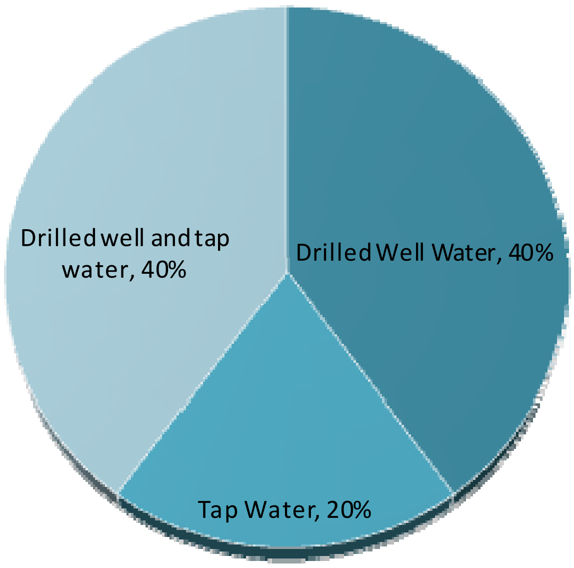

Fig. 1. Sources of water used by sampled factories. Source: Field Survey, 2011

4.2. Method Employed in Production

4.2.1. Batching method

It was observed that the batching method adopted was the same at the fifteen factories. The batching was by volume using a wheel barrow to measure the sand. To an extent, what was referred to as 'full' depend on who is in charge and hence the consistency of one batch differed markedly from another.

4.2.2. Mix ratio

From Fig. 2, 20% of the factories use the specified mix ratio 1:8 cement to sand ratio and 80% use ratio 1:10. This implied that 80% of the block manufacturers did not conform to the 1:8 cement/sand mix ratio specified by the NIS 87:2007 standard.

4.2.3. Method of mixing

The method of mixing observed in all the five factories is manual mixing. It is of note that the volume of materials being mixed is usually very large as a result machine mixing will be much better in producing a homogeneous and uniform material.

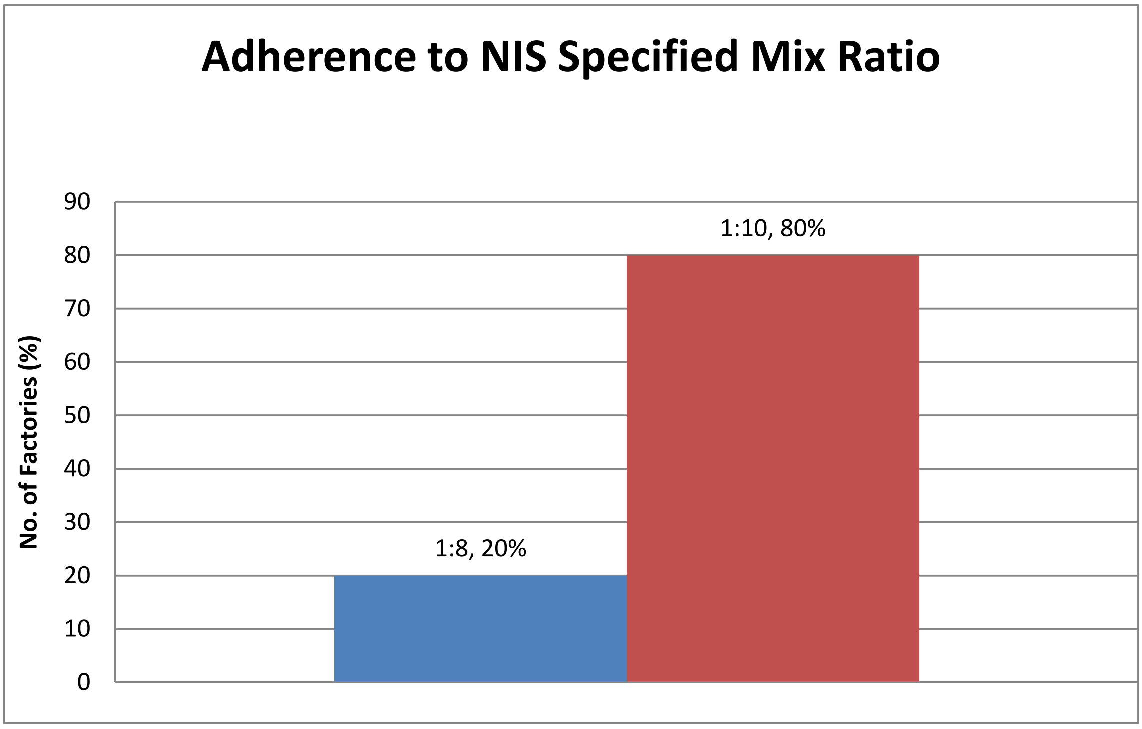

Fig. 2. Mix Ratios and Percentage of use by the Sampled Factories. Source: Field Survey, 2011

4.2.4. Addition of water

There was no scientific basis for proportioning and adding water as it was done at the discretion of the operators in all the factories. This implied that, the addition of water beyond the specified 0.45 water: cement ratio contributes to prolonged setting time and causes reduction in strength as is evidenced in Table 6.

4.2.5. Method of molding

All the factories utilize vibrating machine to compact their blocks.

4.2.6. Curing method and duration

In all fifteen factories, their blocks were cured by spraying water twice daily and for maximum of two days in an open place as against the specified 7days in a covered area.

4.3. Quality Assurance

4.3.1. Test on finished product

All the factories sampled do not carry out any test on finished products.

4.3.2. Mandatory conformity assessment program certification (MANCAP)

All the factories sampled do not have MANCAP certificate as specified and issued by SON.

From Table 3, water absorption for the specimens collected from all the factories are greater than the specified 12%. However, the specimens prepared in the laboratory have an average water absorption value of 4.43%.

In Fig. 3, specimens (S4) Ota recorded the highest water absorption value (16.95%) whereas Pilot Lab. had the lowest (4.0%). The implication of this is that Ota specimens will absorb more water leading to dampness unlike Pilot specimens which absorbs very little water. In contrast, Pilot laboratory specimens on the other hand recorded the lowest water absorption values (4.0%) when compared with the lowest value from Ota (12.94%), Umuahia (13.92%) and FCT (13.18%). According to Oyekan and Kamiyo (2011) the implication of this is that when sandcrete units are exposed to persistent flooding, a highly porous block could absorb much water, consequently become weakened and eventually fail.

From Table 4, the compressive strength values of all the specimens A, B, C, D, and E procured from the various manufacturers indicated very low average compressive strength values far below the specified values of 2.5N/mm2 minimum for non–load bearing blocks and 3.45 N/mm2 minimum for load bearing blocks.

Block samples prepared in the laboratory have high average compressive strength values above the specified values of 2.5N/mm2 minimum for non – load bearing blocks and 3.45 N/mm2 minimum for load bearing blocks. The mean of compressive strength values obtained in Table 4 were plotted against one another and presented in Fig. 4. by Abdullahi (2005).

Table 3. Results of Water Absorption Test on the Specimens

Tests	Specimen Blocks					
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**
Ota Test 1	13.81	11.36	16.50	17.37	12.11	**14.23**
Test 2	12.27	12.27	13.85	15.38	10.26	**12.81**
Test 3	11.63	14.29	12.50	16.00	16.84	**12.25**
Test 4	12.72	13.63	12.86	17.50	16.00	**14.54**
Test 5	14.28	14.29	14.29	18.50	15.79	**15.43**
Mean (%) WA	**12.94**	**13.17**	**14.0**	**16.95**	**14.2**	
Umuahia Test 1	14.05	16.10	14.90	17.25	14.62	**15.38**
Test 2	14.58	15.60	13.80	16.35	15.74	**15.21**
Test 3	13.45	14.10	12.86	14.25	12.95	**13.52**
Test 4	14.60	13.85	16.30	15.60	12.90	**14.65**
Test 5	13.10	12.90	12.95	14.70	13.40	**13.41**
Mean % WA	**13.96**	**14.51**	**14.16**	**15.63**	**13.92**	
FCT Test 1	13.80	16.48	13.90	12.36	14.38	**14.18**
Test 2	12.94	18.20	11.80	12.48	12.40	**13.56**
Test 3	14.32	13.38	14.35	14.86	13.40	**14.06**
Test 4	15.75	14.40	12.92	13.65	13.86	**14.12**
Test 5	12.60	13.25	13.70	12.55	14.12	**13.24**
Mean % WA	**13.88**	**15.14**	**13.33**	**13.18**	**13.63**	
Pilot Lab. Test 1	4.00	4.71	4.62	4.80	4.00	**4.43**

Source: Field Survey, 2011

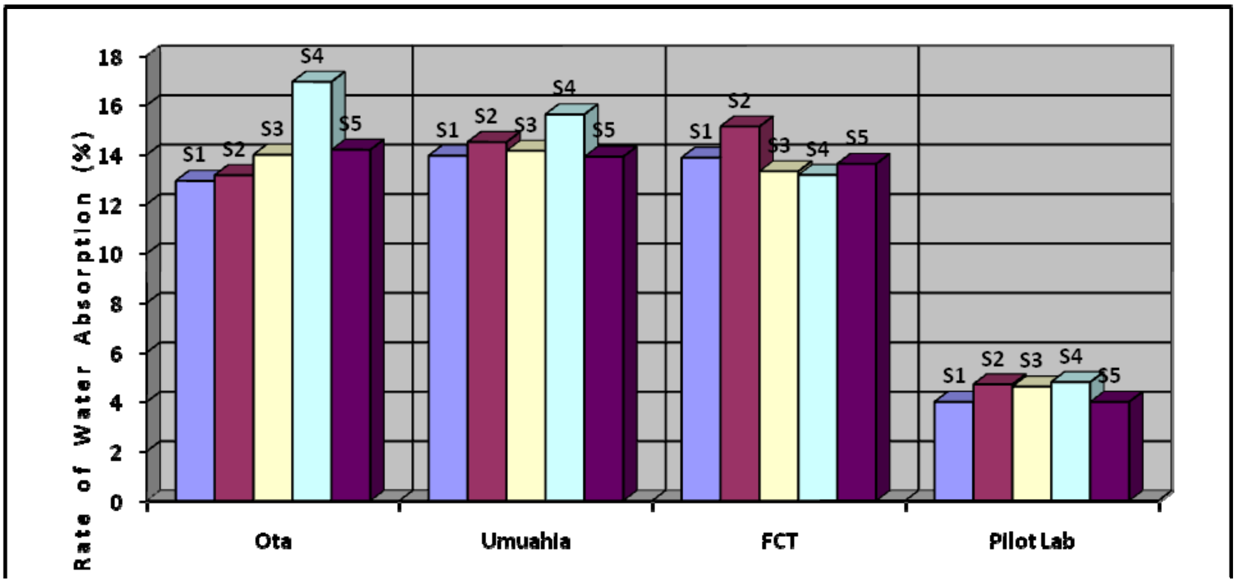

Fig. 3. Mean of Means Values for Water Absorption of all Specimens. Source: Field Survey, 2011

Table 4. Result of Compressive Strength Test for all the Specimens

Specimen		A	B	C	D	E	Mean
Ota	1	1.10	0.66	0.66	1.20	0.88	**0.90**
	2	1.32	0.88	0.88	1.32	0.99	**1.08**
	3	1.10	0.44	0.66	1.43	0.99	**0.92**
	4	1.32	1.10	0.88	1.32	1.10	**1.14**
	5	1.10	0.66	0.77	1.10	0.88	**0.90**
Mean Compr. Str.		**1.19**	**0.75**	**0.77**	**1.27**	**0.97**	
Umuahia	1	1.25	0.98	1.14	1.25	1.21	**1.67**
	2	1.48	1.15	0.90	0.82	1.90	**1.25**
	3	1.90	1.10	0.96	1.32	1.08	**1.27**
	4	1.95	1.20	1.38	1.28	1.10	**1.38**
	5	1.88	1.31	1.66	0.96	0.94	**1.35**
Mean Compr. Str.		**1.69**	**1.15**	**1.21**	**1.13**	**1.25**	
FCT	1	2.15	0.98	1.95	2.18	0.97	**1.65**
	2	2.28	1.78	1.98	2.10	2.46	**2.12**
	3	2.05	2.01	2.20	2.08	1.84	**2.04**
	4	1.56	2.45	2.24	1.96	2.19	**2.08**
	5	1.88	1.98	2.60	1.98	1.96	**2.08**
Mean Compr. Str.		**1.98**	**1.84**	**2.19**	**2.06**	**1.88**	
Pilot Laboratory		3.52	3.63	3.74	3.41	3.52	**3.56**

Source: Field Survey, 2011

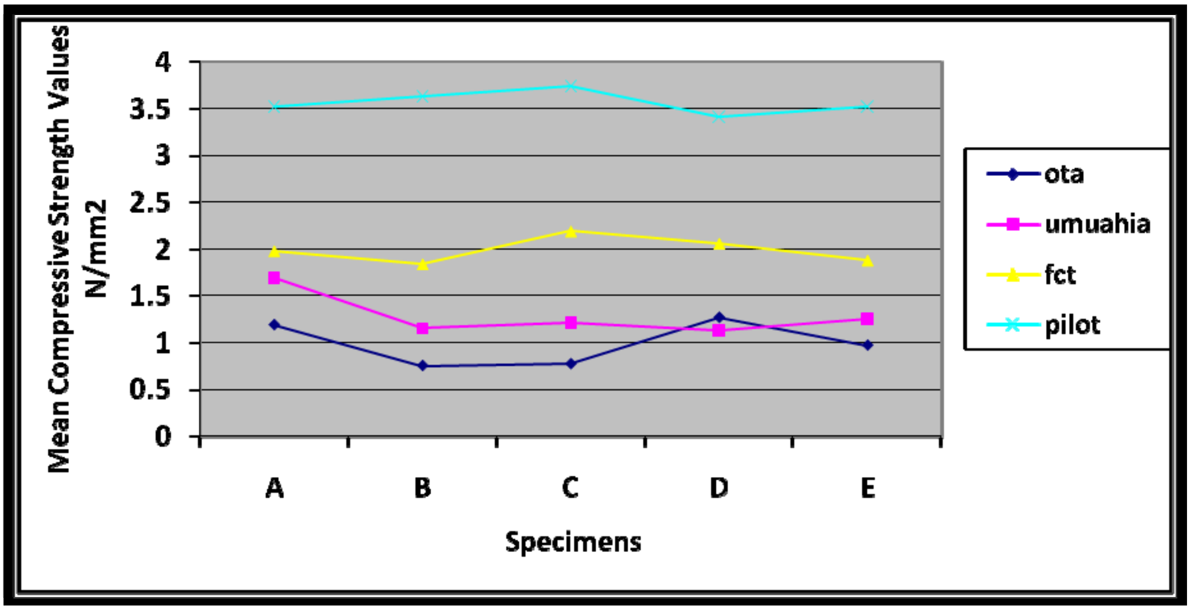

Fig. 4. Mean Compressive Strength Values of all Specimens. Source: Field Survey, 2011

Results in Fig. 4 indicated that specimens A,B,C,D & E from Ota factories recorded the lowest compressive strength values of 1.19N/mm2, 0.75N/mm2, 0.77N/mm2, 1.27N/mm2 and 0.97N/mm2 as compared to the highest values of 3.52N/mm2, 3.63N/mm2, 3.74N/mm2, 3.41N/mm2 and 3.52N/mm2 respectively obtained from similar Pilot laboratory specimens. This means that poor quality control, poor selection of constituent materials and inadequate curing period by the manufacturers put-paid to the low compressive strength values obtained as was also observed.

The reasons for the poor results obtained could be adduced to poor selection and storing of materials (Anosike, 2011) as was observed in the case studies sampled where the fine aggregate was stockpiled directly on unprepared and dirty grounds full of grasses and wood particles and during batching the aggregagtes and soil materials are scooped together. It is believed that the uncontrolled addition of soil materials which contains grasses, humus soil and wood particles could reduce the quality of the fine aggregate materials (Taylor, 2002). During batching it was also observed in the case studies that the workers were inconsistent with the mix proportioning and therefore the specified 1:8 cement and sand ratio was not controlled as in some situations the use of ratio 1:12 cement and sand mix were observed. Furthermore, the poor results obtained from field specimens tested could be attributed to poor curing method as it was observed that most curing platforms were not covered at the top, a technique believed to assist reduce the high rate of hydration of water at the early age of the product owing to direct exposure. At the same time, the two days length of curing period observed at case studies was inadequate as compared to the specified seven days curing period. This inadequate curing period could contribute to the poor development of strength of the products. Although the quality of water utilized in the production of the sandcrete blocks was not tested, the quality of the water for the works used could also impact negatively leading to the poor results obtained from sampled field specimens. That is, the water used for the production could contain deleterious substances in quantities capable of weakening the materials (Anosike, 2011) used in producing the blocks.

On the other hand, good quality sandcrete blocks could be produce if these myriad of impediments identified are improved upon. For example, if fine aggregate materials are properly selected and stored on a well prepared platform that will eliminate or reduce the combing of soil materials during scooping and utilization, good sandcrete blocks could be produced. Also, the batching and mixing of sandcrete materials requires the use of an experienced technical personnel engaged to control this important aspect of the work from inception to completion to enhance consistency in proportioning and mixing. Sandcrete blocks manufacturers in Nigeria must be constantly enlightened by the NIS and other stakeholders in the industry on the importance and the need to adhere to the NIS specified seven days curing period for produced sandcrete blocks which must be laid under a properly prepared environment and platform that will reduce the higher rate of hydration of water and lower strength development observed.

5. Conclusions

The following conclusions were reached, namely: The block manufacturers did not conform to NIS standard specifications. The reasons may be due to ignorance on the part of the sandcrete blocks producers of the existing standard requirements, near absence of checks and balance on the side of the FGN through the NIS on sandcrete block manufacturers, the inability of the NIS to assert itself on the block producers to identify and mete out sanctions on violators, and may be the NIS are comprising the standards they set for the block producers as part of the corruption tendencies ravaging the industry in which they are a stakeholder. The situation can be improved upon if the FGN will empower the NIS to identify, blacklist and mete out adequate sanctions on ill-equipped sandcrete blocks producers. The NIS should also carryout massive enlightenment campaign to educate sandcrete blocks producers on their activities. They should also make it mandatory for all blocks manufacturers to register with them and obtain the necessary training and MANCAP certification before embarking on the business. The production process employed by block manufacturers does not conform to the NIS standard specifications as all of them did not utilize the prescribed mix ratio, curing period and batching method. The reason for this may be attributed to the lack of checks and balance on the side of the NIS on the blocks producers. Another reason may be that the cost of producing the quality sandcrete blocks per unit may be too high. Also the lack of control as well as monitoring of the production facitilities and processes by the NIS could be another reason. The introduction of checks and balance by the NIS The blocks produced by sampled manufacturers are not of good quality as they do not meet the minimum quality requirements specified by the NIS standard specification. In order to enhance the quality of sandcrete blocks produced in Nigeria the NIS was established by the Federal Government of Nigeria as revealed in literature. The NIS 87: 2007 standard specified the use of mix ratio 1:8 cement sand proportion to achieve the minimum compressive strength value of 2.5 N/mm2 for non-load bearing or 3.5 N/mm2 for load bearing walls as well as 0.45 water:cement ratio and maximum specified 12% water absorption. However, from the results of tests conducted, it is established that these specified standards are being undermined by the producer's of the sandcrete blocks and although there are adequate sanctions specified for violators, the agency lacks the will power to enforce it. These action or inaction of government has given the producers the leeway to produce substandard blocks for commercial use.

It can therefore be said that the use of such substandard sandcrete blocks had been a contributory factor to the development of cracks noticed on walls of finished buildings. The presence of cracks in walls of buildings is widely believed to be an indication of poor quality of construction which will eventually result to building structural failure or worse still building collapse as is being experienced in Nigeria over the years (Anosike, 2011). To improve on the situation, it is suggested that the Federal Government of Nigeria should empower the NIS to enforce the sanctions on violators as this will serve as a deterrent to others.

The results obtained from the pilot laboratory samples indicated that the specimens produced are all of good quality as they satisfied the NIS specified standard requirements. This implies that with proper enlightenment and the right attitude good quality sandcrete blocks can be produced for commercial use by manufacturers in Nigeria.

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