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The Effects of Coarse Sand on Sandcrete Blocks

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Abstract:- The construction industry in developing countries faces challenges due to high costs of building materials, often imported. Nigeria, where construction costs are high, is increasingly aware of the need for local materials for functional but low-cost dwellings. Sandcrete hollow blocks, a common walling material in Nigeria, are made from a mixture of river sand, cement, and water. However, the strength of some sandcrete blocks has been found to be below recommended standards, resulting in expensive repair works and reconstructions. Several low-cost materials have been identified as strategies to reduce construction costs, such as compressed stabilized laterite bricks (CSLBs), bamboo fibers as reinforcement in concrete, rice husk ash as a replacement for cement in sandcrete blocks, and ungrounded rice husk ash for lightweight sandcrete with insulating properties and reduced costs. This study aims to develop an alternative cost-effective means of producing sandcrete blocks by a partial replacement of conventional fine sand with sharp coarse sand. Coarse sand is readily available and extensively used in Nigeria in the manufacturing of concrete, producing higher strength concrete than washed fine sand. The study investigates the structural properties of sandcrete blocks produced with varying proportions of coarse sand, cement, and water. The objectives include determining the particle size of the fine and sharp sand used, investigating the structural properties of sandcrete blocks produced with varying proportions of sharp sand, determining the compressive strength of sandcrete blocks produced from fine sand, and determining the optimum percentage of sharp sand that could improve structural performance of sandcrete blocks. Sandcrete blocks are a popular walling material in Nigeria, but they have been linked to failures in the form of cracks and collapses. Poor quality sandcrete used in construction has led to inconsistent quality of sandcrete blocks. Sandcrete blocks are widely used as walling materials in Nigeria and other developing countries, as they are designed to support loads other than their own weight. Recent structural collapses in Nigeria have raised concerns for more in-depth study on the resistance mechanisms of all components of the structure. Researchers have studied the strength deformations and failure mechanisms of concrete masonry under static and dynamic loads. The study aims to address the connection between mixed composition and compactive effort on the strength and economy of sandcrete masonry. The National Institute of Standards and Technology (NIS) specified two types of sandcrete blocks: load bearing (load bearing) and non-load bearing (non-load bearing). The project methodology used fine sand, sharp sand, cement, and water for the production of hollow sandcrete blocks. Laboratory tests were conducted to determine the strength characteristics of the sandcrete blocks, with results showing a compressive strength range of 2.5N/mm2 to 3.45N/mm2. The study aims to improve the strength and economy of sandcrete masonry by using reduced-scale blocks, reducing laboratory space requirements, and enhancing research in areas where sophisticated and heavy equipment is not available.

I. INTRODUCTION

➢ *Background of Study*

The high cost of importing most building materials has a significant impact on the construction industry in developing countries. Recent spikes in the price of building supplies in Nigeria have rekindled a sobering awareness of the need to connect research with manufacturing, particularly on the use of local materials as alternatives for the construction of usable but inexpensive housing in Nigeria's urban and rural areas.

While the cost of construction is rising in every country (Turner and Townsend, 2012), it is widely acknowledged that Nigeria has the highest construction cost (Anyim, 2012), and this is one of the major factors that determines the optimal delivery of housing projects in Nigeria (Akutu, 1983). A safe place to live is as essential to human survival as food and water. Rising construction costs have been blamed for the government's inability to provide adequate homes for its citizens (Pepple, 2012). Njoku (2012) and Taffese (2012) report that materials now make up between 60 and 80 percent of the total cost of building a home. Therefore, construction materials utilised in low-income areas must be able to demonstrate their quality and cost-effectiveness through objective data.

As a result, the quest for low-priced material that is both socially acceptable and economically available, in sufficient quantity to be within the grasp of the average man, becomes a topic of ongoing attention. Many people in the construction industry believe that Africa is a rich source of raw materials that can be put to good use in the region, but this is not the case (Ramachandran, 1983).

The walls are one of the most important parts of any building. There are many varieties of walling material, but sandcrete hollow blocks are by far the most frequent in Nigeria. Sandcrete blocks, as described by Seeley (2012), are a type of building material comprised of coarse natural sand or crushed rock dust, cement, water, and moderate compression into predetermined shapes. They are strong enough to be used as walling materials after setting in a mould.

"Sandcrete" bricks are formed by combining river sand, cement, and water. They find widespread application over the continent of Africa and parts of Asia, including Nigeria. These blocks were traditionally made in many different regions of Nigeria without regard to any specification, either to suit local building regulations or to ensure good quality work, for quite some time, until possibly just a few years ago. The situation has improved in Nigeria since the Standards Organisation of Nigeria has issued guidelines for their production and installation.

Some sandcrete bricks used in construction do not have the required strength. The cement, sand, and mixing techniques all play a role in this.

Recent years have seen a rise in the number of building collapses caused by subpar sandcrete blocks. These building defects manifest as costly repair works and, depending on their severity, total reconstruction.

Thus, several studies' results have uncovered low-cost materials that could be used in the strategy to reduce construction costs. Alagbe (2011), for instance, looked into compressed stabilised laterite bricks (CSLBs). He discovered that it has a low-cost advantage over the sandcrete blocks, and thus he reasoned that using it in building construction will aid in reducing construction costs. The feasibility of employing bamboo fibres as a replacement for reinforcement in concrete for inexpensive building was investigated by Nwoke and Ugwuishiwu (2011). Material suited for low-cost construction was discovered when bamboo fibres were used in place of reinforcement.

Okpala (1993) observed that if rice husk ash could be used in place of cement in sandcrete blocks, construction costs in Nigeria might be cut in half. This is because sandcrete blocks, the primary construction material in the country, account for a disproportionate share of building costs. His research showed that for sandcrete block manufacturing in Nigeria, a 1:6 (cement-sand) ratio with up to 40% cement replacement with RHA and a 1:8 ratio with up to 30% cement replacement with RHA are sufficient. Sandcrete blocks with increased mechanical resistance after adding ungrounded ash outperformed traditional mortar blocks, according to a study by Cisse and Laquerbe (2000). Research conducted in Senegal showed that lightweight sandcrete with insulating qualities might be made by incorporating ungrounded rice husk ash. The increased strength was a result of the pozzolanic reactivity of the ash.

The purpose of this study was to determine whether or not the strength characteristics of sandcrete blocks could be improved by using coarse sand aggregate as a partial substitute for the fine aggregate (sand) in the mortar matrix. Nigeria makes great use of coarse sand, which is easily accessible, in the production of concrete. It has also been discovered that coarse sand results in stronger concrete than cleaned fine sand. Finding the ideal volume % of coarse sand to utilise as a partial replacement for fine sand in the sand-cement matrix was the primary focus of the study discussed in this paper.

Since both conventional fine sand and sharp coarse sand are readily available in our environment, this study is being conducted to develop an alternative cost-effective method of producing these sandcrete blocks for building construction. In accordance with the worldwide trend of Green Approach Strategy in Civil Engineering and building construction, their long-term viability and impact in use are taken into account here.

For this study, we wanted to see if we could improve the strength properties of sandcrete blocks by partially replacing the fine aggregate (sand) in the mortar matrix with coarse sand aggregate. Nigeria makes great use of coarse sand, which is easily accessible, in the production of concrete. It has also been discovered that coarse sand results in stronger concrete than cleaned fine sand. The primary goal of the studies presented in this work was to establish the ideal replacement volume percentage of coarse sand for fine sand in the cement matrix.

The concrete used to make sandcrete blocks results in a pale grey tint. Dry fine aggregate, often known as natural river sand, is combined with cement and water before being compacted and vibrated in an egg layer or static machine to form the final product. Sun-drying the finished blocks after curing them with water at room temperature gives them the strength they need for their intended purpose.

The variety of sizes, shapes, and face treatments available for sandcrete blocks far exceeds that of clay bricks. Because of this, sandcrete blocks are a crucial building material in Nigeria, where they are used to create more than 90% of the country's physical infrastructure. As both load-bearing and non-load-bearing walling units, it sees extensive application in Nigeria, Ghana, and other African countries. Sandcrete blocks have been mass-produced across much of Nigeria for decades, but their production has rarely taken into account regional building codes or guaranteed levels of quality. Standard specifications for compressive strength and water absorption qualities of several types of sandcrete blocks were established in a document drafted by the Standard Organisation of Nigeria (SON).

Considering or inspecting sandcrete blocks to evaluate their worth, quality, importance, and durability is the focus of evaluating the control and modified specimen constructed with sand, by coarse sand.

To that end, the authors of this study experiment with different combinations of coarse sand, cement, and water to see how they affect the structural qualities of the resulting sandcrete blocks.

➢ *Problem Statement*

The quality and cost-effectiveness of construction materials being the major factors that determine the optimal delivery of housing projects in Nigeria, and the rise in the cost of these construction materials had turned the majority to lack a quality shelter of their own.

This accounted for the search for low-cost materials that were socially acceptable and economically available, and an acceptable quality within the reach of ordinary men.

➢ *Aim and Objectives*

This project work was aimed at investigating the structural suitability and adequacy, as well as affordability of using coarse sand as a partial replacement of fine sand in the production of sandcrete blocks for low-cost building and construction purposes where readily available.

- *The Specific Objectives were to:-*

✓ Determine the particle size of the fine and sharp sand used.
✓ Investigate the structural properties of sandcrete blocks produced with varying proportions of sharp sand.
✓ Determine the compressive strength of sandcrete blocks produced from the fine sand.
✓ Find out how much sharp sand should be used to maximise the structural benefits of sandcrete blocks.

➢ *Significance of Study*

This study will reduce the population of Nigerians without shelter and reduce the rate at which constructed structures collapse as a result of the use of low-quality construction materials because of their high cost.

➢ *Scope of Study*

This project was mainly experimental and involved the partial replacement of coarse sand in various percentages with natural river sand and Ordinary Portland Cement in sandcrete blocks, thereby investigating the physical characteristics of the modified sandcrete block. The workability and compressive strength of the modified sandcrete block will be determined and compared to the control sandcrete block specimen.

- *The Specific Scope of this Study Shall Include;*

✓ To obtain relevant pieces of literature in this subject area for review to understand what is currently known on the subject.
✓ To obtain samples of sand, coarse sand and cement for laboratory analysis and block sampling, cured and tested according to the standard procedures.
✓ To analyze and discuss the results obtained in (ii) and compare these results with standard specifications for sandcrete blocks for building construction.
✓ To make a conclusion based on the results analyzed and discussed in (iii) above and make further recommendations.

➢ *Method of Study*

The method used in this study involved the collection of sharp sand Ladoke Akintola University of Technology, LAUTECH, in Ogbomoso North Local Government. The sharp sand was replaced with 0%, 2%, 4%, 6%, 8% and 10% of fine sand by weight control sample. The sandcrete blocks were made from natural sand and Ordinary Portland Cement and tested under the compression machine at the Structural Laboratory of the Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso.

II. LITERATURE REVIEW

A. Introduction

Researchers are now motivated to identify viable alternatives to cement and sand in sandcrete block production, so that production costs can be lowered without sacrificing the necessary strength, as we are living in an era of sustainable development. The high price of cement and sand, two of the key ingredients in making sandcrete blocks, likely plays a role in this.

Sandcrete blocks, made by combining sand, cement, and water, are used in construction all over the world, whereas clay bricks made in the same way are used in others. But clay bricks are created when clay is shaped and then baked in a kiln.Compressive force is used to shape the sand, cement, and water mixture into blocks of sandcrete. However, they are widely employed in Nigeria and other African nations. These blocks weren't made to any standards, either for compatibility with local building materials or for high quality, until maybe a decade ago. However, things have changed now that the Nigerian Industrial Standard (NIS) has been implemented, which details the requirements for producing and using these blocks in Nigeria. The Standards Organisation of Nigeria has published this guide.

The impact of granite fines on the structural and hygrothermal properties of sandcrete blocks was studied by Oyekan and Kamiyo. After 28 days, they noted an increase in compressive strength of more than 15% for blocks manufactured with a mix proportion of 1:6 and more than 4% for blocks made with a mix percentage of 1:8. They also found that 15% was the sweet spot for granite fines content. They came to the conclusion that blocks made using granite coarse aggregate as a partial sand replacement had much better compressive strength values, and this was true regardless of the size of the coarse aggregate employed. As for the ideal aggregate content, they found that it was 25% when using a single size aggregate of 5mm, 30% when using a single size aggregate of 10mm, 35% when using a single size aggregate of 15mm, and roughly 25% when using a mixed coarse aggregate of 10mm and 15mm. Oyekan investigated the use of crushed waste glass in place of sand and cement in the manufacture of sandcrete blocks. According to his findings, the optimal ratio of crushed waste glass to new glass is 1:6 (at 15%) and 1:8 (20%).

The effectiveness of concrete created by partial replacement with Portuguese rice husk ash was evaluated by Sampaio et al. There was supposedly a strength boost proportional to the amount of rice husk ash used. The inclusion of ungrounded rice husk ash allowed for the production of lightweight, insulating sandcrete at a lower cost, as shown by the mechanical resistance of sandcrete blocks obtained when the ash was added (Cisse and Laquerbe, 2002). The increased strength was a result of the pozzolanic reactivity of the ash. Silica gravel and crushed limestone were utilised as coarse aggregates in the rice husk ash cement concrete developed by Mehta, P. K. and Pitt, N. Based on their findings, concrete made with crushed limestone aggregate is 23% stronger than concrete made with siliceous gravel aggregate. They speculated that the increased strength was due to the interfacial connections formed between the cement paste and aggregate. Sandcrete blocks are widely utilised in construction throughout Nigeria. Buildings constructed using sandcrete blocks have a long history of problems, including cracking and collapse. It has been determined that low-quality sandcrete used in their construction was directly responsible for these failures. This research was conducted with the specific goal of perfecting a system for mass-producing sandcrete blocks suitable for use in building construction.

B. Materials for the Production of Sandcrete Blocks

Sandcrete blocks are made from a cement and sharp sand mixture with the smallest possible amount of water, and in certain circumstances, admixture, then shaped and allowed to dry naturally. Sandcrete block, as defined by NIS 87:2000, is a composite material formed from cement, sand, and water. They claim to be a type of masonry unit that goes beyond the dimensions for bricks in terms of length, width, and height when utilised normally. As a result, the block can be manufactured in both solid and hollow rectangular kinds (for standard walls) and in a wide variety of decorative and perforated patterns, forms, sizes, and styles (for screen walls or sun breakers). Both the standard and screen wall jointing for beddings and perpends measures 25 mm in thickness. More than 90 percent of homes in Nigeria are built using sandcrete blocks as walling units (Baiden and Tuuli, 2004). Sandcrete, once it has cured, possesses a high compressive strength that increases with density. NIS 87:2007 specifies a minimum strength between 2.5N/mm2 and 3.45N/mm2. However, due to variations in production techniques and material qualities, Abdullahi (2005) claims that sandcrete blocks are of varying grade. In his research, Abdullahi (2005) found that sandcrete blocks made in some areas of Minna, Niger State, Nigeria below the required minimal NIS level for compressive strength. Crushing strength of sandcrete blocks was discovered to improve with less sand specific surface area and with curing of the block through water sprinkling by Uzoamaka (1977a). In their research, Oyekan and Kamiyo (2011), Oyetola and Abdullahi (2006), and Rahman (1987) found that the optimum water/cement + RHA ratio increases with rice husk ash contents and that up to 40% RHA could be added as a partial replacement for cement without any significant change in compressive strength at 60 days and 28 days. Maximum stress, or compressive strength, is calculated by dividing the maximum load measured by the testing equipment by the specimen's cross-sectional area.

Several factors, including quality control (Afolayan et al., 2008), material choice (Abdullahi, 2005), and curing procedure, contribute to compressive strength. Several studies have looked into the potential benefits of using CKD in Portland cement. Reports on the usage of CKD mixed with Portland cement, fly ash, and ground granulated blast furnace slag were published in a series (Detweileret al, 1996;Bhatty,1983). Cement made using just CKD had lower workability, setting times, and strength, according to the experiments. The alkalies in the dust were blamed for making people weak.

Fly ash added to CKD is thought to have diluted the alkalies, making the mixture stronger. In general, the addition of slag to a cement-CKD blend reduced workability but resulted in greater strengths than blends without slag. It was discovered that the alkalies in the dust could be neutralised by the fly ash and/or slag, and that blended cement with high sulphate produced the highest strength.

The blended cement's characteristics are heavily dependent on the dust's alkali-to-chloride-to-sulfate ratio.

Cement kiln dust, as stated by Ravindrarajah (1982), can be used in concrete and masonry blocks without compromising their durability or versatility. According to his findings, CKD might be used in place of Portland cement for as much as 15% of the total mix. Higher dust percentages slowed the setting, decreased workability, and increased water requirements.

Daugherty and Funnell (1983) found that adding up to 10% inter-ground CKD had no negative effects on the final Portland cement concrete's setting time, soundness, or shrinkage.

Although strength measurements were inconsistent, this was likely due to the dynamic nature of dust. The mechanical qualities of blended cement made with by-pass dust were investigated by Abo-El-Eneinet al. (1994). Due to the high free lime content in the CKD, both the initial and ultimate setting periods of cement pastes were reduced. Cement mixtures that included as much as 15% kiln dust set harder and cured faster. Compressive strengths dropped when more than 15% CKD was substituted for Portland cement.

C. Generation of Coarse Aggregate and Their Properties

➢ *Origin of Coarse Aggregate*

The coarse aggregate is the by-product which is formed in the processing of weathering of rock which may be mechanical or chemical resulting in the broken down of rock into coarse aggregates of different sizes.

➢ *Physical and Chemical Properties*

Tables 4 and 5 detail the sample's physical and chemical qualities as determined by testing against Indian standards for coarse aggregate.

Table 1 Showing the Physical Properties of Coarse Sand And Natural Sand (Ilangovana *et al*, 2008).

Property	Coarse Sand	Natural Sand	Test Method
Specific gravity	2.54 - 2.56	2.60	IS2386 (Part III)- 1963
Bulk Density (kg/m^3)	1720 - 1810	1460	IS2386 (Part III)- 1963
Absorption (%)	1.20 – 1.50	Zone-II	IS2386 (Part III)- 1963
Moisture Content (%)	NIL	1.50	IS2386 (Part III)- 1963
Fine particles less than0.075mm (%)	12 – 15	6	IS2386 (Part III)- 1963
Sieve analysis	Zone-II	Zone-II	IS 383 – 1970

Table 2 Showing the Typical Chemical Properties of Coarse Sand and Natural Sand (Ilangovana *et al*, 2008)

Constituents	Coarse Sand (%)	Natural Sand (%)	Test method
SiO_2	62.48	80.78	IS 4032- 1968
Al_2O_3	18.72	10.52	
Fe_2O_3	6.54	1.75	
CaO	4.83	3.21	
MgO	2.56	0.77	
Na_2O	Nil	1.37	
K_2O	3.18	1.23	
TiO_2	1.21	Nil	
Loss of ignition	0.48	0.37	

➢ *Advantages of Sharp Aggregate*

The specific gravity depends on the nature of the rock from which it is processed and the variation is less (Joseph *et al*, 2012).

➢ *Disadvantages of Sharp Aggregate*

- Shrinkage is more in sharp sand when compared to that of fine sand (Ilangovana*et al*, 2008)
- Water absorption is present so that increases the water added to the dry mix(Sivakumar and Prakash, 2011).

D. Behavior and Experiences of Sandcrete Blocks

In Nigeria and other underdeveloped countries, sandcrete blocks are widely used as a walling material, and their popularity cannot be overstated. When manufactured correctly, the density and compressive strength of sandcrete blocks will exceed the requirements of BS 2028 (1968) for structural masonry.

It is not typical for sandcrete block walls to be able to withstand loads greater than their own weight. But long before the actual event, one of the early warning indications of collapse is the appearance of major critical structural fissures (Figure 1). In light of recent structural collapses in Nigeria and elsewhere, as documented by Wenapere (2008), Gajananet al (1983), Adisa (1997), and Ogar(1997), there is a pressing need for a more thorough and intensive investigation of the mechanism of resistance of all components of the structure. While several studies have been conducted on the subject of steel and reinforced concrete, concrete framework, concrete masonry blocks, and block walls, only a small number of articles have focused on sandcrete.Block housing is all that's left in Wenapere and Ephraim. Few experiments have been documented on sandcrete block walls.

Fig 1 A typical sandcrete wall failure in Ogbomoso, Nigeria

Load transfer from the frame to the block wall is one possible cause of structural cracks (Figure 1), while unequal foundation movement is another. Therefore, it is reasonable to assume that the block wall's strength will be sufficient to bear the weight of the wall itself, as well as the impacts of any additional environmental or accidental loads, and any stresses transferred from the structural frame. In addition, the block wall should offer the structural frame acceptable in-fill constraint. Recent works by authors like Abrams(1996, 1997), Andam (2002a, b), Page (1981), Paulson et al (1990), and Stroven (2002) present the state-of-the-art understanding of the strength deformations and failure mechanism of concrete masonry when subjected to static and dynamic stresses. Ephraim et al. (1990), Liauwet al. (1983), and Madanet al. (1997) are only a few of the researchers who have looked into the issues with frame-in-fill interaction. Wenapere (2003), Andam (2002a, b), Chandhari and Gumel (2000), and Uzomaka (1977) are just

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a few of the few notable studies that have sought to examine the link of mixed composition and compaction effort on the strength and economy of sandcrete brickwork.

A model study is arguably the more realistic way ahead, and is also provided for in Act 318 (1) and BS. 8110 (1997), when investigating the block wall in a laboratory due to its sheer scale and the loading equipment needs. Most studies of masonry models have involved miniature versions of walls made from test versions of concrete or brick. Using smaller blocks for testing will lower the amount of room needed in the lab and the weight of the necessary loading equipment. Especially in places where expensive and bulky machinery is unavailable, this would undoubtedly improve the quality of research.

E. Specification for Sandcrete Blocks

According to the NIS, there are two distinct kinds of blocks: load-bearing Type A blocks and non-load-bearing Type B blocks. Table 6 provides the NIS-approved sizes for sandcrete blocks.

Sandcrete blocks with no voids or webs, such as ornamental and ventilating blocks, are another option for non-load-bearing wall construction. The percentage of core void space in hollow blocks is larger than 25% of the total unit's volume. Both load-bearing and non-load-bearing walls can be built with hollow sandcrete blocks because they are produced using lightweight aggregate (Punmia, 1993). Historically, the term "decorative block" referred to a solid block with textured decorative faces that could be utilised to give permanent ventilation without needing ventilation blocks and an aesthetically pleasing look and light without the need for burglar-proofing or louvres or shutters.

Table 3 Types of Sandcrete Blocks and their usage (Nis 587: 2007)

Type	**Work size (mm) Length x Height x Thickness**	**Web Thickness**	**Usage**
Solid Blocks	450 x 250 x 100	-	For non-load-bearing partition walls
Hollow	450 x 250 x 113	25	For non-load-bearing partition walls
Hollow	450 x 250 x 150	37.50	For load-bearing walls
Hollow	450 x 250 x 225	50.00	For load-bearing walls

III. PROJECT METHODOLOGY

➢ *Materials*

The materials used for the block production are; fine sand, sharp sand, cement and water. The clean fine, sharp river sand is free from clay, loam, dirt and organic or chemical matter of any description and will pass through the 4.70 mm zone of British Standard test sieves. The sand had a specific gravity of 2.65 and an average moisture content of 0.50% and sharp sand was collected from Ogbomoso North Local Government Area, the water used was potable water, which was colourless, odourless, and tasteless that was free from organic matter of any type was gotten from LAUTECH and the cement which was Ordinary Portland Cement was purchased from a retail store in Ogbomoso.

➢ *Manufacturing of Sandcrete Blocks*

A metal hollow block mould is used to create the blocks, which are all hollow. In this study, we employed a cement-sand ratio of 1:6, or one part (by volume) of cement to six parts (by volume) of confectionery crisp sand. Buildings in Nigeria typically use hollow sandcrete blocks, which have dimensions of 225 mm x 225 mm x 450 mm and a void volume of one-third. Sharp sand is used for volume substitutions of natural sand at the following percentages: 0%, 2%, 6%, 8%, and 10%.

The blocks were made by manually mixing and turning the ingredients over and over until the desired hue and consistency were achieved. The adherence was ensured by adding water and giving it a good stir. After being pressed into the metal block mould, crushed, and smoothed using a wooden face tool, the finished product was ready for use. Once the blocks had been removed from the metal block mould, they were stacked on pallets in rows, one on top of the other, with a gap between every two blocks, and placed in a cool, dry place to cure. During this time, they are constantly soaked with frequent waterings. Dry-bulb temperature in the lab is 27 2°C, and relative humidity is 50 5%. Compressive strength was measured again at 7, 14, 21, and 28 days of age. At each age and % of sharp sand substitution for natural sand, an average of three samples are evaluated.

➢ *Laboratory Tests*

- *Sieve Analysis Test*

A granular sample of the sharp sand was gathered from the site and put through the experiment. Before doing the actual test, the samples were left out in the sun for 24 hours to dry. The sieve sizes for grading were determined in accordance with BS882 (16), and the experiment was conducted accordingly. After that, a kilogramme of the sample was manually weighted on scales. The empty pan was placed on the scale, and the reading was reset to zero to account for the weight of the pan. After some time, the pan was taken away and reweighed after being filled with sand. If the recorded weight is below or above the specified quantity, then some sand was taken or added. BS 812(16) provides the standard operating procedure for sieve analysis.

- *Compressive Strength Test*

Sandcrete block has a relative range of minimum compressive strength specified in NIS 87: 2007 which is between 2.5N/mm^2 to 3.45N/mm^2. Samples were cast in a standard mould measuring 450 mm by 225 mm by 252 mm, allowed to cure for 7, 14, 21, and 28 days, respectively, before undergoing a compressive strength test in accordance with IS 516: 1959 to determine the final strength of the mix.

IV. RESULTS AND DISCUSSIONS

A. Particle Size Distribution

The result of the particle size distribution of the sharp sand is presented in Table 4

B. Strenght Characteristics of Sharp Sand In Compressive Strenght

Particle size distribution is a laboratory technique used for establishing the distribution of particle size in a granular sample. Sieve analysis also known as grading analysis is one of the most fundamental methods used for engineering soil classification. Particle size distribution is carried out on the granular samples to determine the relative proportions of the different grain sizes which make up a given granular mass.

Information on particle size distribution can usually be used to determine the suitability and grading of the granular samples to be used for sandcrete block moulding.

Sieve analysis involves the washing of the granular sample through sieve No 200. The samples collected were weighed, the sieve assemblage was cleaned with the wire brush and the sample was passed through it. Then, the sieve was placed on the sieve shaker which vibrated mechanically first at a low speed and then at a higher speed to ensure that the assemblage was properly shaken.

The respective weight of the sieve and the number of samples retained on them were recorded.

Table 4 Particle Size Distribution

BS Sieve (mm)	Weight Retained (g)	Percentage Retained	Cumulative Percentage Retained	Percentage Passing
6	0	0	0	100
5.6	15.6	3.12	3.12	96.88
2.8	86.9	17.38	20.5	79.5
1.0	110.8	22.16	42.66	57.34
0.50	214.1	42.82	85.48	14.52
0.355	37.8	7.56	93.4	6.96
0.125	29.8	5.96	99	1
PAN	5	1	100	0
	500	**100**		

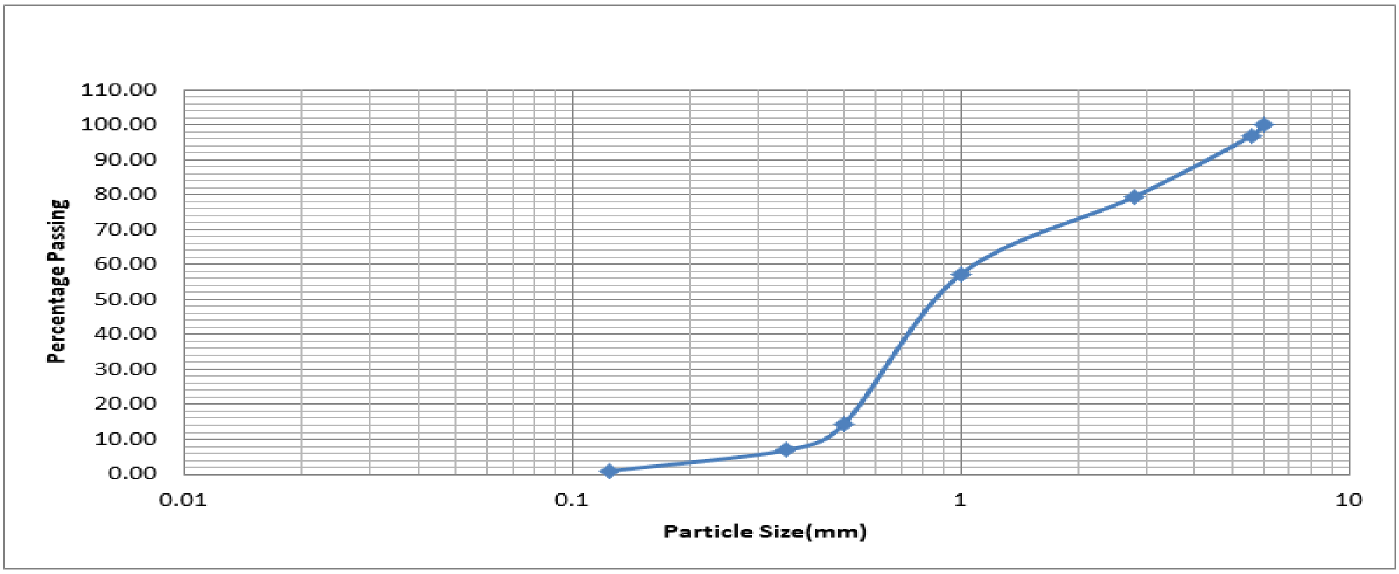

Fig 2 Chart showing particle size distribution

C. Result of Compressive Strength of Control Sandcrete Blocks

The compressive strength of sandcrete blocks using a standard cement-to-sand mix ratio of 1:9 at curing ages of 7, 14, 21 and 28 days are given in Table 5. Table 5 shows the compressive strength of sandcrete blocks with 0% replacement which serves as the control. The results reveal that the compressive strength increases gradually from 2.59 N/mm^2 to $2.78N/mm^2$ for 7 days and 28 days. The increase is reasonable because sandcrete blocks harden and gains strength as it hydrates and also, Portland cement is a hydraulic cement which means that it sets and hardens due to chemical reaction with water.

The results obtained also do comply with the standard limit for compressive strength of sandcrete blocks according to Nigerian Industrial Standard (NIS 87:2007) which is $2.5N/mm^2$ to $3.45N/mm^2$.

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Table 5 Compressive Strength of Sandcrete Blocks (N/Mm^2) (0% Coarse Sand Replacement

fine: Coarse 94% : 6%	**7days**			**14days**			**21days**			**28days**		
Samples	A	B	C	A	B	C	A	B	C	A	B	C
Weight(kg)	19.3	18.6	18.9	19.5	19.4	19.1	19.1	19.4	19.2	19.6	19.1	19.4
Average Weight(Kg)	**18.93**			**19.33**			**19.23**			**19.37**		
Compressive Strength(N/mm^2)	2.67	2.59	2.50	2.69	2.62	2.53	2.73	2.66	2.57	2.79	2.71	2.62
Average Compressive Strength(N/mm^2)	**2.59**			**2.64**			**2.72**			**2.78**		

D. Result of Compressive Strength of Sandcrete Blocks Made With Coarse Aggregate (Coarse Sand)

The compressive strength of sandcrete blocks using a partially replaced quantity of coarse sand at the curing age of 7, 14, 21 and 28 days are given in Table 6 to Table 11.

Table 6 shows the compressive strength of sandcrete blocks with 2% Coarse Sand replacement. The results reveal that the compressive strength increases gradually from 2.70 N/mm^2 to 2.83N/mm^2 for 7 days and 28 days. The result was discovered to satisfy the standard limit for compressive strength of sandcrete blocks according to Nigerian Industrial Standard (NIS 87:2007) which is 2.5N/mm^2 to 3.45N/mm^2.

Table 7 reveals that the compressive strength results in 4% Coarse Sand replacement. The compressive strength increases from 2.78 N/mm^2 to 2.91 /mm^2 for 7 days to 28 days respectively It was observed that there was a great increase at this addition of 4% which makes it the most suitable.

Table 8 indicates that the compressive strength results in 6% Coarse Sand replacement. The compressive strength increases from 2.55 N/mm^2 to 2.71N/mm^2 for 7 days to 28 days respectively.

Table 9 shows that the compressive strength results in 8% Coarse Sand replacement. The compressive strength increases from 2.53 N/mm^2 to 2.69N/mm^2 for 7 days to 28 days respectively.

Table 10 reveals that the compressive strength results in 10% Coarse Sand replacement. The compressive strength increases from 2.52 N/mm^2 to 2.64N/mm^2 for 7 days to 28 days respectively.

Table 11 shows the result of the summary of strength development for different percentages of Coarse Sand replacement at ages 7, 14, 21 and 28 days.

From the results obtained, it could be concluded that the compressive strength of sandcrete blocks with 2%, 4%, 6% 8% and 10% Coarse Sand replacement satisfy the standard limit for compressive strength of sandcrete blocks according to Nigerian Industrial Standard (NIS 87:2007) which is 2.5N/mm^2 to 3.45N/mm^2

Table 6 Compressive Strength of Sandcrete Blocks (N/Mm^2) (2% Coarse Sand Replacement).

fine: Coarse 98% : 2%	**7days**			**14days**			**21days**			**28days**		
Samples	A	B	C	A	B	C	A	B	C	A	B	C
Weight(kg)	19.2	19.0	19.4	19.3	19.6	19.4	19.5	19.2	19.1	19.3	19.0	19.7
Average Weight(Kg)	**19.20**			**19.43**			**19.27**			**19.33**		
Compressive Strength(N/mm^2)	2.74	2.70	2.65	2.80	2.75	2.70	2.85	2.81	2.76	2.88	2.83	2.79
Average Compressive Strength(N/mm^2)	**2.70**			**2.75**			**2.81**			**2.83**		

Table 7 Compressive Strength of Sandcrete Blocks (N/Mm^2) (4% Coarse Sand Replacement).

fine: Coarse 96% : 4%	**7days**			**14days**			**21days**			**28days**		
Samples	A	B	C	A	B	C	A	B	C	A	B	C
Weight(kg)	19.4	18.9	19.4	19.3	19.4	19.2	19.4	19.2	19.2	19.8	19.4	19.5
Average Weight(Kg)	**19.23**			**19.30**			**19.27**			**19.57**		
Compressive Strength(N/mm^2)	2.81	2.74	2.79	2.87	2.80	2.84	2.91	2.84	2.88	2.94	2.87	2.91
Average Compressive Strength(N/mm^2)	**2.78**			**2.84**			**2.88**			**2.91**		

Table 8 Compressive Strength of Sandcrete blocks (N/mm^2) (6% Coarse Sand replacement).

fine : Coarse 96% : 4%	**7days**			**14days**			**21days**			**28days**		
Samples	A	B	C	A	B	C	A	B	C	A	B	C
Weight(kg)	19.1	18.8	18.4	19.2	19.2	18.9	19.2	19.5	19.2	19.2	19.2	19.6
Average Weight(Kg)	**18.77**			**19.10**			**19.30**			**19.33**		
Compressive Strength(N/mm^2)	2.52	2.62	2.52	2.57	2.57	2.67	2.71	2.61	2.61	2.66	2.76	2.65
Average Compressive Strength(N/mm^2)	**2.55**			**2.61**			**2.65**			**2.71**		

Table 9 Compressive Strength of Sandcrete blocks (N/mm^2) (8% Coarse Sand replacement).

fine : Coarse 98% : 2%	**7days**			**14days**			**21days**			**28days**		
Samples	A	B	C	A	B	C	A	B	C	A	B	C
Weight(kg)	18.8	19.0	18.8	19.1	19.4	19.2	19.7	19.2	19.4	19.1	19.1	19.0
Average Weight(Kg)	**18.87**			**19.23**			**19.43**			**19.67**		
Compressive Strength(N/mm^2)	2.37	2.59	2.52	2.67	2.59	2.44	2.39	2.54	2.62	2.46	2.70	2.62
Average Compressive Strength(N/mm^2)	**2.53**			**2.60**			**2.64**			**2.69**		

Table 10 Compressive Strength of Sandcrete blocks (N/mm^2) (10% Coarse Sand (replacement)

Cement : Sand 14% : 86%	**7days**			**14days**			**21days**			**28days**		
Samples	A	B	C	A	B	C	A	B	C	A	B	C
Weight(kg)	19.1	19.6	19.4	18.1	19.4	18.6	19.6	19.6	19.5	19.8	19.7	19.8
Average Weight(Kg)	**19.37**			**18.7**			**19.75**			**19.77**		
Compressive Strength(N/mm^2)	2.28	2.67	2.61	2.74	2.40	2.80	2.47	2.82	2.88	2.94	2.52	2.88
Average Compressive Strength(N/mm^2)	**2.52**			**2.58**			**2.56**			**2.64**		

Table 11 Summary of compressive strength of sandcrete blocks made with Coarse Sand (CS) as a partial replacement.

Coarse Sand %	**7 Days**	**14 Days**	**21 Days**	**28 Days**
0	2.59	2.64	2.72	2.78
2	**2.7**	**2.75**	**2.81**	**2.83**
4	2.78	2.84	2.88	2.91
6	2.55	2.61	2.65	2.71
8	2.53	2.6	2.64	2.69
10	**2.52**	**2.58**	**2.56**	**2.64**

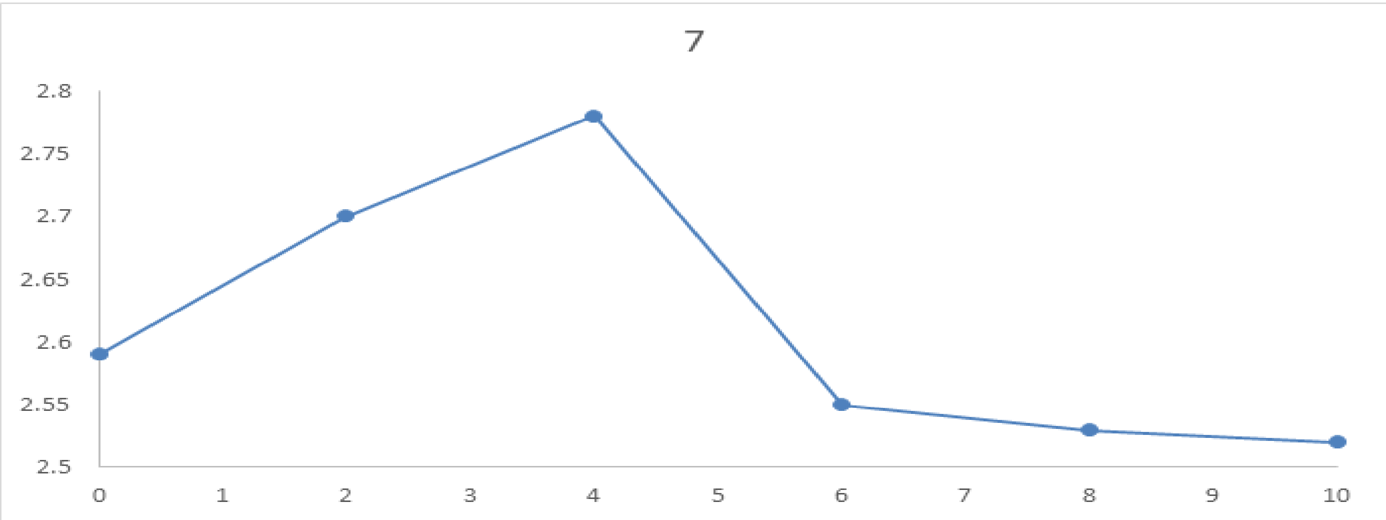

Fig 3 Effect of Coarse Sand replacement on the compressive strength of sandcrete blocks at age 7 days.

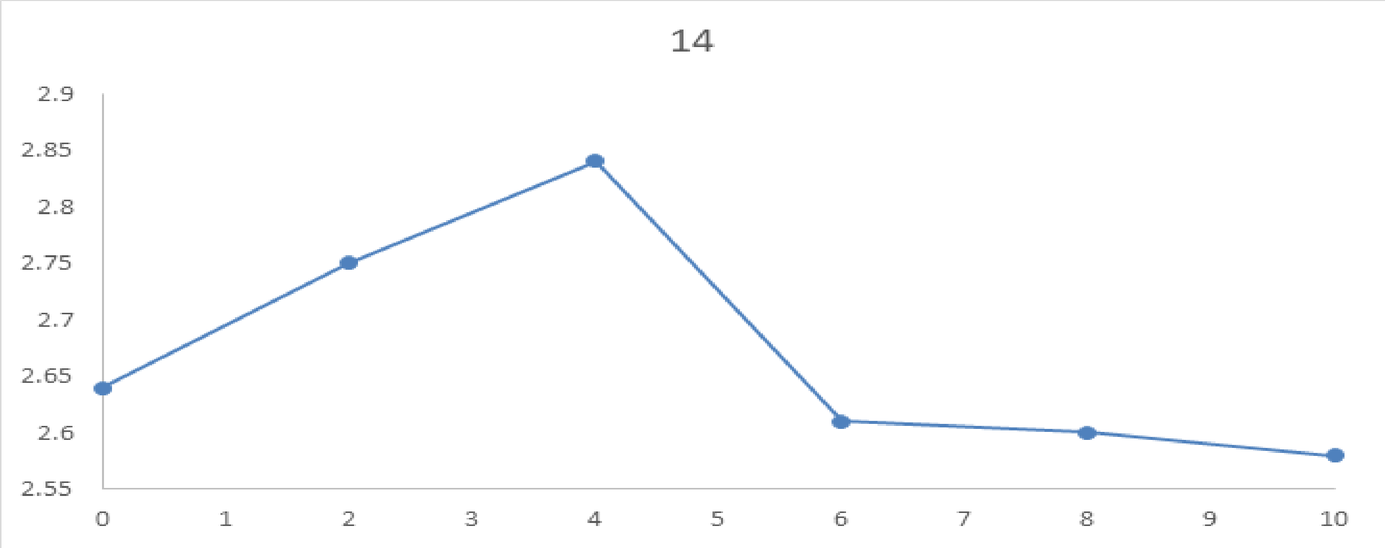

Fig 4 Effect of Coarse Sand Replacement on the compressive strength of sandcrete blocks at age 14 days.

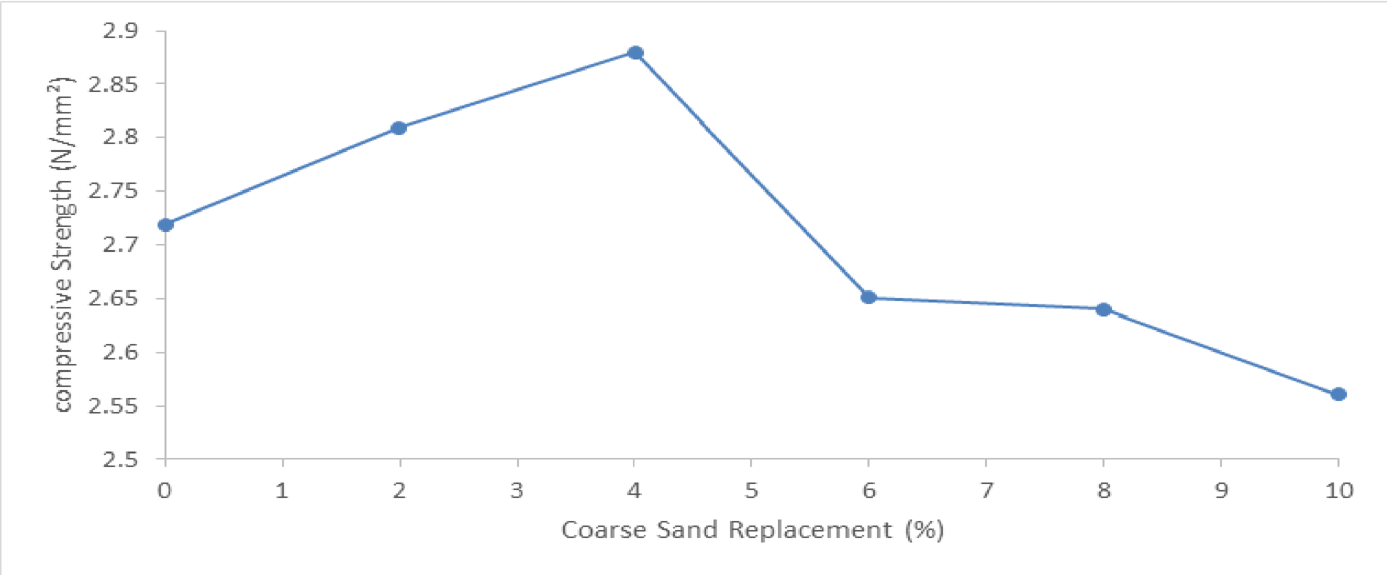

Fig 5 Effect of Coarse Sand (CS) replacement on the compressive strength of sandcrete blocks at age 21 days.

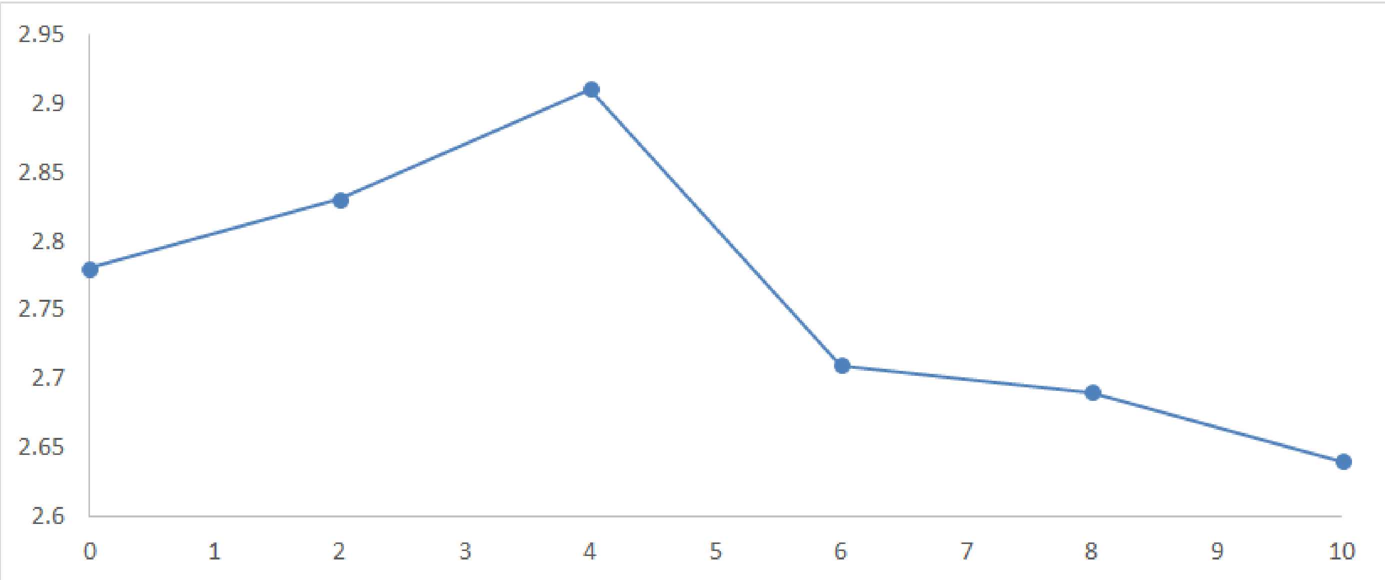

Fig 6 Effect of Coarse Sand (CS) replacement on the compressive strength of sandcrete blocks at age 28 days.

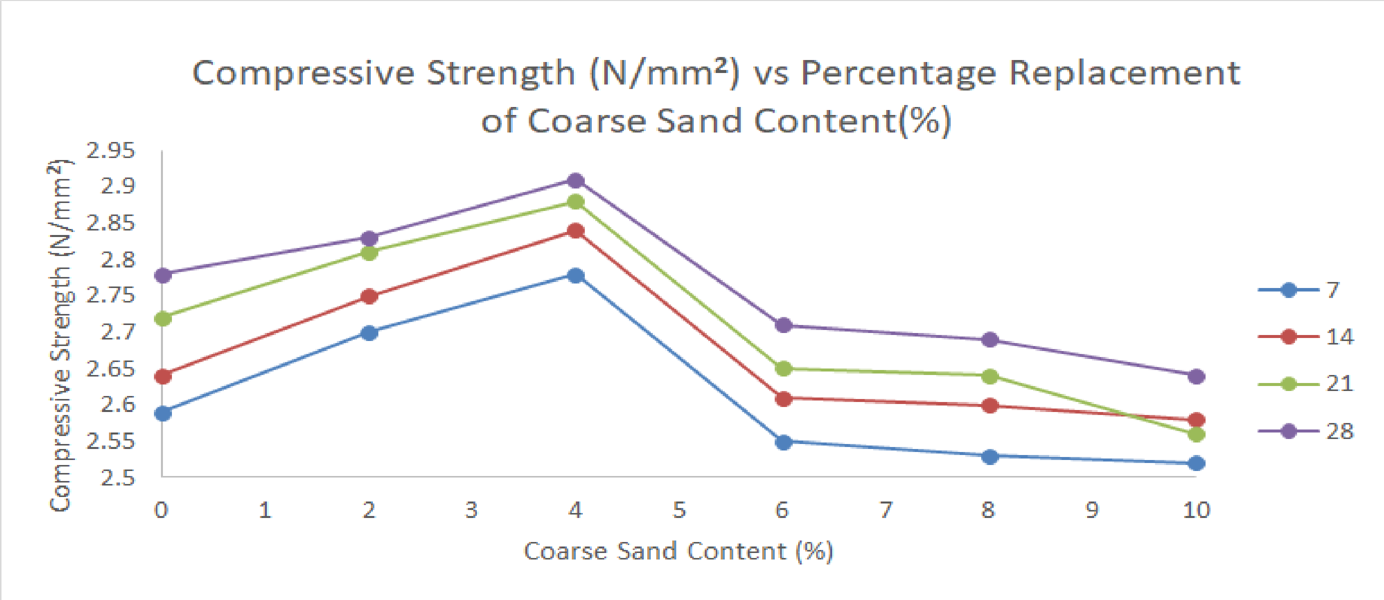

Fig 7 Strength development of Coarse Sand (CS) sandcrete block at 7, 14, 21 and 28 days.

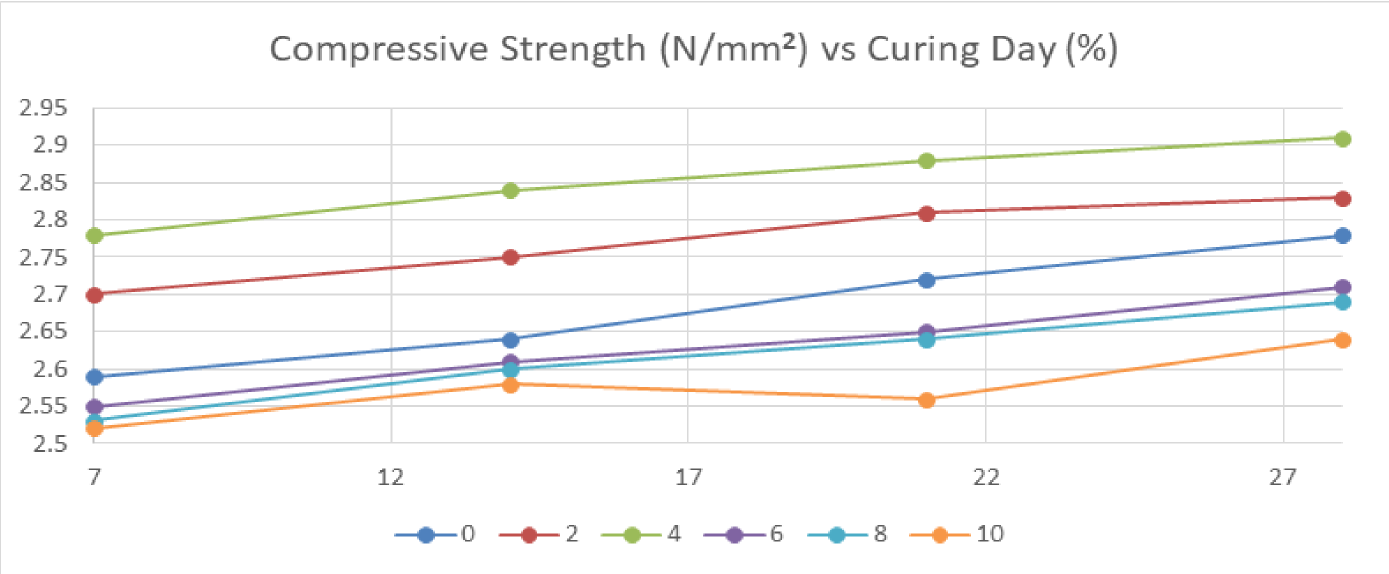

Fig 8 Strength development of Coarse Sand (CS) sandcrete block at 0, 2, 4, 6, 8, and 10 replacement for variation of curing days

E. Comparison of Cost Effectiveness of Sandcrete and Coarse Sand Blocks.

The quality and cost-effectiveness of construction materials employed in housing Development are among the major factors that determine the optimal delivery of housing projects in Nigeria (Akutu, 1983). Therefore, materials to be used for building construction must provide objective evidence of quality and cost-effectiveness in terms of functional requirements and low-income economy respectively. Given this, the search for low-cost material that is socially acceptable and economically available, at an acceptable quantity within the reach of an ordinary man becomes a Subject of continuous interest. The belief that the African region is full of raw materials suitable for local uses encourages this, yet the construction sector is not making Optimal use of them (Ramachandran, 1983). The most significant element of a house in housing development is the wall which is a component of many constituent materials. In most villages, mud and clay materials are still being used for wall making with their acceptability as the last alternative for the poor but, with some level of quality attendant problem (Nwanga, 2005), especially in an area of high flooding potential. Hence, many such houses are deprived of their social acceptability. However, some road construction workers sand individual house developers use the coarse aggregate as a base course for road work. (Journal of Chemical, Mechanical and Engineering Practice, Vol. 2 No. 3, December 2012 10) and landscape materials respectively. Geographically, Varghese (2008) recognizes parental materials from which coarse aggregate is generated are igneous rock and other types of rock. It is formed by tectonic activities of volcanic eruption, ejecting up to the terrestrial or the outer crust some molten magma that later solidifies into igneous rocks (Becksmann,1995). This deposit is usually used for concrete of high compressive strength in the Construction industry. There is no doubt, that the coarse aggregate (Coarse Sand) which in most cases undergoes no significant chemical change in its production is very good for walling units. This production would help to increase the availability of local building materials and in turn, would influence positively the cost of housing Development in Nigeria.

F. Determination of Cost of Sandcrete and Coarse Blocks for Comparison on Cost Effectiveness.

➢ *Sandcrete Blocks Cost Estimation.*

- *MATERIALS: Cement and Sand (1: 9) + Water*

✓ 1m^3 of Cement for Control = 38.53kg
✓ Then, cost/bag of cement = #1850.00
✓ Transportation = #80.00
✓ Loading / offloading = #15.00 / bag
✓ Total cost = #1945.00 /bag
✓ For 1m^{3}of cement for control = 0.7706bag x #1945.00 = #1498.82
✓ **Now for 6m^3 of sand**
✓ 1m^3 of sand for control = 289.44kg
✓ Then, cost/tone of sand = #1000.00
✓ For, 1m^3 of sand = 0.058tonne x #1000.00 = #58.00
✓ Now, for 6m^3 of sand = 6 x #58.00 = #348.00
✓ Water is 50% of cement which implies 0.5m^3 = #972.50
✓ Cost of Sandcrete (1: 9) ratio = # 1498.82 + #348.00 + #972 50 = #2819.32
✓ Then, add waste and Shrinkage at 5% and 10% respectively. i.e. 15% of #2819.32 = #422.90
✓ Total cost = #2819.32 + #422.90 = **# 3242.22**

- *Labour*

✓ Assumed hand molding = #400.00 / bag
✓ Then, for 0.7706bag = 0.7706 x #400.00 = #308.24
✓ Total cost of labour and materials = #3242.22 + #308.24 = #3550.46
✓ Thus, 1bag = 30blocks of 450 x225x 250 Specification
✓ Therefore, 0.7706bag = 0.7706 x 30 = 23.12blocks = 23blocks
✓ Hence, cost/block of (225mm) = #3550.46 / 23 = #154.34
✓ Therefore, each block of Sandcrete for control will cost = **# 154.34 (without profit)**

➢ *Coarse Sand Blocks (@ 4% Partial Replacement)*

- *Materials.*

✓ Cement, Sand and Coarse aggregate(1 : 7.6 : 0.4) =Cement (100%), Sand (96%), COARSE SAND (4%)
✓ Cost / m^3 of cement = #1498.82 **(established)**
✓ FOR COARSE SAND.
✓ Coarse Sand per 5tonne = #15000.00
✓ Then, for 0.4 part of coarse sand = #15000.00/5m^3 = # 3000.00 / m^3
✓ = # 3000.00 x 0.3 = #900.00
✓ Water quantity is constant at 50% of cement = 0.5m^3 = #972.5 **(established)**
✓ Therefore, cost of coarse sand block materials = # 1498.82 + #900.00 + #972.50 = #3371.32
✓ Then, add waste and bulk loss @ 5% and 10% of the total material cost respectively.
✓ 15% of #3371.32 = # 505.70
✓ Total = #3371.32 + #505.70 =**#3877.02**

- *Labour (Hand Moulding)*

✓ Each bag cost #400.00 for mixing and moulding
✓ Then, 0.7706bag = 0.7706 x 400 = #308.24 **(as established)**
✓ Thus, 1bag = 30blocks of 450 x225x 250 Specification
✓ Therefore, 0.7706bag = 0.7706 x 30 = 23.12blocks = 23blocks
✓ The total cost of labour and material = #3877.02 + #308.24 = #4185.26
✓ Hence, cost/block of (225mm) = #4185.26 / 30 = #139.51
✓ Therefore, each block of coarse sand material @ 4% partial replacement will cost = **#139.51(without profit).**

V. CONCLUSIONS AND RECOMMENDATION

➢ *Conclusions*

The following are the findings from the research work;

- The fine and sharp sand is "uniformly graded".
- The strength of the sandcrete block increases with the number of days of curing.
- The strength of the sandcrete block increases with an increase in the percentage of fine sand replaced with sharp sand. However, above 4% replacement in the percentage of fine sand, a noticeable decrease was observed.
- The optimum percentage of sharp sand for replacement of fine sand in sandcrete block is 4%.

➢ *Recommendation.*

Based on the conclusions made above, the following recommendations are made:

- Sharp sand addition of 4% is recommended for use in the production of sandcrete blocks to improve performance under environmental loading.
- Further investigation can also be conducted on the performance of sharp sand in Sandcrete Blocks using materials from other locations in Ogbomoso.

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