Available online www.jsaer.com

Journal of Scientific and Engineering Research, **2016, 3(3):414-422**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Improving on the quality of sandcrete blocks produced in the warm humid climatic zone of Nigeria

UcheFelix Ikechukwu[1], John Ezeokonkwo[2]

[1]Department of Building, Imo State University, Owerri, Nigeria
[2]Department of Building,Nnamdi Azikiwe University Awka, Anambra State, Nigeria

Abstract The quality of sandcrete blocks produced in Nigeria is a suspect oweing to the fact that there is no appropriate standards and lack of compliance to the existing ones in the country. For this reason, the study seeks to work towards improving the quality of sandcrete blocks produced in the Warm Humid Climate (WHC) of Nigeria through the production process. Laboratory tests were conducted on some block samples collected from about 50 per-cent of the major block producing firms in Owerri Metropolis (part of the WHC in Nigeria). Statistical analysis were carried out on the tests results of the various block samples collected in the area to obtain Statistical Arithmetic mean, Mean variation, Standard deviation and Coefficient of Variation for the respective types of block. It was therefore discovered that the mix design, mechanical method of compaction, and 28-day curing age improve the properties of the blocks. Qualities of the blocks aremaximized especially, when the three conditionalities (factors) are applied simultaneously. Coefficient of variations of the blocks produced in the area however, are high in the range of 0.041 to 0.105 but; it was recorded very low on blocks involving mix design and the mechanical method of production respectively at range (0.001 – 0.041). Besides, the least values were noted on blocks that were mix designed and mechanically produced at a time. The three factors in the blocks production process are very significant in their influences on quality of sandcrete blocks produced in the area. Thus, it is suggested that strong emphasis be placed especially, on the mix design approach in the batching stage of the production process, with a view to making 'a difference' in the blocks quality particularly; when it is not a common practice in the Nigeria construction industry.

Keywords Sandcrete Blocks, Quality improvement, MixDesign, Mechanical Production Method, and 28-day Curing Age.

Introduction

Building materials account for over 60 percent of the total cost of building construction projects therefore, their quality is of primary concern for their reliabilities and efficient performances in buildings [1]. In Nigeria and other developing countries in Africa, over 90 percent of building structures are constructed using sandcrete blocks [2]. This makes block an important material component in building construction as load bearing and non-load bearing walling units. British standard 6073: 1981, part 1 defines block as a masonry unit of large size in dimension than specified for bricks but, no dimension should exceed 650mmnor should the height exceed either its length or six times its thickness.

Sandcrete block as one of the basic and commonest building materials used in multiple numbers in Nigeria is very popular across the nation, because of the ease in their production and laying processes. For this reason, the production of this material becomes an all comers' affair in many parts of the country without any guide or reference to suit local building requirements for good quality works for a long time; hence the quality is a suspect.

The properties/quality of sandcrete blocks produced in Nigeria and in the WHC zone in particular is influenced by many factors; from the constituent ingredients, the production process to the conditions of the environmental climate. Since Sancrete block constitutes predominantly the component of building fabric, is it basically used as walling unit in most parts of the country; hence it must be designed and produced to ensure that it conforms to the required standards in respect to the comfort and safety of occupants and the building structure.

Although standards exist for the quality management of construction materials, recent studies show that materials like sandcrete blocks, paints, etc. still have poor qualities. Consequently, Olateju, (1993) revealed earlier an upward trend in the use of substandard materials and contributions of poor site work supervision to the incidence of building failures in Nigeria [3]. In Ondo State, it was reported that the average compressive strength of 150mm and 225mm sizes of sandcrete block stood at 0.55N/mm^2 and 0.45N/mm^2, which are very much lower than those stipulated by the relevant codes and standards. They also stated that the coefficient of variation (CV) stood at 0.54 and 0.71 for 150mm and 225mm sandcrete blocks respectively. These values are high and they indicate a very poor quality control condition in the production process, within the climatic zone.

Anosike et al, (2012) in their study, carried out experiments for the assessment of compressive strength of sandcrete blocks produced in Ogun State [2]. In their findings, it was remarked that low compliance to stipulated requirements resulted to as low as average of 0.66N/mm^2 compressive strength value and as much as 16.95% water absorption capacity. The study revealed very low quality and high degree of variability in the property of sandcrete block produced in the area.

Thus, quality of sandcrete block is usually reflected in the values of their properties. Among the common factors that influence quality of sancrete block, production process is the one that caneasily be controlled more than the others in a given locality. Sancrete block production process therefore, basically involves; Mix ratio or Composition of the constituent ingredients (batching), Method of compaction and Curing age. These among other factors influence the quality of sandcrete block produced in Nigeria [4]; hence could be used to improve the block quality produced within the locality.

Method of the Experiments and Analysis

The samples of the blocks produced in the study area were collected from 52 block producing firms using random sampling procedure in a strata arrangement. An ex post fact research design was adopted to obtain information on the major properties of the blocks produced in the area, with appropriate laboratory equipment s. To evaluate the objective of the study on the output parameters (Density, Rate of Water Absorption and Compressive Strength) for the improvement of quality of the blocks produced in Owerri Metropolis, the following statistical parametric tools were established:

i. Arithemetic mean
ii. Standard Deviation (σ)
iii. Coefficient of variation (C_v)

According to Okereke (2008) [5], the mathematical expressions of the above parameters are as expressed in Eqs. (3.1) – (3.3) as follows:

i. $\tilde{y} = \sum \frac{Y_i}{N}$ … **Equ (1)**

ii. $\sigma = \frac{\sqrt{\sum(\bar{y} \; - yi)^2}}{N-1}$ … **Equ (2)**

iii. $Cv \; = \frac{\sigma}{\bar{y}}$ … **Equ (3)**

where,

$\sum y_i$ is the summation of the sample results; N - sample population;

σ - standard deviation; Cv – coefficient of variation;∑- summation of the sample result;y_{i} - result on studied of ith property;$\bar{y}$ - arithmetic mean of the property; and N -1 - degree of freedom.

Data collected were subjected to statistical analysis to obtain mean values which were used to obtain sample variance and standard error of the properties of the blocks samples. With these data, analyses were made and conclusion drawn on the critical factors and production conditions that affect the properties of the sandcrete blocks produced in the study area.

Results and Discussion

Density of Blocks

The results of statistical analysis of the data on density of the blocks produced in Owerri Metropolis are as shown in Table 1. From the results, the following deductions were made:

Table 1: Density (ρ) of the Sample Blocks Produced in the Study Area

Method of Production	Sizes of Block	7 Day – Age				14 Day – Age				28 Day - Age			
		$\bar{\rho}$	σ^2	σ	Cv	$\bar{\rho}$	σ^2	Σ	Cv	$\bar{\rho}$	σ^2	σ	cv
Manual Production	150mm Solid	1787	11512	107	0.06	1781	1174	108	0.061	1831	11270	106	0.059
	225mm Hollow	1748	7001	84	0.048	1773	5384	73	0.041	1799	6676	82	0.046
Mechanical production	225mm Hollow	1827	2967	55	0.03	1851	3141	56	0.03	1888	5017	71	0.038
	Designed 225mm Hollow	1933	4	2	0.001	1958	16	4	0.003	1986	16	4	0.003

Source: Field Work Experiment – (2011- 2012)
Legend: $\bar{\rho}$ = Mean Density, σ^2= Variance, σ = Standard Deviation, and**cv** = Coefficient of Variation

Effects of Some Production Factors on Density Property of the Blocks

Effect of Curing Age on Density

The value of the mean density increases with the age of curing. For instance, the density value of all the 150mm solid manually produced block (SMPB) were 1787, 1781 and 1831kg/m^3 at age 7, 14, and 28 days respectively, as shown in Fig.1.

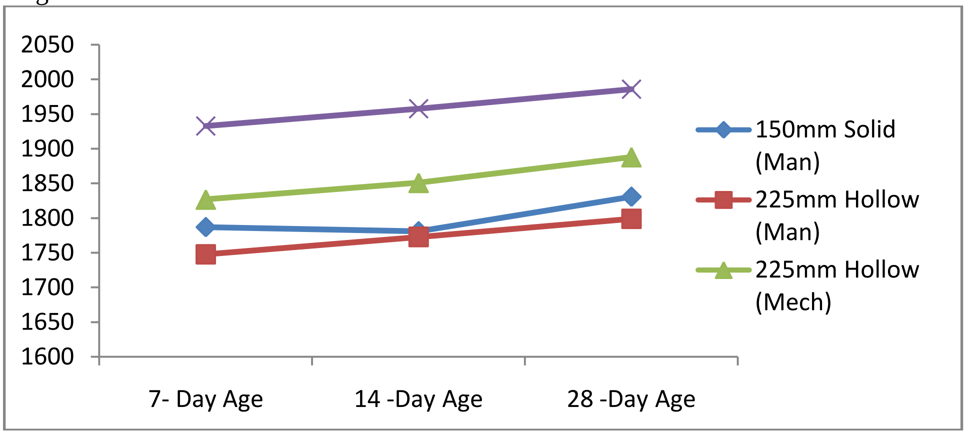

Figure 1: Effect of Curing Age on Density of Blocks

The initial density at age 7 is higher than that at age 14 days because of the weigth of the mixing water, but at subsequent days there is a corresponding increase in the density. Densities of other respective types/forms of blocks increases fairly proportionally as the curing age increases, as it can be seen in Fig. 1.

Effect of Method of Compaction on Density

The density of mechanically produced blocks are by far higher than those of manually compacted ones. For instance, while manually compacted 225mm hollow blocks have density value of 1799kg/m^3 at 28 days, those compacted mechanically have a density of 1888kg/m^3 at the same corresponding age. This shows that mechanical compaction has positive effect over manual compaction, as shown in Fig. 2.

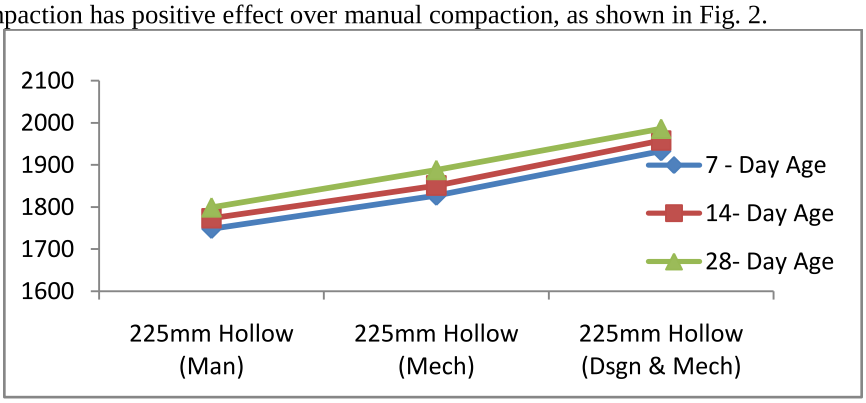

Figure 2: Effect of Method of Compaction on Density of Blocks

Effect of Mix Design on Density

Of interest is the effect of mix design on the density of sandcrete blocks. From Table 1, it could be seen that the designed mix of 1:12 for the same 225m hollow blocks produced in the study area showed a remarkable increase of about 5% over and above that of non-designed mix of the same size and age.

It could be seen from Table 4.1 that the coefficient of variation for the density of 150mm solid sandcrete block produced manually at curing ages of 7, 14 and 28-days was found to be 0.060, 0.061 and 0.059 respectively, while the Cv for 225mm hollow blocks at the same ages was 0.048, 0.041 and 0.046 respectively. For the mechanically produced 225mm hollow blocks, the Cv at the same curing ages of 7, 14 and 28 was found to be 0.030, 0.030 and 0.038 respectively as shown in the same Table. Results show that there was higher degree of variability in the density of manually produced blocks than those produced mechanically. This may be due to subjective factors associated with manual production of blocks. The Cv for 150mm solid blocks produced manually has the highest degree of variability than others, while the Cv of the density for blocks with designed mix, mechanically produced has minimal values of 0.001, 0.003, and 0.003 at the respective ages. This shows that blocks from designed mix usually have very low level of variability in their properties because of accuracy in batching of ingredients which took into consideration the properties of the respective ingredients,(Fig. 4.3).

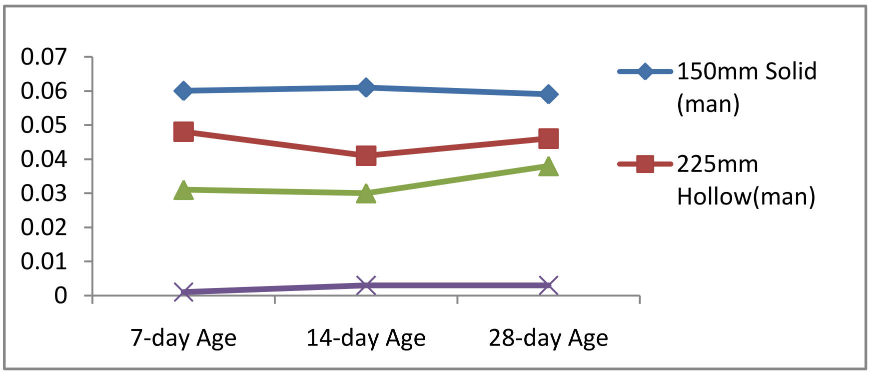

Figure 3: Cv of Density for Different Types of Blocks at Different Ages

Rate of Water Absorption (Roa) Of Blocks

The results of statistical analysis of the data on rate of water absorption of the blocks produced in Owerri Metropolis are as shown in Table 4.2. From the results, the following deductions were made:

Table 4.2: Rate of Absorption (*W*) of the Sampled Blocks Produced in the Study Area

Methods of Production	**Sizes of Block**	**7 Day – Age**				**14 Day – Age**				**28 Day – Age**			
		$\bar{w}$	σ^2	σ	Cv	$\bar{w}$	σ^2	σ	Cv	$\bar{w}$	σ^2	σ	cv
Manual Production	150mm Solid	10.90	1.23	1.11	0.102	10.60	1.23	1.11	0.105	10.20	1.04	1.02	0.10
	225mm Hollow	11.00	0.92	0.96	0.087	10.70	0.81	0.90	0.084	10.40	0.77	0.88	0.085
Mechanical production	225mm Hollow	10.00	0.20	0.44	0.044	9.80	0.30	0.55	0.056	9.40	0.15	0.38	0.040
	Designed 225mm Hollow	9.20	0.01	0.1	0.01	8.90	0.01	0.1	0.01	8.50	0.04	0.2	0.02

Source: Field Work Experiment – (2011 – 2012)

Legend:$\bar{w}$= Mean Rate of Water Absorption, σ^2= Variance, **σ** =Standard Deviation, and **cv** = Coefficient of Variation

Effects of Some Production Factors on the RoA Property of the Blocks

Effect of Curing RoA

The rate of absorption decreases in the mean values with the age of curing for all categories of the block samples. The rate of absorption (RoA) for 150mm manually produced solid blocks were 10.90, 10.60 and 10.20 percents at 7, 14 and 28 days respectively, while in those of manually produced 225mm hollow blocks, there is a corresponding decrease in values of RoA at 11.00, 10.70, and 10.40 percent.

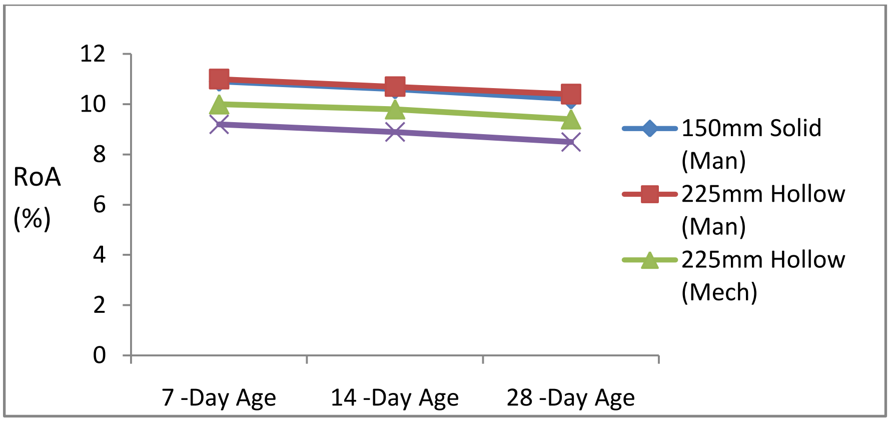

Figure 4: Effect of Curing Age on Rate of Water Absorption of Blocks

Effect of Method of Compaction on RoA

From Table 2, it could be seen that the 225mm hollow sandcrete blocks that were produced and compacted mechanically have RoA values that are significantly lower than those compacted manually. For example, while manually compacted 225mm hollow blocks have RoA value of 10.40 percent at 28-day age; those by mechanical compaction have RoA value of 9.0 percent. These are indications that the more closely the constituent particles of the blocks, the lesser the porosity; hence the RoA reduces. It can be inferred further that mechanical method of compaction is more effective, and so when adopted in block production, it affects positively the RoA of the blocks, by reducing the rate. It is mostly appreciated when fine aggregate used in the mix is hard, and with limited quantity of silt and clay particles, as it is the case with river sand.

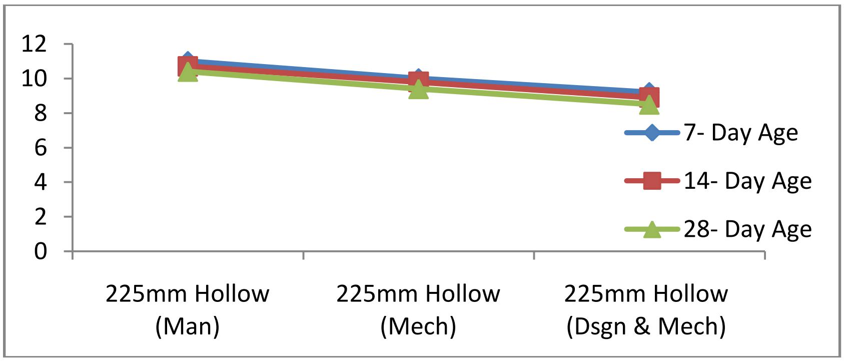

Figure 5: Effect of Method of Compaction on Rate of Water Absorption of Blocks

Effect of Designed Mix on RoA

It could be seen also in Table 2 that the 225mm hollow blocks produced from designed mix and were mechanically produced in a laboratory have RoA values far lower than those of the undersigned and mechanically produced blocks, at the respective curing ages. The 225mm mix designed hollow and mechanically produced block at 28-day age have RoA value of 9.40 percent, while the undesigned (conventional) have 10.40 percent at the same 28-day age. The blocks from designed mix have RoA value of about 9 percent lower than that from non-designed mix. The reason for the positive effect of the use of mix design in sandcrete block production is more scientific and results in accurate batching of the ingredients than the usual practice of specifying sandcrete mix by ratios and the rule of thumb.

Generally, among the different sizes, forms and production methods of blocks, the 150mm solid blocks manually produced have the highest absorption rate values, while the 225mm hollow blocks, machine produced have the lowest absorption rate. It could be explained as due to the volume of void in each block type. In the hollow block type produced mechanically, the volume of void is drastically reduced through proper compaction, where as in the case of manually produced blocks, the amount of void left after compaction is considerable high. This results to more capillary movement of moisture in the component in an attempt to fill up thevoid [6].

In the same vein, the CV values of blocks from designed mix and mechanically produced were insignificant for all the properties tested, because sandcrete mixes were designed and batching controlled during the production process with adequate compaction method which resulted in the reduction of voids; hence the least values of the coefficient of variance and standard deviation. he result is presented in Fig. 6.

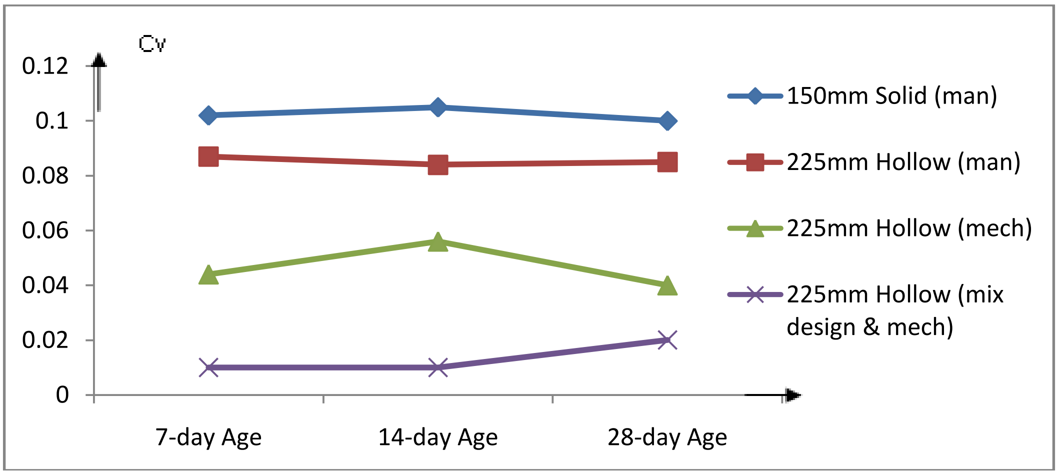

Figure 6: C_V of Rate of Water Absorption for Different Types of Block at the Different Ages

Compressive Strenght of The Blocks

Strength in this case, is expressed as compressive strength, which is the amount of force the block is capable of resisting before failure occurs over a unit cross-sectional area. Thus, the statistical analyses of the data on compressive strength of the blocks produced in Owerri Metropolis are as shown in Table 3.

Table 3: Characteristics of Compressive Strength (*R*) of Blocks Produced in the Study Area

Methods of Production	Sizes of Block	7 Day – Age $\bar{R}$	σ^2	Σ	Cv	14 Day – Age $\bar{R}$	σ^2	σ	Cv	28 Day – Age $\bar{R}$	σ^2	Σ	Cv
Manual Production	150mm Solid	1.73	0.019	0.137	0.079	1.82	0.015	0.12	0.066	1.95	0.012	0.11	0.056
	225mm Hollow	1.70	0.005	0.070	0.041	1.81	0.005	0.074	0.041	1.90	0.007	0.084	0.045
Mechanical production	225mm Hollow	2.02	0.013	0.114	0.056	2.11	0.009	0.095	0.045	2.20	0.008	0.091	0.041
	Designed 225mm Hollow	2.20	0.01	0.1	0.045	2.34	0.09	0.13	0.056	2.42	0.01	0.1	0.041

Source: Field Work Experiment– (2011 – 2012)

Legend: $\bar{R}$= Mean Compressive Strength; σ^2= Variance; **σ** = Standard Deviation, and C_v= Coefficient of Variation.

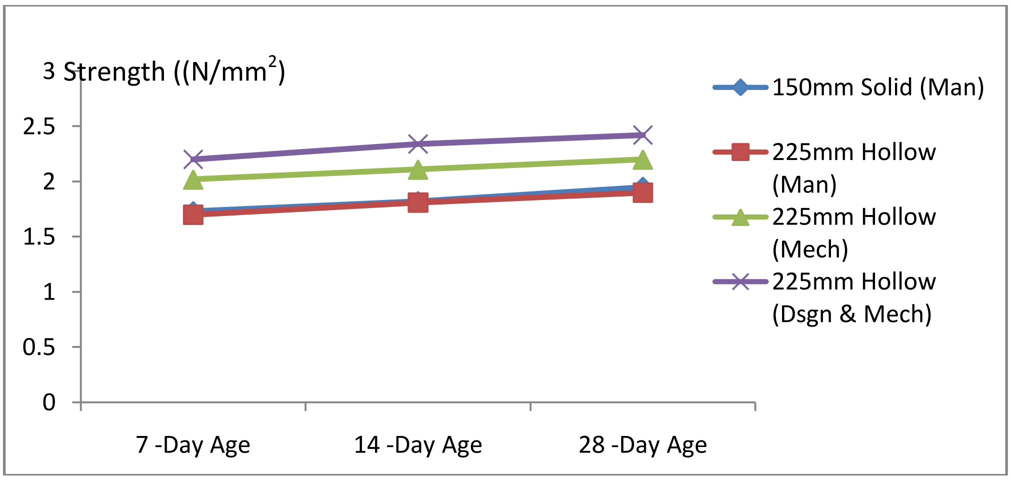

Figure 7: Effect of Age of Curing on Compressive Strength of Blocks

Effects of Some Production Factors on the Strength Property of the Blocks

Effect of Curing on the Strength

The strength values of the sampled block of the respective sizes produced manually and mechanically show steady increase as the curing age of the blocks irrespective of production method. For instance, the mean strength of the 150mm solid blocks manually produced was found to be 1.73, 1.80, and 1.94.3N/mm,at 7, 14, 28-day curing ages respectively. The increase in strength as the curing age increases, indicates process of hydration in the newly produced blocks after the blocks had set. This process reduces porosity of the block and increases density with consequent increase in the strength progressively, untill the blocks attain their maximum strength. This is explained by the mechanics of physical matters where, the internal bond strength increases with decrease in porosity, building up shear resistance against any external or applied forces [6].

Effect of Method of Compaction on the Strength

The compressive strengths of mechanically compacted blocks are by far higher than those of manually compacted blocks in their corresponding ages of curing respectively. For example, while manualy compacted 225mm hollw blocks have strength value of 1.90N/mm^2 at age 28 days. Those compacted mechanically have a strength value of 2.20N/mm^2 at the same age.This explains the positive effect mechanical compaction has over manual compaction.

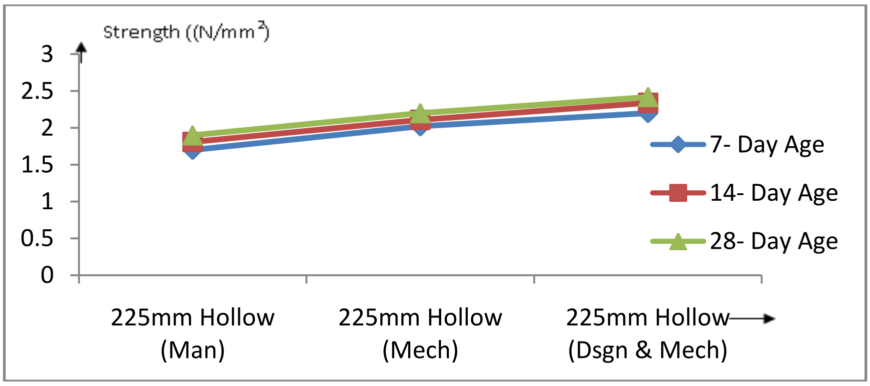

Figure 8: Effect of Method of Compaction on the Strength of Blocks

Effect of Designed Mix on Compressive Strength

The effect of mix design on the strength is significantly positive. It could be seen in Table 3 that the strength of (controlled) 225mm hollow block from desinged mix was found to be 2.20, 2.34, and 2.42N/mm^2 at 7, 14, and 28-day ages respectively. These strength values for the respective curing ages are by far higher than the corresponding strength of the non-designed or conventionally produced 225mm hollow blocks (Ex post facto), even though mechanically compacted also at the ages respectively. The reason is that the constituent ingredients (independent variables) were controlled as opined byVeh-matti, (2011) [7]. It can therefore be seen that the strength characteristics of the designed mix blocks as produced in the area increased remarkably with about 10 percent over and above those of undesigned ones with the same sizes and corresponding ages.

The coefficient of variation however, are higher in the 150mm hand mould solid blocks than the 225mm hand moulded hollow blocks; and as a result, the Cv values for 150mm hand moulded solid blocks are 0.079, 0.066 and 0.056 at the respective curing ages, while those for (controlled) 225mm hollow blocks are 0.041, 0.041 and 0.044 respectively. The mechanically produced 225mm hollow block for the various curing ages also have Cv values of 0.056, 0.045 and 0.041 respectively as can be seen in Table 3. It would therefore be said that the controlled machine moulded blocks of different sizes and production methods have least degree of the variation in their compressive strength.

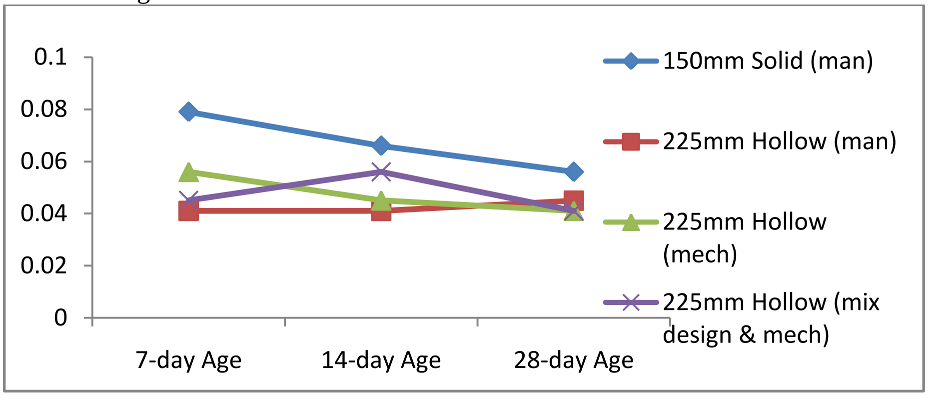

Figure 9: Coefficient of Variation of Compressive Strength for Different Types of the Block at Different ages

Summary on Findings

From the tests conducted on the samples in the study area, it could be conclusively summarized that quality of the blocks produced in the area is mainly dependent on the following key factors:

i. The method used in determining the quantity of the respective ingredients;
ii. The method of compaction and
iii. The age of curing.

Generally, tests results on the properties of the blocks produced in the study area revealed that blocks produced either mechanically, with mix design or cured up to 28- day of age have advantage of higher density, lower RoA and higher compressive strength in the study area. Thus, the combination of the three factors in the block production process especially, in the case of mix design and mechanical production method shows a remarkable improvement on the properties of the blocks produced in the area, as seen in Fig.1 – 9.

Coefficient of variation (C_V) on the block properties however, does not identify a definite pattern in the study nevertheless, it is seen to be at the least values for the sandcrete blocks that were mix designed and mechanically compacted at all ages of curing in Fig. 3, 6, and 9, for the properties of the sandcrete blocks produced in the study area.

Conclusion and Recommendations

Although the factors that can influence the quality of sandcrete block produced in the study area are not limited to mix design of the constituent ingredients, method of compaction and curing age, their implications on the properties of the blocks are significant in the study. The effect of any production process in the block making can easily be predicted and the process also be controlled for improved quality of sandcrete block.

According to Ikechukwu (2015) [4], A mix design of the constituent ingredients can be optimized for improved and desired quality of a sandcrete block in the study area. Besides, the more compacted the mix in a mould, the higher the quality because; the bond between the constituent materials in a matrix is made stronger. None the least is the fact that when a freshly made sandcrete block is exposed to the atmosphere longer, the hydration process of the masonry composite material persists to further improve the quality of the sandcrete blocks especially, in the study area.

It is therefore, recommended that cautious attention be drawn to the block production process in the study area in order to complement the basic principle of quality control measure on sandcrete block production. As a matter of urgency, an enforceable policy on code of practice for sandcrete block production will be established with effective implementation machinery, for improved quality of sandcrete blocks produced in Nigeria.

References

[1]. Okereke, P. A. (2002). Climatic Conditions and Construction Materials: INFRADEV Associate, Owerri, Nigeria.

[2]. Anosike, M. N., & Oyebade, A. A. (2012). Sandcrete blocks and quality management in Nigeria Building Industry. *Journal of Engineering, Project, and Production Management*, *2*(1), 37.
[3]. Olateju, O. T. (1993). Need for Quality Control in the Nigerian Building Industry: Journal of Studies in Environment Design in West Africa, Nigeria.
[4]. Ikechukwu, U. F. (2015). Improving the Properties of Sandcrete Blocks Produced in the Warm Humid Climatic (WHC) Zone of Nigeria. A Ph.D. Dissertation in Construction TechnologyPresented and Successfully Defended in the Faculty of Environmental Sciences, Imo State University, Owerri.
[5]. Okereke, P. A. (2008).Quality Control of Concrete in Building Production in Nigeria: Faculty of Engineering and Environmental Sciences, Imo State University, Owerri. Vol.1, No.2. Owerri, Nigeria.
[6]. Taylor, G. D. (2002). Materials in Construction: Principles, Practice and Performance: Pearson Education Limited, England.
[7]. Veh-matti, T. T. (2011).Experimental Optimisation and Response Surface. Chemometrics in Practical Application: Helsinki Metropolis University of Applied Sciences, Finland.