Assessment of Sandcrete Blocks Quality in Owerri, Imo State, Nigeria

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Authors' contributions

The sole author designed, analyzed, interpreted and prepared the manuscript.

Original Research Article

ABSTRACT

This study assessed the production management practice being adopted in the manufacture of quality sandcrete blocks in selected sampled parts of Owerri municipal, Imo State, Nigeria. Myriads of literature identify sandcrete blocks as a significant material being used in the building & civil engineering practice and assert that its application as a walling material cannot be over emphasized. Sandcrete block manufacturers in Owerri, Imo State were used for the assessment of the quality of their products in line with the Nigeria Industrial Standard (NIS) specifications. The study adopted field sampling, experimentations and work study methods to determine the compressive strength and water absorption rate properties of the selected sampled sandcrete blocks. The results of the study reveals among others that the mean compressive strength values obtained were as low as 1.92N/mm2, and about 17% water absorption rate from sampled commercial blocks. The results obtained did not compare favorably with the NIS specified acceptable minimum standard values. The study therefore underpinned poor production quality control practice as well as lack of impact of regulatory bodies in Imo State as among factors that contributed to the negative results obtained.

Keywords: Compressive strength; management practice, quality; sandcrete block; water absorption.

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1. BACKGROUND OF THE STUDY

In developing countries like Nigeria, the construction industry is a very important sector of the economy. Over 90% of physical infrastructures in Nigeria are being constructed using sandcrete blocks [1]. 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 walling unit. Block is defined 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 [2]. 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 [3]. In the year 2000, and in an attempt to enhance the best materials and manufacturing practice the Standards Organization of Nigeria (SON) developed a reference document which prescribed the minimum requirements and uses of different kinds of sandcrete blocks [4]. Among the objectives of this document is 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 [5], 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 variations that can be attributed to man, machine, raw materials and method. It is against these assignable causes of variations that this study assessed the production management practice being adopted in the manufacture of sandcrete blocks in Imo State, Nigeria with the view to assess the level of conformance among block manufacturers to best practice using the NIS as a yardstick for performance measurement and evaluation.

2. THEORETHICAL FRAMEWORK

Quality is defined as "fitness for purpose" or compliance with specification [6-8] or the totality of features required by a product or service to satisfy stipulated and implied needs [9]. Similarly, [10] 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". Quality assurance on the other hand may be defined as the systematic monitoring and evaluation of the various aspects of a project, service or facility to maximize the probability that minimum standards of quality are being attained by the production process. The SON was established by Act 56 of 1971 as the sole statutory body responsible for standardizing and regulating the quality of all material products in Nigeria, and the NIS for sandcrete blocks is a standard reference document developed by the SON which prescribes the minimum requirements and uses of sandcrete blocks [4] hence the decision to use it as a valid standard document to evaluate the production management practice of sandcrete blocks in this study.

2.1 Sandcrete Block

[4] defines sandcrete block as a composite material made up of cement, sharp sand and water, molded into different sizes. The block can 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 sun breakers. Sandcrete block is widely used as walling unit and over 90% of houses in Nigeria are being constructed of sandcrete blocks [1]. In the hardened state sandcrete block has a high compressive strength and this strength increases with density. The range of the minimum strength specified in [4] is between 2.5N/mm2 to 3.45N/mm2. According to [11] the quality of sandcrete blocks, however, is inconsistent due to the different production methods employed and the properties of constituent materials. [12] studied the compressive strength of sandcrete blocks produced in some parts of Minna, Niger State and discovered that they were below the minimum NIS standard requirement. In similar development, [7] investigated the quality management practice of sandcrete blocks in selected sampled regions of Nigeria using compressive strength and water absorption tests as evaluation parameters and the study underpinned the negative results obtained as impact of poor production management practice adopted in the manufacture of sandcrete blocks in these parts of Nigeria. [13] found that the crushing strength of sandcrete blocks increases

with decreasing specific surface area of sand and that curing of block by water sprinkling enhances their strength. [14-16] 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 RHA contents and that up to 40% RHA could be added as partial replacement for cement without any significance in compressive strength at 60 days and 28 days respectively. According to [17],[12] compressive strength is influenced by the level of quality control employed, good selection of materials and adequate curing method, 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 of 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 [18]. Decorative block is 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 or shutters. It is as well as used to provide permanent ventilation without using ventilation blocks.

3. MATERIALS USED IN MAKING SANDCRETE BLOCKS

Aggregate: According to [19] 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 [8]. Aggregates 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 aggregates smaller than 0.06mm are classified as silt and clays, and are considered as harmful ingredients [12],[8].

Fine Aggregate (Sharp Sand): Sand is the product of natural and 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 2mm, an individual particle in this size range is termed 'sand grain'. The next smaller size class in geology is silt, particles smaller than 0.0625mm 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 1.0 mm), and (v) very coarse sand (1 mm to 2mm) [7].

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 sand but coarser than river sand. It is cheaper than river sand and has higher crushing strength because of its coarse nature [16]. 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 color which is retained when used. [20] 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 and its particles pass through the No. 4 ASTM sieve.

Cement: For construction purposes, cement is term restricted to the bonding materials used with stones, bricks and sand, a compound of lime. On adding water to cement hydration takes place and a large quantity of heat is released forming gel 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 and Materials [21] has

specified certain physical requirements for each type of cement as 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 [22]. Portland cement to be used for the production of sandcrete blocks must comply with all the prescribed requirements in [23-24] respectively. All factories within the scope of this study used Ordinary Portland Cement (OPC) Dangote and BUA brands which conformed to [25] as evidenced by the certification mark [25], ISO 9001: 2008 on the product bags. The Pilot specimen blocks were produced with Dangote cement brand.

Water: The strength and workability of sandcrete blocks depends greatly on the amount of water used in mixing. The purpose of using water is to activate the hydration of cement. However, it is believed that the use of raw water from a variety of sources in the production of blocks is common. Water to be used for the production of concrete or sandcrete blocks must be free of suspended particles, inorganic salts, acids and alkalis, oil contamination and algae [19]. In the light of the above [26-28] asserts that there is likelihood for the use of water with high level of impurities to account for poor compressive strength, dimensional unstable and non-durable blocks. Consequently minimum standard recommended the use of potable water in the production of sandcrete blocks in Nigeria. In the production of sandcrete blocks, water is necessary for mixing cement and sand, to wash aggregates and in curing of blocks after manufacture.

4. TEST METHODS

Laboratory experiments, work study and field survey were adopted to carry out this study. The field survey entailed collecting sandcrete block specimens from randomly selected block manufacturing factories for laboratory tests. The compressive strength test and water absorption test were the properties tested on the block sampled. Pilot laboratory produced blocks were used as control sample. Only 450mm x 225mm x 225mm size hollow sandcrete blocks were obtained and utilized in evaluating the block samples. In all, a total of thirty-five (35) pieces of

sandcrete blocks were obtained and deployed for each of the two evaluation parameters tested. A total of six (6) blocks manufacturing factories equipped with molding machines were identified in Owerri municipal, Imo State. The choice of Owerri municipal for the study being that it is the capital of Imo State and also the commercial nerve centre of the State where economic and construction activities are highest. Random sampling method was adopted to select four (67%) of the blocks manufacturers, and from each of the manufacturers selected, five (5) pieces of blocks (as an acceptable number recommended by NIS) were sampled from among their stockpiles. Also, the Pilot Laboratory randomly selected five (5) pieces of blocks from the specimens that was produced. In all, a total of twenty-five pieces of blocks specimens were obtained comprising, twenty (20) from the field factories in addition to the five (5) pieces sampled from among pilot laboratory specimens. The objectives of sampling the blocks was to evaluate its quality and compare the results obtained with the [4] minimum standard specification for high quality and high performance sandcrete blocks in order to compare their quality and level of compliance to the standard best practice.

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 on duty 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 factory sites in Owerri municipal, 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 Dept. of Building workshop and tested at the FUTO Central laboratory. The purpose of this pilot laboratory production was to compare the results obtained with those obtained from field survey along with the NIS specified standards.

Table 1. Types of sandcrete blocks and their uses

TYPE	BLOCK SIZE (mm)	WEB THICKNESS (mm)	USAGE
Solid Block	450 x 225 x 100 (4 inches)	-	For non-load bearing and partition walls
Hollow Block	450 x 225 x 113	25	For non-load bearing and partition walls
Hollow Block	450 x 225 x 150 (6 inches)	37.50	For load bearing walls
Hollow Block	450 x 225 x 225 (9 inches)	50.00	For load bearing walls

Source: NIS 587: 2007

4.1 Compressive Strength Test

For specimens prepared in the laboratory, the tests was carried out on attaining 7 days curing age (as recommended by NIS) whereas those that were procured from the various manufacturers were already between 3-7days old before procurement and so were tested without further curing upon delivery. The laboratory specimens were prepared using the Nigeria Industrial Standard [4] specifications as guide. Fine aggregate was sieved with a 5mm aperture mesh sieve. The mix proportion used was 1:6 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 means of machine vibration. The blocks were then released onto a flat timber board laid under the machine. The molding machine used has the capacity for three blocks of 450mm x 225mm x 255mm size blocks at once. The blocks were left on the wooden boards for 24hours to air-cure before spraying them with water twice daily for 7 days. Smooth surface wooden 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 blocks were measured and found to be adequate. All samples were tested using HFI compressive strength test machine of 1500KN capacity. The compressive strength test values obtained from all test specimens were derived from the crushing values obtained using the compression test machine.

4.2 Water Absorption Test

All specimens were first subjected to 'water absorption' tests before the compressive strength tests were conducted. According to [28] the rate of water absorption of aggregates influences 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 equation 1;

$$\frac{M2 - M1}{M1} \times 100\% \qquad \dots \text{Equation (1)}$$

Where M1 = mass of dry sample and M2 = mass of wet sample (after 24hours in water).

5. RESULTS AND DISCUSSIONS

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 analyzed using the simple percentage method. The results from the interview, work study and laboratory experimentations are presented in the form of frequency tables, bar charts and pie charts.

5.1 materials utilized

Fine aggregate: Results presented in Table 2 indicated that all four factories sampled utilized plaster sand, sharp sand, clay and or 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 the literature. Though no attempt was made to determine the reasons for the variations among the manufacturers, but of significance is the fact that two factories B(25%) and C(40%) added clay soil in the mixture in the given percentage proportions. However, of note is Factory A with 50% stone dust representing

half of the entire aggregate materials used in the production of the sandcrete blocks. The reasons adduced by the factory owners when interviewed where that in practice, the choice of mixing the plaster sand with clay were to obtain a more sticky mass of substance that could easily bind and produce stickier materials, provide better dimensional stability when wet and as well produce stronger mass when dry as characterized by clay. Another reason may be to maintain the overall volume of plaster sand as well as to reduce the cost of soft sand required since the volume reduces drastically after sieving. Similarly among the manufacturers, Factories A and D utilized stone dust in place of clay soil in the proportion of A(50%) and B(20%) respectively. The reason for adding stone dust may not be unconnected to the improvement of strength and durability requirements. The Pilot laboratory utilized a mixture of zero clay and stone dusts with only sharp sand and soft sand in the proportion of 70% and 30% respectively to produce their specimens.

Water: Results presented in Fig. 1 indicate that all the factories investigated used potable water as specified in [4] for mixing. 40% utilized tap water, 40% drilled well water and 20% a combination of tap and drilled well water. The drilled well (borehole) water was valid as potable because it was physically observed that the workers on the site of works were seen drinking it directly from the hose pipe. Further in Fig. 1, it was observed that few of the factories combined the use of both the tap water and drilled water to carry out their production activities. The combination maybe to prevent a situation of lack of water from any of the sources at peak period of need. This may be a positive proactive measure taken by these factories because most of the time especially during the dry season of the year in Nigeria the drilled (borehole) water tends to dry up partially and sometimes completely. Production may stop for some factories at this time or the cost of production may be increased when sourcing for alternative water supply.

Table 2. Proportion of fine aggregate used by the various factories

	Constituent of Fine Aggregate (%)			
Factories	**Sharp Sand**	**Soft Sand**	**Clay**	**Stone Dust**
Owerri A	30	20	0	50
B	40	35	25	0
C	40	20	40	0
D	40	40	0	20
PILOT Lab.	70	30	0	0

Source: Field Survey, 2021
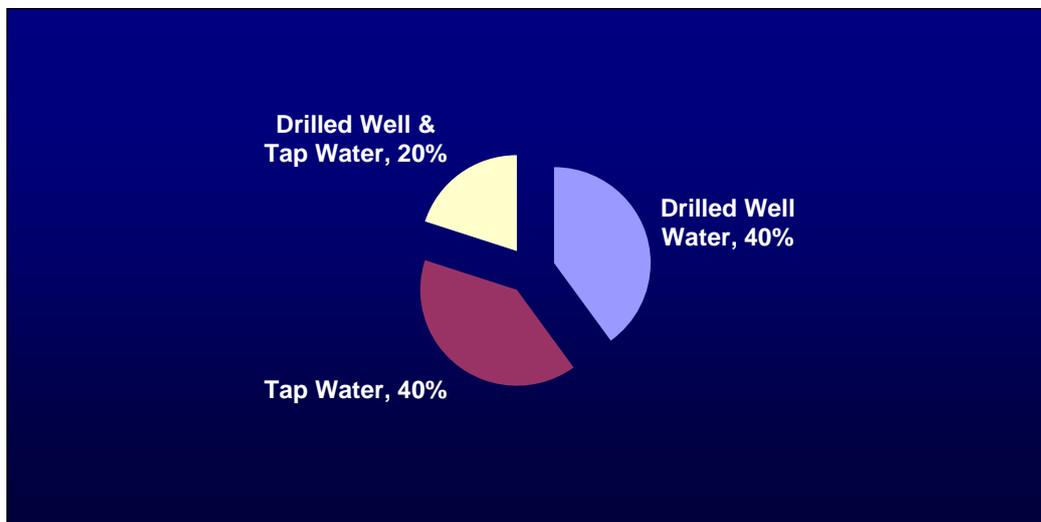
Fig.1. Sources of water used by sampled factories
Source: Field Survey, 2021

Test on raw materials: All the factories do not perform any test on the fine aggregates used for production. Although the factory heads interviewed claimed to know the importance of sieving of the fine aggregates supplied to their sites before deployment, however, they intentionally avoid the practice because according to them the practice will not only reduce the quantity of the sand but will also increase the unit price of their product, and that the major consideration of buyers remains the unit price.

6. METHOD EMPLOYED IN THE PRODUCTION

6.1 Batching Methods

It was observed that the batching method adopted was the same for three factories A, B and C, that is, 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 was in charge and hence the consistency of one batch differed markedly from another. However, of interest was factory D which batched with shovel, claiming that though batching of materials by weight or volume is the standard format however, the use of shovel for batching being used by them had been an alternative option comparable to the standard methods.

6.2 Mix Ratio

From Fig. 2, 10% of the factories use the specified mix ratio 1:8 cement to sand ratio and 90% of the block manufacturers did not conform to the 1:8 cement/sand mix ratio specified by the [4] standard but rather use 1:10 mix ratio.

6.3 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 homogenous and uniform material.

6.4 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 evidence in Fig. 3.

Results obtained from Fig. 3 indicates that water absorption for the specimens collected from all the factories is greater than the specified 12% minimum requirement. However, the specimens prepared in the laboratory had an average water absorption value of 4.43%. Still on Fig. 3 results, specimens (S4) recorded the highest water absorption value (16.95%) whereas Pilot laboratory specimen (S4) had the highest (4.8%). The implication of this is that Owerri specimens will absorb more water that will result to dampness on walls where they are used unlike pilot specimens which absorbs very little water. Similarly, Pilot Lab. Specimens (S1) on the other hand recorded the lowest water absorption values (4.0%) when compared to the lowest value from Owerri Specimens (S1) of 12.94%. According to [14] 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.

7. SUMMARY OF OTHER TESTS CONDUCTED

Results of further interviews and observations conducted and presented in Table 3 reveal that all the factories investigated utilized the services of their vibrating block molding machine to produce their blocks. This development is good and it is an acceptable standard. Also observed is the fact that the curing method and duration of curing or their blocks after manufacture is adequate for twice curing per day for seven days. This also is a good practice as specified [25]. However and maybe expectedly, none of the factories carries out test on their finished products and none of the factories seemingly, had the MANCAP certification affixed on their manufactured blocks. The two requirements are specified in [27]. These two identified negligences by the factories may imply that they may have willfully undermined the expected standard practice.

The results presented in Table 4 indicates that the compressive strength test values of all the specimens A, B, C and D produced from the various manufacturers indicated very low average compressive strength values far below the acceptable specified values of 2.5N/mm2 minimum for non-load bearing blocks and 3.45N/mm2 minimum for load bearing blocks.
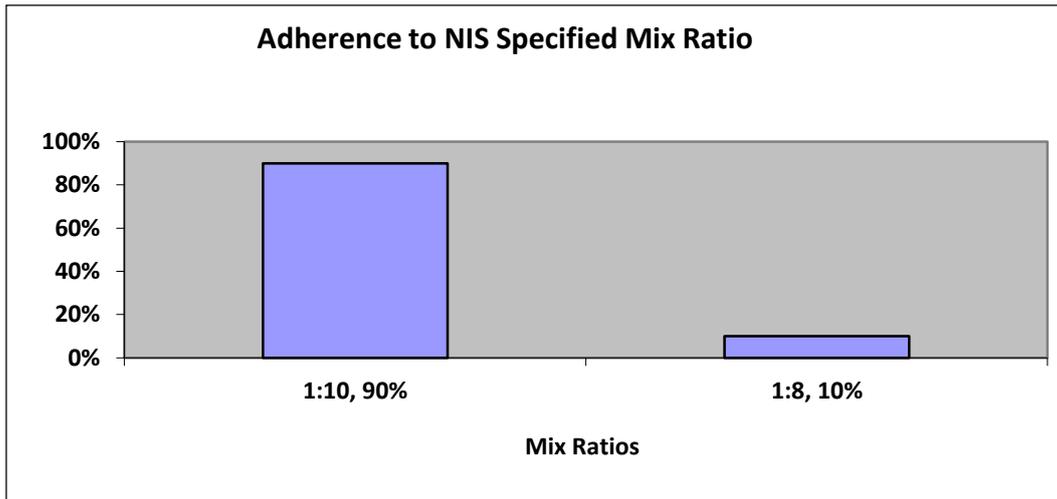
Fig. 2. Mix ratios and percentage of use by the sampled factories
Source: Field Survey, 2021
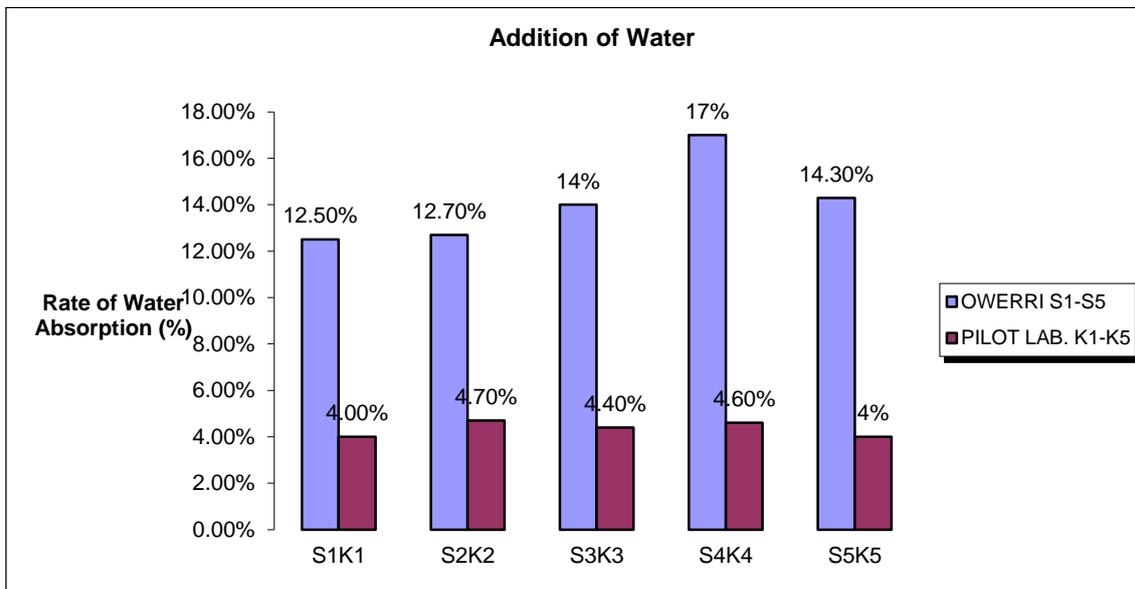
Fig. 3. Mean of means values for water absorption tests on specimens
Source: Field Survey, 2021

However, the 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 3.45N/mm2 minimum for load bearing blocks. This means that poor quality control, poor selection of constituent materials and inadequate curing periods by the manufacturers may have accounted for the low compressive strength values obtained. These poor results obtained as well as the highlighted bad manufacturing practices observed in this study corroborates the assertion by [14] that sandcrete blocks being manufactured and used in Nigeria are of very poor quality. The study findings also validates the results from the study carried by [12] on sandcrete blocks manufactured in Bosso, Niger State which were found to be of very poor quality. Further study was carried out by [7] in Umuahia, Abia State and Abuja, Federal Capital Territory (FCT) to compare with the results obtained in Ota, Ogun State. The results obtained from these parts of the country also indicates that the quality of sandcrete blocks being manufactured and used for commercial purposes in those locations are of poor quality.

Table 3. Results obtained from other tests conducted

1.	Method of Moulding	All factories utilized vibrating machine
2.	Curing method and duration	All factories cured by spraying water twice daily for two days in an open place. Twice spray per day for 7 days in an enclosed place is the standard requirement.
3.	Finished product	No factory carries out test on finished products
4.	MANCAP Certification	No factory had MANCAP certification.

Source: Field Survey, 2021

Table 4. Result of compressive strength test obtained from the samples

Sample	A	B	C	D	E (PILOT LAB.)
1	2.10	1.66	1.90	1.70	3.62
2	1.90	1.78	1.98	2.45	3.70
3	2.20	2.15	1.90	1.90	3.74
4	2.05	1.85	2.15	2.06	3.44
5	2.10	2.15	2.20	1.98	3.55
Mean Compressive Strength	2.07	1.92	2.03	2.02	3.61

Source: Field Survey, 2021

8. CONCLUSIONS

The following conclusions were reached, namely:

i. Lack of monitoring and certification of blocks produced and marketed in Owerri, Imo State by the Government agencies.
ii. The blocks manufacturers in Owerri municipal, Imo State did not conform to NIS minimum standard production process as all of them did not utilize the prescribed mix ratio, curing period, and batching method nor possess the MANCAP certificate.
iii. 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 specifications.
iv. The results of the study infers therefore that the claim that sandcrete blocks being manufactured and used for commercial purpose in Nigeria are of poor quality and non-compliant to acceptable NIS prescribed standard specifications has merit and therefore upheld.

9. RECOMMENDATION

The study recommends that the relevant government agencies, Standard Organization of Nigeria and Consumer Protection Council should forthwith establish their presence in Imo State to ensure checks and balance as necessary.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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