

THE EFFECT OF CURING ON THE STRENGTH OF SANDCRETE BLOCKS.

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CERTIFICATION

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DEDICATION

This work is specially dedicated to my late Dad, for his tremendous sacrifice paid even in distress. and also to my loving mom who is a great pillar in my life and wonderful family.

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ABSTRACT

One of the basic needs of man is housing. Over 90% of physical infrastructure in Nigeria are being constructed using sandcrete blocks making it a very important material in building construction. It is widely used in Nigeria, Ghana, and other African countries as load bearing and non-bearing walling units. For a long time in Nigeria, sandcrete blocks are manufactured in many parts of the country without any effort to satisfy local building requirements or good quality work. In the year 2000, and in an attempt to enhance the use of the best materials and manufacturing practice, the Standard Organization of Nigeria developed a reference document which prescribed the minimum requirements and uses of different kinds of sandcrete blocks. This study put into consideration the effects of curing on the compressive strength property of 150mm thick sandcrete blocks produced by commercial block industries in Benin metropolis of Nigeria. Commercial sandcrete blocks were randomly selected from three (3) block moulding sites, the curing practices and the mix ratio of the blocks gotten from the various sites were taken into account and was left for 28 days after which the compressive test was done on them. The mix ratio gotten from the sites were 1:12, 1:14 and 1:16. Also, in the structural Laboratory of the University of Benin, sandcrete blocks were moulded with the same mix ratio from the various sites as control and also to the standard 1:6 mix ratios and was cured for 28 days by watering every morning and evening up to the testing dates. The 28-day compressive test results were compared with those cured in the sites. The results gotten from site range from 0.303N/mm^2 to 0.763N/mm^2 , while those cured in the University Laboratory range from 0.425N/mm^2 to 0.875N/mm^2 . These results indicate the 28-day compressive strengths of blocks. The compressive strengths of all the blocks made from site and laboratory for mix ratios of 1:12, 1:14 and 1:16 were below the minimum requirements

of 2.8N/mm² by the British Standard BS 6073, although the block from the laboratory gave a higher value of compressive strength to that of the site for each corresponding mix ratio. The value gotten from the standard mix ratio (1:6) was 3.058N/mm² which was more than the minimum specification for sandcrete blocks. This study concludes that improper curing method and mix ratios are responsible for the poor quality of commercial sandcrete block made in Benin metropolis.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

One of the basic needs of man is housing. In many developing countries like Nigeria, there is a perpetual problem of accommodation and inadequate housing. A research showed that about seven million Nigerians have no accommodation. It is important to note that majority of housing units in Nigeria are constructed using sandcrete blocks, which has ordinary Portland cement as a basic constituent. In fact, twice as much sandcrete is used in building construction in Nigeria than the total of all other building materials. According to Neville and Brook (1990), sandcrete is a product of water, cement and sand. The growing demand for sandcrete blocks has brought pressure on the supply of the raw materials and also raised the issues of sustainability of raw materials and affordability of the built shelter. In order to minimize the quantity of the materials used in producing a block unit, blocks are made to incorporate different sizes of rectangular block shapes. The quality of blocks produced differs from each manufacturer, due to the different methods of production shape and concrete mix design used in the production and the properties of the constituent materials. The word sandcrete has no standard definition. What most workers have done was to define it in a way to suit their own purpose. The word for it in some local dialect means brick earth and the name 'sandcrete' is merely a translation.

The strength characteristics of sandcrete, are influenced by a variety of factors whose effects are not sufficiently understood to permit accurate results, particularly under SFD test condition.

It has been found that, the mixing ratio of sand and cement influence its strength characteristics, the time of mixing sandcrete with cement, does influence its strength characteristics. Also, the time lapse between mixing and compaction, has been found to affect its strength. A time lag will not only reduce the hardening effect of cement, but will require extra energy to breakdown the aggregation of particles to achieve the desired density. An increase in strength with age and curing temperature, has also been reported for cement stabilized sandcrete, but this depends on the nature and texture of sand and the percentage of cement added. Vallenger (1980) observed that the compressive strength of sandcrete materials, increases with increased cement content.

However, we should also understand that strength of sandcrete is not a function of its life span and durability. Sandcrete blocks comprise of natural sand, water and binder. Cement, as a binder, is the most expensive raw material in the production of sandcrete blocks. This has necessitated producers of sandcrete blocks to produce blocks with low Ordinary Portland Cement content that will be affordable for people and with much gain. The poverty level amongst West African Countries and particularly Nigerian, has made these blocks widely acceptable among the populace, so as to minimize the cost of construction works and affordability.

The improper use of these blocks, leads to micro cracks on the walls after construction. The use of other cheaper local materials as stabilizer and admixtures, will greatly enhance the production of sandcrete blocks with the desired properties at low cost. It will also drastically reduce the cost of production and consequently the cost of construction works. Block has a composition of usually one is to six (1:6) mix of cement and sharp sand, with the barest minimum of water mixture, and in some cases admixture, that are mixed, moulded and dried naturally.

NIS (2000) defines sandcrete block as a composite material made up of cement, sand and water, moulded into different sizes. Blocks can therefore, be made either in solid and hollow rectangular types, or decorative and perforated in different designs, patterns, shapes, sizes and types. Sandcrete mix design involves selecting the correct proportions of cement, fine sand and water to produce sandcrete blocks having the specified properties.

Various mix design methods, have some limitations. Resources are sometimes being wasted in order to get the right mix proportions. Basically, the problem of designing a sandcrete mix consists of selecting the correct proportions of cement, fine sharp sand and water to produce blocks having the specified properties.

The general approach to mixture proportioning, involves identifying a starting set of mixture proportions, performing one or more trial batches, and adjusting the proportions in subsequent trial batches until all criteria are satisfied. This reveals that time and energy used in order to get the appropriate mix proportions may be enormous. And the method used might not be cost effective. The earliest method of mix designs was by historical records. As at then, there was no means to achieve an efficient optimized mixture for a given criterion (FHWA, 2007). This was followed by conventional methods of designing sandcrete mixtures which were based on laid down rules, design standard and codes of practice. These methods took care of the shortcoming of the historical methods. Despite all the advantages of the conventional method, the methods cannot be used to achieve an efficiently optimized mixture for a given criterion.

1.2 Statement of the Problem

Structural failure and building collapse are common phenomena in modern Nigeria. As the pressure on housing increases with the population, the need to procure cheaper alternatives and improve on delivery time for construction are bearing heavily on quality. This is more

evident in the erection of the new buildings. Since most of the modern buildings are framed in reinforced concrete, the low compressive strength of the blocks used for such buildings do not cause immediate failure. However, when the structures are exposed to extra loading and use, they start to fail. Cracks, deflections, excessive moisture penetration and low bearing capacity are the bane of these structures erected with the sandcrete blocks. This study was carried out to see how the average strength of sandcrete blocks produced in the Benin area can be increased primarily by curing.

1.3 Aim and Objectives

The aim of this is to show how the curing of sandcrete blocks can affect the compressive strength of sandcrete blocks produced manually compared to those produced by block moulding industries, using Benin metropolis as a case study.

The main objectives of this study are:

1. To ascertain the different kind of curing method, procedures used in Benin City and to check their suitability in production of sandcrete blocks.
2. To compare the compressive strength of sandcrete block produced from the various block industries with the standard values specified by Nigerian Industrial Standard (NIS) and other Civil Engineering bodies.
3. To determine the curing method best suitable for producing sandcrete blocks.

1.4 Scope of the Work

The scope of this study is to examine the experimental analysis of sandcrete block production by using different curing methods used by different block industries in Benin City.

Compressive strength experiments are used in analyzing the effect of the samples to civil engineering work by using sandcrete block as a test measure.

1.5 Justification of Study

As a result of the increasing cost of block production, and building failures due to cracks, an experimental research is necessary to examine the different curing methods used in the production of sandcrete blocks. The compressive strength of sandcrete blocks obtained is used to ascertain the best curing methods, which can be used for other construction purposes.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Housing is one of the requirements of man; the ambition of all people to own or have access to decent shelter is not a luxury but a necessity. Different Materials are used around the globe for housing especially for walling (W.O. Ajagbe et al, 2013).

Freestanding walls and building structures with load bearing walls are common in Nigeria because they are simple to construct and easily affordable. Sandcrete skin panels and blocks can sometimes be used to provide aesthetic value to buildings and also, when adequately prepared, to control moisture infiltration and wind action. This utility value of Sandcrete in comparison to its cost and its adaptability to climatic factors is responsible for its wide application; most especially in small to medium buildings in countries within tropical rainforests where a considerable amount of precipitation and high average temperatures are predominant (O. Alohan, 2003).

It plays critical role in a nation's economy such as Nigerian economy because of the transient trend in national growth. The rapid growth in the country's economy and population requires additional physical infrastructures to accommodate additional various component of the Gross National Product (GDP). These physical infrastructures include residential and commercial buildings, agricultural and health facilities to mention but a few. On the other hand, it requires the integration of engineering, project, and production management techniques. Over 90% of physical infrastructures in Nigeria are being constructed using sandcrete blocks (Baiden and Tuuli, 2004). This makes sandcrete blocks a very important material in building construction.

It is widely used in Nigeria, Ghana, and other African countries as load bearing and non-load bearing walling units. The British Standard 6073(1981) defines a block as a masonry unit of larger size in all dimensions than specified for bricks, but no dimension should exceed 650mm nor should the height exceed either its length or six times its thickness.

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

Many Years after the introduction of the standards, variations in quality still exist in the quality of blocks being produced by these manufacturers. According to the NIS document, chance and assignable variations are two factors known to cause variations in the quality of sandcrete blocks. Chance variations are variations in quality as a result of environmental influences such as temperature, radiation, noise etc. The effects of chance variations are usually unnoticed. Assignable variations on the other hand, are the sources of variation that can be attributed to man, machine, raw materials and method.

Blocks are those building unit used in the construction of wall and partitions. They are of sizes and weights that can be easily handled by the bricklayer, with the facing surface layer than that of a brick but conveniently dimensioned. Sandcrete blocks are available for the construction of load bearing and non-load bearing structures (Hodge, 1971). Load bearing

blocks must conform to building by- law regarding their crushing and to the amount of solid mineral contained in section.

Sandcrete blocks are the most prominent of the concrete masonry units in the building industry today especially in the construction of residential, industrial and commercial buildings (Ejeh, 1982). They could be used as external walls (i.e., 460 mm thick blocks) or as partition walls (the 150 mm thick blocks.). The later (150 mm) is usually non-load bearing. They are made from a cement/sand mix usually 1 part of cement to 6 or 8 parts of sand (1:6 or 1:8) with a water/cement ratio of between 50 and 75% (B.S. 3921: 1969).

Historically, most concrete masonry units are manufactured on the local level and industry standards are not always adhered to (Ewa and Ukpata 2013, Aiyewalehinmi and Tanimola 2013, Mahmoud et al 2010, Abdullahi 2005). Variations in shape, size and surface texture are common features. There is no complete standardization of sizes in the industry for sandcrete blocks and sizes must be checked in each locality. Cement stabilized laterite and cement stabilized sand (Sandcrete) increases in strength with cement content and that at high cement content, the granules of sandcrete blocks behave elastically (Adepegba, 1975). It was also observed that the most economic range of the use of cement stabilized sand lies between 0-10 percent cement content by weight (Ejeh 1982)

Sandcrete block is a building material made from Portland cement and sharp sand. It is similar to, but weaker than mortar, and its mix ratio is circa 1:6. Sandcrete is usually used as hollow rectangular blocks, often 45 cm wide, 15 cm thick, and 30 cm with hollows that run from top to bottom and occupy around one third of the volume of the block. The blocks can be joined together with mortar. The final compressive strength of sandcrete can be as high as 4.6 N/mm²,

which is much less than that concrete's 40 N/mm^2 (Wikipedia on sandcrete). Sandcrete is unsuitable for load-bearing columns, and is mainly used for walls, or for foundations if no suitable alternative is available. As a material for walls, its strength is less than that of fired clay bricks, but sandcrete is considerably cheaper. Sandcrete block is the main building material for walls of single-storey buildings (such as houses and schools) in countries such as Ghana and Nigeria (Wikipedia on sandcrete). Measured strengths of commercially available sandcrete blocks in Nigeria were found to be between 0.5 and 1 N/mm^2 , which is well below the 3.5 N/mm^2 that is legally required. This low strength may be due to the need of the manufacturers to keep the price low, and since the main cost-factor is the Portland cement, manufacturers reduce it, which results in a block that behaves more like loose sand. Addition of coarse aggregates has been tried, since this is a cheap way to increase compressive strength. But since the cement content of sandcrete is small, so also is the amount of water that is added to the sand/cement mix to cure it. Adding more solid materials makes the mix much less fluid, and more difficult to cast into blocks.

Sandcrete blocks also help in the task of transferring the actual load from the overlaying structural element to the foundation. thus, the load bearing wall are those walls acting as supports for the whole structure and transmit the weight to the ground surface underneath it for stability (NIS:2000). Sandcrete blocks possess an intrinsic low compressive strength, making them susceptible to any tragedy such as seismic activity. Previous researches show dismal results in the production of sandcrete blocks which had exhibited compressive strength far below the standard requirement for the construction of houses but more viable option would be the use of bricks in the construction of houses. Sandcrete blocks have been used for a long time throughout the country (NIS:2000). The importance of the blocks as part of local building materials cannot be over emphasized in building and construction industry.

However, it is observed that clay suitable for making high strength bricks are not available in every place in Nigeria and the clay bricks produced and presently used in construction, are not uniform in quality. The rapid changes in the use of brick to block in Nigeria have encouraged the investigations into the use of sandcrete blocks to be more elaborate. It was also realised that in some places in Ondo and Ekiti States with rivers, it is easier to obtain river sand rather than clay for making blocks (oyelade O.A. 2011). Also in Minna communities, sand is easily obtained from borrow pits and riverbeds situated in the environment which enhance the use of sand for block making (Abdullahi, M. 2005).

In the hardened state, sandcrete has a high compressive stress and this strength increase with density. The range of minimum strength specified by (NIS, 2007), is between 2.5N/mm^2 to 3.45N/mm^2 . According to (Abdullahi, 2005) the quality of sandcrete blocks, however, is inconsistent due to the different production methods employed and the properties of constituent materials. He studied the compressive strength of sandcrete blocks produced in some parts of Minna, Niger State, Nigeria and discovered that they were below the minimum specified by NIS. (Uzoamaka 1977a) found that the crushing strength of sandcrete blocks, increases with decreasing specific surface of sand and that curing of block by water sprinkling enhances their strength. (Oyetola and Abdullahi, 2006) studied the possibility of using rice husk ash (RHA) in the production of sandcrete blocks and reported that the optimum water/cement + rice husk ash (RHA) ratio increases with rice husk ash contents and that up to 40% RHA could be added as partial replacement for cement without any significant change in compressive strength. Compressive strength is influenced by the level of quality control employed (et al 2008) good selection of materials and adequate curing method among others (Abdullahi, 2005). The NIS specified two types of blocks, namely types A (load bearing) and type B (non-load bearing), and these blocks can also be solid or hollow.

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. Originally, a decorative block was understood to be a solid block with decorative textured faces used to provide an attractive appearance and light, without need for burglar-proofing or any kind of louvers, shutters as well as to provide permanent ventilation without using ventilation blocks (Wikipedia on types of sandcrete block).

The frequent failure of building in Nigeria is a concern to all stakeholders. In the past, incessant building failures resulting in the loss of lives and properties in Nigeria have been reported (fakere et al, 2012). The global concerns for sudden collapse of building across the world, and in Nigeria in particular demand that materials used for construction of building meet minimum requirement. In some cases, even though the building has not totally collapsed, the aesthetics value is lost to cracks and other defects. Parts of this problem is due to the poor quality of sandcrete blocks used as walling units (fakere et al, 2012). Sandcrete block is a common building material used in Nigeria and sub-Sahara Africa, and accounts for more than 60% of material in most building (fakere et al, 2012).

The most essential and expensive constituent of sandcrete block, is cement; to minimise cost and maximise profit, commercial producers of these blocks reduce the quantity of cement needed to give acceptable quality required by various standards. sandcrete blocks are the most widely used walling unit in Nigeria, accounting for 90% of houses (Baiden & Tuuli 2004). For a long time in Nigeria, sandcrete blocks have continued

to be manufactured in many parts of the country without effort to satisfy local and building requirements or quality

2.2 PORTLAND CEMENT

Portland cement is a modern type of cement which is obtained by intimately mixing together calcareous materials (such as limestone or chalk), and argillaceous, or other silica-, alumina-, and iron oxide- bearing materials found as clay or shale, burning them at a clinkering temperature and grinding the resulting clinker. This definition is on the basis of the American Standards, Original British and new European standards. No material other than gypsum, water and grinding aids may be added after burning. Modern cement known as Portland cement was patented by Joseph Aspdin, a Leeds builder in 1824. (Neville et.al, 2010). The mixing and grinding of the raw materials can be done in water or in a dry condition, hence, the names wet and dry process. This mixture is fed into a slightly inclined rotary kiln, sometimes (in the wet process) as large as 7m (23ft) in diameter and 230m(750ft) long. The mixture is fed at the upper end while pulverized coal (or other source of heat e.g., gas) is blown in by an air blast at the lower end of the kiln where the temperature may reach up to 1500⁰ (2750⁰F), as the raw materials move down the kiln, any moisture goes off and CO₂ is liberated from the calcium carbonate. The dry material then undergoes a series of chemical reactions and finally in the hottest part of the kiln, 20 to 30 percent of the material becomes liquid and lime, while silica and alumina recombine. The mass fuses into balls 3 to 25mm in diameter known as clinker. The clinker drops into coolers, become very hard and is inter ground with gypsum in order to prevent flash-setting of the cement. Cement has as many as 1.1×10^{12} particles per kilogram.

Portland cement is a vital constituent of cement. However, little or no information is available to majority of users of Portland cement on the strength grade. This ignorance is considered mostly by those at the marketing and distribution end as bliss. Three (3) grades of Portland cement are currently available in the market worldwide; the 32.5, the 42.5 and the 52.5. These designations are called the strength classes and sometimes a further sub-class is indicated by attaching “R” or “N” to the figure (i.e., 32.5N or 42.5R or 52.5R) where “R” indicates that the cement will attain rapid strength and “N” indicates that the cement will attain normal strength. There have been however, recent reports insinuating that the use of 32.5N grade cement causes buildings to collapse or that sandcrete blocks made with the same cement causes buildings to fail.

Four major compounds are regarded as the constituents of cement; these are listed in Table 2.1 below along with their abbreviated symbols used by cement chemists. (Neville et al, 2010)

Table 2.1: Main Compounds in Portland cement (Neville and Brooks, 2010)

S/N	NAME OF COMPOUND	OXIDE COMPOSITION	ABBREVIATION
1	Tricalcium silicate	$3C_aO \cdot S_iO_2$	C_3S
2	Dicalcium silicate	$2C_aO \cdot S_iO_2$	C_2S
3	Tricalcium	$3C_aO \cdot Al_2O_3$	C_3A
4	Tetracalcium Aluminoferrite	$4C_aO \cdot Al_2O_3 \cdot Fe_2O_3$	C_4Af

Table 2.2: Examples of raw materials for Portland cement manufacture.

Calcium	Silicon	Aluminum	Iron
Limestone	Clay	Clay	Clay
Marl	Marl	Shale	Iron ore
Calcite	Sand	Fly ash	Mill scale
Aragonite	Shale	Aluminum ore refuse	Shale
Shale	Fly ash		Blast furnace dust
Sea shells	Rice hull ash		
Cement dust	Kiln Slag		

Source:(Taylor, 1997)

2.3 BASIC CHARACTERISTICS OF PORTLAND CEMENT

I. HYDRATION

Hydration in concrete is defined as the chemical reaction between cement and water (Khurmi et.al, 2007). The product of this reaction is a very hard and strong binding medium for the

aggregate particles in concrete. In the presence of water, the silicates and aluminates of Portland cement form products of hydration or hydrates which in time produce a firm and hard mass (Neville et.al, 2010). The rate of setting and hardening of cement, and also the rate of evolution of heat and resistance to sulphate attack are affected by the different proportions of different cement compounds. The sum of the percentage of tri-calcium silicate and di-calcium silicate for Portland cement varies from 70% to 80% (Khurmi et.al, 2007).

II. FINENESS

The rate of hydration depends on the sizes of the cement particles and for rapid development of strength, a high fineness is necessary (Neville et.al, 2010). Since hydration starts at the surface area of the cement particles, it is the total surface area of cement that represents the material available for hydration and as such fineness is a vital property of cement. It follows that for a more finely ground cement, the rate of hydration would be higher than that of a coarser cement. For quality control purposes in the cement industry, the fineness is easily determined as the residue on standard sieves such as No. 200 mesh (75) and No. 325 mesh (45). It is generally agreed that cement particles larger than 45 may never hydrate completely (Kumar Mehta et.al, 2006).

III. STIFFENING, SETTING AND HARDENING OF CEMENT

The physical aspects of an ongoing process of cement hydration are explained by (Kumar Mehta et.al, 2006) as thus;

A. STIFFENING

This is the loss of consistency by the plastic cement paste and is associated with the slump loss phenomenon in concrete. It is the free water in a cement paste that is responsible for the

plasticity of cement. The gradual loss of free water from the system as a result of the formation of hydration products, surface absorption by poorly crystalline products such as ettringite and C-S-H, the evaporation causes the paste to stiffen and finally to set and harden.

B. SETTING

The term “setting” refers to the solidification of the plastic cement paste. The beginning of solidification is called the “initial set” which marks the point in time when the paste has become unworkable. The time taken to solidify completely marks the “final set” which should not be too long in order to avoid delays in the construction process.

C. HARDENING

This refers to the phenomenon of strength gain with time. The composition of the cement, temperature of the surroundings, moisture and particle size of the cement particles all have impacts on the hardening of the cement.

2.4 TYPES OF PORTLAND CEMENT

The ASTM has designated five types of Portland cement, designated as types I to V. Physically and chemically, the types differ primarily in their content of C_3A and also in their fineness. In terms of performance, they differ primarily in the rate of early hydration and in their ability to resist sulphate attack. The general characteristics of these types are listed in the table 2.2 below.

Table 2.3: General features of the main types of Portland cement

(from iti.northwestern.edu)

S/N	TYPE	CLASSIFICATION	CHARACTERISTICS	APPLICATIONS
1	Type I	General Purpose	Fairly high C ₂ S content for good early strength development.	General construction (mostly buildings, bridges, pavements, precast units, etc.)
2	Type II	Moderate sulphate resistance.	Low C ₃ A content (8%)	Structures exposed to soil or water containing sulphate ions.
3	Type III	High early strength	Ground more finely, may have slightly more C ₂ S	Rapid construction, cold weather concreting.
4	Type IV	Low heat of hydration (Slow reacting)	Low content of C ₃ S (50%) and C ₃ A	Massive structures such as dams (Now raw).
5	Type V	High sulphate Resistance	Very low C ₃ A content (5%)	Structures exposed to high levels of sulphate ions.
6	White	White colour	No C ₄ AF, low M _g O	Decorative (otherwise has properties similar to type I)

The differences between these Cements are rather subtle. All five types contain about 75% calcium silicate minerals and the properties of mature concrete made with all five are quite similar. Thus, these five types are often described by the term “Ordinary Portland Cement”, or “OPC”.

There is little difference between type I and type II cement, and it is common to see cement meeting both designations labeled as “Type I/II”. Type II and V OPC are designed to be resistant to sulphate attack. Sulphate attack is an important phenomenon that can cause severe damage to concrete structures. It is a chemical reaction between the hydration products of C_3A and sulphate ions that enter the concrete from the outside environment. Type III cement is designed to develop early strength more quickly than type I while type IV is designed to release heat more slowly than type I. white Portland cement (WPC) is made with raw ingredients that are low in iron and magnesium, the elements that give cement its grey colour. (iti.northwestern.edu)

2.5 AGGREGATES

Aggregates are particles of random shape which occur naturally as sand, gravel, granite, boulders, crushed rocks, stones or rocks that can be crushed into particles. They are mineral particles which have rocks their mineral origin unless otherwise specified. (Akinyemi, 2005)

Aggregates are inert mineral materials used for the manufacture of mortars and concrete (Khurmi, et.al, 2007). According to Indian standards (Is: 383-1970), a good aggregate for concrete construction should be sufficiently strong, chemically inert, sufficiently hard and durable.

The quality of aggregates used in the production of concrete is of great importance production of concrete is of great importance because approximately three-quarter of the volume of

concrete is occupied by aggregates. The aggregates limit the strength of the cement and the properties of the aggregates affect the durability and structural performance of the concrete. Aggregate characteristics that are significant for making concrete include porosity, grading or size distribution, moisture absorption, shape and surface texture, crushing strength, elastic modulus and the type of deleterious substances present.

2.6 TYPES OF AGGREGATES

There are various methods of classifying aggregates but the size classification would be applied for the purpose of this research work.

2.6.1 COARSE AGGREGATES

This term is used to describe particles larger than 4.75mm (retained on No.4 sieve). Typically, coarse aggregates contain particles in the size range from 4.75mm. It may be crushed gravel or stone.

2.6.2 FINE AGGREGATES

This term is used to describe particles smaller than 4.75mm. Typically, the particles contain particles in the size range 75 (No. 200 sieve) to 4.75mm. According to the BS EN 1034-2: 2002 as recorded by (Manning et.al, 2004), fine aggregates for other uses including concrete, is a material passing the 4mm sieve. Natural fine is distinguished from manufactured fine aggregate in that the manufactured aggregate is crushed and screened to produce the required sizes and natural aggregates are only screened to produce the required sizes.

2.7 CHARACTERISTICS OF AGGREGATES

The basic characteristics of aggregates have a considerable influence on the mix proportions and economy of concrete. For example, the aggregates of rounded shape (river or sea shore

gravel) have minimum voids. This gives a minimum ratio of surface area to the volume thus requiring minimum cement paste to make a good concrete.

Table 2.4: particle shape classification of aggregates with examples (From Neville & Brooks, 2010)

S/N	CLASSIFICATION	DESCRIPTION	EXAMPLES
1	Rounded	Fully water-worn completely shaped by attrition	River or sea-shore gravely desert and wind-blown sand.
2	Irregular	Naturally, irregular or partly shape by attrition and having rounded edges	Other gravels, land or dug flint.
3	Flaky	Materials of which the thickness is small relative to the other two dimensions	Laminated rock.
4	Angular	Possessing well defined edges formed at the intersection of roughly planar faces	Crushed rock of all types, talus crushed slag.
5	Elongated	Materials usually angular in which the length is considerably larger than the other two dimensions	—

6	Flaky and elongated	Materials having the length considerably larger than the width and the width considerably larger than the thickness.	—
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2.8 QUARRY DUST

Quarry dust or manufactured sand is produced while blasting, crushing and screening coarse aggregates. Quarry dust has rough, sharp and angular particles and as such causes a gain in strength due to a better interlock and a concomitant loss in workability. The use of quarry dust sometimes causes an increase in the quantity of cement required to maintain workability. Manufactured sand otherwise known as quarry fines consist of a graded mix of coarse sand, medium sand and fine sand sized particles, including clay/silt fraction otherwise known as filler grade. In the U.S.A, limestone and granite account for 86% of the rock used to make manufacture sand with the remainder made from basalt, dolomite, sandstone and quartzite (Ahn and Fowler, 2001).

Manufactured sand is increasing becoming more accepted as an alternative to natural sand where the natural sources are becoming less available due to resource being depleted because new deposits are being harder to obtain and the need to make use of ever-growing stock piles of quarry fines (Manning et.al, 2004). Various rock types produce different types or different qualities of quarry dusts due to the inclusion of their fresh minerals. Also, it has no uniformity and similarity to river sand. Although now it is used for road works and manufacture of cement bricks, the construction industry is afraid to use quarry dust for concrete or such strong

constructions due to a high percentage of minerals other than quartz. Therefore, detailed studies on various quarry dusts are needed to find out their suitability.

Properties of quarry dust mainly depend on the properties of the parent rock such as chemical and mineralogical composition, physical and chemical stability, petrographic characteristics, specific gravity, hardness, strength, pore structure and colour. As far as quarry dust quality is concerned, the most important property is the mineralogical composition.

Engineering research carried out by various Scientist and Engineers have predicted that 5% content by mass of mica in sand reduces the 28 days strength of concrete by about 15% even when the water/cement ratio was kept constant. Muscovite mica is much more harmful than biotite mica (Jayawardena et.al, 2006). In their research, they revealed that hornblende biotite gneiss, migmatite and migmatite gneiss showed mica percentages higher than 5% (5%-20%). Mica percentages in charnockite and granitic gneiss are suitable rocks that can be crushed and used as fine aggregates in concrete.

Sulphide minerals such as pyrites and marcasite react with water and oxygen in the air to form a ferrous sulphate which subsequently decomposes to form a hydroxide. This hydroxide reacts with calcium aluminates in the cement and may form sulphuric acid which can attack the hydrated cement paste (Neville et.al, 2010).

2.9 WATER

Water is used in the production of concrete to mix the constituent materials to form a paste and the quality of water used in the mixing of the concrete directly affects the quality of the concrete. The strength of the concrete to be produced is also fraction of the quality of water used. Impurities present in the water affects the setting of the cement, and may adversely affect the strength of the concrete or cause of staining of the concrete. This may also cause

the corrosion of reinforcements. The quality of water to be used in the making of concrete should be fit for drinking (Neville et.al, 2010).

The water used in concrete in addition to reacting with the cement and causing it to set and harden, also facilitates mixing, placing and compaction of the fresh concrete (Omorieg, 2002). It is also used for curing purposes. If the quality of water is too small, it produces a dry mix and the cement in the concrete would not be properly hydrated hence, resulting in a low strength concrete because of the binding medium for the aggregates.

On the other hand, if the quantity of water used in the production of concrete is too high, bleeding of the concrete occurs and because of the excess water, segregation of the constituent materials also occurs. The presence of algae in mixing water causes air entrainment with a consequent loss of concrete strength. It should also be noted that algae may be present on the aggregates in which case, the bond between the aggregates and the cement paste is weakened.

2.10 SANDCRETE BLOCK MIX DESIGN

The coarse aggregates most employed in concrete block production are those that pass through a 3/8 in (9.5 mm) sieve and are retained by a number 4 (4.8 mm) sieve. Preferably, the aggregate particles' shape must be cubic, which allows use of larger amounts in concrete mixtures without altering the block's surface texture. To ensure adequate cohesion of the mix, the fine aggregate (or mixture of fine aggregates) must have a fineness modulus of 2.20 to 2.80 and the percentage of fine aggregate that passes through a number 50 (0.3 mm) sieve must be between 25 and 35 %. The proportion of coarse aggregate (with respect to total aggregates) should be within a range of 20 to 40 %. Moreover, the exact proportion must be defined experimentally, taking into account both the surface texture and cohesion of the concrete. This should be done by molding 2x4 in (5x10 cm) specimens composed of a 1:9

(cement: aggregate) mixture with different coarse aggregate: total aggregate ratios varying from 10 to 50 %, by 10 % intervals. The most suitable ratio is that which allows the mixture to satisfy requirements of cohesion and texture, but also that which contains the largest possible amount of coarse aggregate. In the industrial market, surface texture is a characteristic often influenced by consumer perception, although there is a tendency to produce coarser textures for structural blocks – especially for those with elevated compressive strength ($F_{bk} > 1305 \text{ psi} - 9.0 \text{ N/mm}^2$) – and finer textures for cladding blocks.

As mentioned above, in addition to evaluating the texture of the mixtures, cohesion tests must also be carried out (following the procedure presented below). With respect to mixture cohesion, the smaller the amount of cement in the mixture, the less cohesive it will be.

Mixtures with small amounts of cement are involved in the production of blocks used for cladding. Hence, following the determination of the ideal proportions of coarse and fine aggregates using a cement: aggregate ratio of 1:9, it is recommended that more tests be performed on mixtures with lower ratios (1:13 to 1:15) to evaluate cohesion in these critical cases. It is worth emphasizing that the density value determined for the molding of the specimens will greatly influence both their texture and cohesion. For this reason, the present method refers to a density of 131.09 lb/ft^3 (2100 kg/m^3), which is very close to the average density of concrete blocks obtained with the use of the best vibro compression machines available

Cement:		MATERIALS		
Aggregate Ratio				

	Cement	Coarse Aggregate	Coarse sand	Fine sand
1:11	1.00	3.30	3.17	2.53
1:9	1.00	2.70	4.23	2.07
1:7	1.00	2.10	3.27	1.61

2.11 TYPES OF SANDCRETE BLOCKS

Types of sandcrete blocks and their usage

(Work size (mm) Length x Height x Thickness)

1. Solid Blocks 450 x 225 x100 - For non-load bearing and partition walls.
2. Hollow 450 x 225 x 113 25 For non-load bearing and partition walls.
3. Hollow 450 x 225 x 150 37.50 For load bearing walls.
4. Hollow 450 x 225 x 225 50.00 For load bearing walls

Source: NIS 587: 2007

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

2.12 PROPERTY OF SANDCRETE BLOCK

STRENGTH

Strength is the most commonly measured property of sandcrete block and is often used as the basis for assessing SANDCRETE block quality. This is partly because strength measurement gives a direct indication of concrete's ability to resist loads and partly because strength tests are relatively easy to conduct. The age at which a given strength is required will vary depending on the need. The rate at which strength development will also influence the risk of cracking is noted. In many cases, strength alone is not sufficient to determine the suitability of a sandcrete block for a specified application.

DURABILITY

This is the ability of sandcrete block to withstand effects from weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Different sandcrete block require different degrees of durability depending on the exposure environment and the properties desired. Sandcrete ingredients, their proportioning, interactions between them, placing and curing activities, and the services environment determine the ultimate durability of the sandcrete blocks.

USES OF SANDCRETE BLOCKS

Sandcrete block as an engineering element has find its way into variety of use such as partitioning of walls, frame works for building structure, it's also use use as a load bearing element for buildings such as load bearing wall, non-load bearing partition wall, load bearing partition wall etc.

CURING SANDCRETE BLOCKS

It includes wetting of blocks with water so as to permit proper hydration and hardening to take place and eventually achieve full strength.

The application may be done by watering can, rubber hose or buckets, or sprinkling water on the blocks and covering with a tarpaulin or damp sacks.

TESTS ON SANDCRETE CONSTITUENT

Fine Aggregates Testing

Sand used for sandcrete block production shall be clean and free from deleterious materials. Therefore, it is required to conduct tests on samples to ensure the suitability of the sand prior to its utilization.

1. Sieve Analysis

Sieve analysis may be performed based on Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates (ASTM C136 / C136M – 14) or any other applicable standards. It shows the suitability of sand for sandcrete blocks.

For example, if quantity of fine materials is high, then it is highly possible that block strength would be compromised.

2. Silt and Clay Content Test

This test can be conducted based on Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis (ASTM D7928 – 17) and IS: 2386 (Part II) 1963.

3. Organic Content Test

Organic content test can be performed based on Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils (ASTM D2974 – 14)

2.13 TESTING OF SANDCRETE BLOCKS

1. COMPRESSIVE STRENGTH TEST

This test is used to evaluate compressive strength of sandcrete block. Compression strength is the ability of blocks to resist an axially applied load on the edge or the bed face of the block. Compression testing machine is employed to evaluate the compressive strength of blocks. The test is conducted on blocks at 28 days of age and three samples are tested. The load is exerted on the block till it crushes; at this point maximum compressive load will be recorded.

2. BULK DENSITY

This test begins by labeling and numbering samples. Then, weigh each sample in dry states and record their masses. The dimensions (the length, breadth and height) of each block are taken from which volume of samples are computed. Finally, the bulk densities are calculated using the results.

3. WATER ABSORPTION

Water absorption test on sandcrete block include weighing samples in air, then fully immersed them in water for 24 hours. After that, the wet samples are taken out and weighed.

These values will be used to compute water absorption capacity which is expressed as a percentage. Water absorption is equal to the block wet weight minus dry weight divided by volume of block multiply by 100.

4. DIMENSION TEST

It is the measure of block dimensions and compare it with applicable standards.

2.14 COMPRESSIVE STRENGTH OF SANDCRETE BLOCKS TEST

Compressive strength of sandcrete block test provides an idea about all the characteristics of sandcrete blocks. By this single test, one can conveniently judge whether mixing and molding

of blocks has been done properly or not. Sandcrete blocks compressive strength for general construction varies from 15MPa to 30MPa and higher in commercial and industrial structures. Compressive strength of sand create Blocks depends on many factors such as water-cement ratio, cement strength, quality of the aggregate, quality control during production of sandcrete block etc.

Test for the compressive strength of sandcrete blocks is carried out either on cube. Various standard codes recommend cube as the standard specimen for the test. American society for Testing Materials ASTM C39/C39M provides standard Test methods for compressive strength of cube sandcrete specimens. These specimens are tested by compression testing machine after seven (7) days of curing and twenty-eight (28) days of curing. Load should be applied by the compression machine gradually at the rate of 140kg/cm^2 per minute till the specimen fails. Load at the point of failure divided by the area of the specimen gives the compressive strength of the sandcrete block.

2.15 PREVIOUS WORKS

A number of studies have been conducted on the significance of curing to the strengths of sandcrete blocks. According to (Hamza, 2009), to gain enough strength before being laid, sandcrete blocks should be allowed to mature for at least 28 days. During this period, the blocks are cured to prevent loss of moisture needed for hydration reaction to continue. However, commercial blocks producers hardly keep to this practice as the blocks are usually hurriedly sold to meet demands of mostly ignorant customers. Curing produces good quality blocks, prevents premature drying out with radiation and wind. Curing could be done by covering the blocks with polythene, by spraying with water and or with hot steam (Yusuf, 2011).

(Okafor, 2012) found that in order to minimize cost and maximize profits, producers of sandcrete blocks in Nigeria reduce the quantity of cement needed to give acceptable quality of sandcrete blocks, leading to the flooding of low – strength blocks in the commercial markets. According to (Abdullahi, 2005), the compressive strengths of sandcrete blocks in Minna, Nigeria range between 0.11N/mm² and 0.75N/mm², while (Ewa and Ukpata, 2013) also found that the compressive strengths of sandcrete blocks produced by commercial block industries in Calabar range between 0.23 N/mm² and 0.58 N/mm². A number of reasons including poor curing have been suggested for the low strengths of these blocks.

Similarly, (Anosike and Oyebande, 2012) have argued that there is a low compliance in the compressive strength of sandcrete blocks produced commercially in parts of Nigeria. Inadequate curing period by the manufacturers accounts for the negative results in the strengths of blocks. This is supported by (Ewa and Ukpata, 2013) in a similar study in Calabar Nigeria.

Also, (Okoh bobby Sunday, 2014) ascertains and recommends that adequate mix ratios, material selection, curing methods, quality control in production and compaction adhere for optimum sandcrete strength in Benin metropolis.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter entails the description of the experimental procedure and tests carried out and the order in which they were carried out, as well as the precautions taken in the course of the laboratory project work. Commercial sandcrete blocks were randomly selected from three (3) blocks moulding sites in Benin. Collection of blocks was done three/four days after production and initial curing at sites. The compressive strengths of the blocks were determined in accordance with BS 6073. The cement used by all manufacturers was the DANGOTE ordinary Portland cement manufactured by the United Cement Company of Nigeria. The mix ratios observed in all the sites range from 1:12 to 1:16 (cement: sand), producing between 40 to 52 blocks per bag of cement. This ratio is more than the standard which is 1:6, and the standard was made in the laboratory. The following experiments and tests were carried out sequentially:

1. Moisture content test
2. Sieve analysis test
3. Specific gravity test
4. Casting of sandcrete blocks cubes.
5. Sandcrete block compressive strength tests for twenty-eight days.

MOISTURE CONTENT TEST

This is the quantity of water contained in a material, such as soil (called soil moisture), rock, ceramics, etc. water content is used in a wide range of scientific and technical areas, and

is expressed as a ratio, which can be range from 0 (completely dry) to the value of the minerals porosity at saturation.

TEST PROCEDURES

- I.** Clean the container with lid dry it and weigh it (w_1)
- II.** Take a specimen of the sample in the container and weigh (w_2)
- III.** Keep the container in the oven. Dry the specimen to constant weight maintaining the temperature of 110°c for a period varying the type of the soil but usually 16 to 24 hours.
- IV.** Record the final constant weight (w_3) of the container with the dried soil sample.

$$\text{Moisture content} = \frac{(\text{weight of wet} - \text{wt of dry}) \times 100\%}{\text{Wt of wet sample}}$$

$$\text{Moisture content} = \frac{\text{wt of moisture} \times 100\%}{\text{Wt of dry sample}}$$

Another method of carrying out moisture content test are geological methods, satellite remote sensing method, Etc.

3.2 SIEVE ANALYSIS

Sieve analysis is a laboratory test that measures the particle size distribution of a soil by passing it through a series of sieves. Soil retained on it is termed as gravel fraction. A set of British standards (BS) sieves of sizes – 1.0mm, 0.85mm, 0.60mm, 0.50mm, 0.30, 0.25, 0.180 and pan and a weighing balance were used for the analysis. The sieves were arranged by keeping the largest aperture sieve at the top and smallest aperture at the bottom. A lid was placed at the top sieve and a pan at the bottom sieve.

The test was carried out for each aggregate sample collected from each of the block manufacturing industries using the following procedure:

The samples were spread out in the sun to dry for a period of 24 hours before the test was carried out. hundred grams (100g) of each of the samples was weighed on a weighing balance and poured on the uppermost sieve. Sieve sizes for grading purposes which conforms to BS 882 (16) were utilized. The sieves were shaken mechanically. The residues retained on each sieve was weighed and recorded. The cumulative weight passing through each sieve was calculated as a percentage of the total sample weight.

3.3 SPECIFIC GRAVITY TEST OF FINE AGGREGATE

Specific gravity is considered to be a measure of strength or quality of a material. The following apparatus were used to conduct the specific gravity test on the fine aggregates used in this research: Specific gravity bottle, distilled water and soil samples and the following procedure was adopted:

An Empty bottle was cleaned, weighed and designated (W1). The bottle was filled with onethird of the total volume of the sand sample, weighed and designated (W2). The bottle was filled with distilled water, weighed and designated (W3). Then the content of the bottle was discarded and it was rinsed thoroughly. The bottle was then filled with distilled water to the meniscus, weighed and designated (W4). The Specific gravity (SG) was calculated using equation below

$$S.G = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

3.4 APPARATUS

1. Bucket

2. Cement sample
3. Sensitive weighting machine
4. Clean water.

3.5 TEST PROCEDURE

The materials required are mostly cement and sharp sand; and equipment like; head pan, shovel, wheelbarrows and fabricated molding box. The cement is usually stored in dry place and used within the first two months in order to avoid the absorption of water. Okhuahe sand was used as fine aggregates and it was made free from deleterious substance by washing, 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. River sand particles are fine, but likely to vary in size and it is most suitable for plastering work. Erosion sand is similar to river but coarser than river sand. It is cheaper than river sand and has higher crushing strength because of its coarse nature. This sand is used mainly for building, mortar and block molding.

The research procedure followed as sequential order as given below

- Okhuahe sand was obtained from a borrow pit.
- The cement and sand were measured in the ratio 1:6 by volume batching with the aid of head pans.
- The materials were then thoroughly mixed together manually until a homogenous mix with uniform color was obtained.
- Water was added in sufficient quantity to ensure workability of the mixture and the water was judged to be sufficient when a quantity of the mixture was pressed between the palms caked without bringing out water.

- In the case of the power operated method, the composite mixture (mortar) was introduced into the mold in the block molding machine and the block vibrated for a minute for adequate compaction.
- For the hand ramming method, the composite mixture was introduced in the mold; in-built with the machine, the cover of the machine was smashed against the top of the mold for several numbers of times for adequate compaction.
- Also, for the manually compacted method, the composite mixture was introduced into the mold; smashed on the ground through a height of 0.6m in order to achieve an appreciable compaction.
- Water was sprinkled on the blocks twice daily for proper curing for several days.

3.6 MIX DESIGN

To cast sandcrete test cubes, a mix design was made. The mix design method adopted is the British method of mix design restricted to designing sandcrete mixes to meet workability, compressive strength and durability requirements using Portland cements complying with BS 12 or BS 4027 and natural aggregates complying with BS 882.

3.7 PROCEDURE

The design procedure is split into stages, each dealing with a different fine aggregate and different mix ratios and having as its end result either one of the main mix parameters of final constituents or one constituent.

- In stage one, consideration of the ratio of the different fine aggregate to cement was determine by weight for various ratios.

- Stage two provides a value for the free water content required in achieving the specified workability.
- Combination of the two previous stages would produce the cement content (mortar).
- The total aggregate content is then obtained from the consideration of the expected density of mix.

This stage completes the design. The proportions of the fine and cement in the total trial mix calculated.

3.8

A manual hand mixing was used to thoroughly mix the constituent materials of mortar that is cement, sand and water. It took approximately five (25) minutes to produce a good concrete mix. While mixing of the concrete was done automatically, a shovel was used to firmly mix the constituency.

3.9 MIX RATIOS PRACTICES

3.9.1 FROM LABOURATORY

The mix ratio adopted from the labouratory was 1:6.

3.9.2 FROM SITE 1

The mix ratio adopted from site 1 was about 1:12

3.9.3 FROM SITE 2

The mix ratio adopted from site 2 was about 1:14

3.9.4 FROM SITE 3

The mix ratio adopted was about 1:16

3.10 CURING PRACTICES

3.10.1 FROM LABOURATORY

The curing practiced on the 1:6 sandcrete block, was done by sprinkling water on the blocks daily and was kept from drying under sun by placing these blocks in the laboratory.

3.10.2 FROM SITE 1

No actual curing practice was observed from site 1, as the blocks are allowed to dry off after moulded and left for like five days before it is allowed to be sold

3.10.3 FROM SITE 2

The curing practices done by site 2 was sprinkling of water after the block has been moulded and was strong enough to accept water, sprinkling of water was done only a day after which its left to dry under sun.

3.10.4 FROM SITE 3

No actual curing was done by site 3, but enough water is put into production, and may be cured for just a day after which it is left to dry.

3.11 TEST ON HARDENED SANDCRETE BLOCKS

The test was carried out to determine the compressive strength for sandcrete blocks cubes made with 1:6 mix ratios and then tested at ages 28 days with use of a compression machine.

3.12 COMPRESSIVE STRENGTH TEST ON SANDCRETE BLOCKS

For specimen prepared in the laboratory the test was carried out on attaining 28 days curing age. Smooth surface wood (serving as base plate) was placed at the bottom and top of each specimen block so as to ensure uniform distribution of load for accurate crushing. To obtain the compressive strength in N/mm^2 , the load recorded was divided by the effective surface area of the block. The effective surface area of the block = Total surface area. This is given

by $(450 \times 125) = 56250\text{mm}^2$. All samples were tested using HFI compressive strength machine 1500KN capacity. The compressive strength values obtained from all tests specimens were derived from the crushing values obtained using compression test machine. The mix proportion used was 1:6 of cement and sand batched by volume. The composite materials were mixed with mixing machine and the water component used was obtained from the tap in the laboratory. The mixed materials were poured into the moulds and compacted by rammer. The blocks were then released onto a floored ground under the mould. The blocks were left on the smooth ground for 24hrs to air-cure before spraying them with water twice daily for 28 days to cure. The cured sandcrete blocks was tested by crushing after twenty-eight (28) days respectively.

3.13 WEIGHING OF BLOCKS

The weight of the sandcrete blocks were taken after allowed to dry completely and before crushing them and allowed to dry. The weighing balance was used to determine the weight of the concrete block before it is crushed by the compression machine.

3.14 APPARATUS

1. Allow sandcrete blocks to dry completely.
2. Clean the bearing surface of the testing machine.
3. Place the specimen in the machine in such a way that the load should be placed on the opposite sides of the cube.
4. Align the specimen centrally on the base plate of the machine.
5. Apply the load gradually without shock and continuously at the rate of 140kg/cm^2 per minute till the specimen fails.

6. Record the maximum load.

Note that a machine load is tested at each selected age. The average of the three gives the compressive strength of the concrete.

Compressive strength (N/mm^2) = failure load/ surface area.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 PRESENTATION AND DISCUSSION OF RESULTS

This chapter present the data acquired during the course of the investigation. The following results were obtained during the course of the investigation into “the effect of curing on the compressive strength of sandcrete blocks”

1. Moisture content test results
2. Sieve analysis results
3. Specific gravity test results
4. Compressive test results

4.2 DENSITY OF BLOCKS

The results of the dry densities of the blocks are presented in table 1 and 2. The densities range from 1580 kg/m³ to 1920 kg/m³. The densities obtained from the site samples are 1580kg/m³, 1876kg/m³ and 1759kg/m³ and that obtained from the labouratory is 1916kg/m³ values are below 2146.46 kg/m³ to 2209.60 kg/m³ recorded in Akeem, Ayodeji & Aliu (2012) with mix ratio of 1:9. The poor mix ratio in order to maximize profits reduces the cement contents in the blocks. As cement which has a higher specific gravity than sand is reduced in the mix, the weights of the blocks are also reduced; this is responsible for the low-density blocks in the commercial market. The low densities also indicate low vibrations. Vibrations tend to compact aggregate and reduce pore spaces between aggregate. This has a tendency to increase the strength of the block.

4.3 MOISTURE CONTENT TEST RESULTS

To determine the moisture content of the fine aggregate, tests were carried out using two methods, the oven drying method, and the speedy moisture content tester method. The results of the oven drying method is presented below:

Can no.	Wt of empty can (g)	Wt of can and wet sample (g)	Wt of can and dry sample (g)	(M.C moisture × 100)/ dry wt
AB.	13.73	75.40	73.09	3.06
K.	17.87	69.98	67.41	3.67
W.	16.21	72.10	69.84	3.13

Table 4.1: moisture content of fine aggregate using oven drying methods

$$\text{Average moisture content} = \frac{3.06+3.67+3.13}{3} = \frac{9.86}{3} = 3.28\%$$

4.4 SIEVE ANALYSIS RESULTS

The results of the sieve analysis test carried out on 100g of fine aggregate (Okhuie river sand) is presented below, and the particle size distribution is presented thereafter.

Tab 4.2: Sieve analysis test

Sieve size (mm)	Mass Retained (g)	Percentage Retained (g)	Mass Passing (g)	Percentage passing (%)
2.36μ	1.76	1.76	98.24	98.24
2.00μ	1.80	1.80	96.44	96.44
1.18μ	9.45	9.45	86.99	86.99

600μ	30.65	30.65	56.34	56.34
425μ	23.90	23.90	32.44	32.44
300μ	13.33	13.33	19.11	19.11
212μ	10.57	10.57	8.54	8.54
150μ	4.85	4.85	3.69	3.69
75μ	3.00	3.00	0.69	0.69

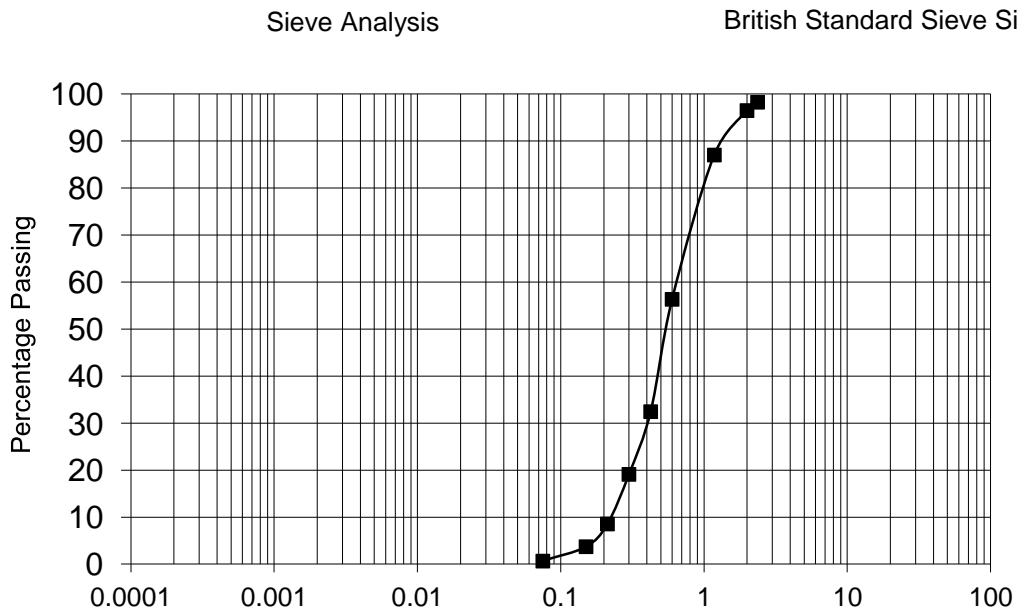


Fig 4.1 sieve Analysis

4.5 SPECIFIC GRAVITY TEST RESULT

Table 4.3 specific gravity analysis for fine aggregates

Bottle number	Ehi	A20
Bottle weight (w_1)	15.05g	16.05g
Bottle + Sample (w_2)	57.27g	59.56g
Bottle + Water (w_3)	69.70g	73.50g
Bottle + Sample + Water (w_4)	95.48g	99.17g

W_1 = Mass of measuring cylinder (container)

W_2 = Mass of container + fine aggregate

W_3 = Mass of container + fine aggregate + water

W_4 = Mass of container + water

Specific Gravity, S.G = mass of coarse aggregate/mass of equal volume of water

$$S.G = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= \frac{(57.27 - 15.05)}{(57.27 - 15.05) + (69.70 - 95.48)}$$

$$= \frac{42.22}{(42.22 - 25.78)}$$

$$= \frac{2.57}{(59.56 - 16.05)}$$

$$= \frac{(59.56 - 16.05)}{(59.56 - 16.05) + (73.50 - 99.17)}$$

$$= \frac{43.51}{(43.51 - 25.78)}$$

$$= 2.44$$

Average specific gravity = $\frac{2.57+2.44}{2} = 2.51$

2

4.6 COMPRESSIVE STRENGTH

compressive strength of blocks from site industry

Table2 and Figure1 show the results of the compressive strength for the site-cured blocks. The values for the 28-day strengths range from 0.3MPa to 0.8MPa. **table 4.4: Compressive strength results for various sites**

	Curing Age	Weight of blocks (kg)	Density of blocks (kg/m²)	Average density of blocks	Crushing load (KN)	Compressive strength (C.S) (N/mm²)	Avg C.S (N/mm²)
Site 3 (1:16)	28	20	1580	1580	18.14	0.310	0.303
		20	1580		16.93	0.290	
		20	1580		18.03	0.310	
		23	1811		49.70	0.85	

Site 1 (1:12)	28	24	1890	1876	38.21	0.65	0.763
		24.5	1929		46.17	0.79	
Site 2 (1:14)	28	22	1732	1759	29.636	0.590	0.587
		22.5	1772		27.652	0.592	
		22.5	1772		29.031	0.578	

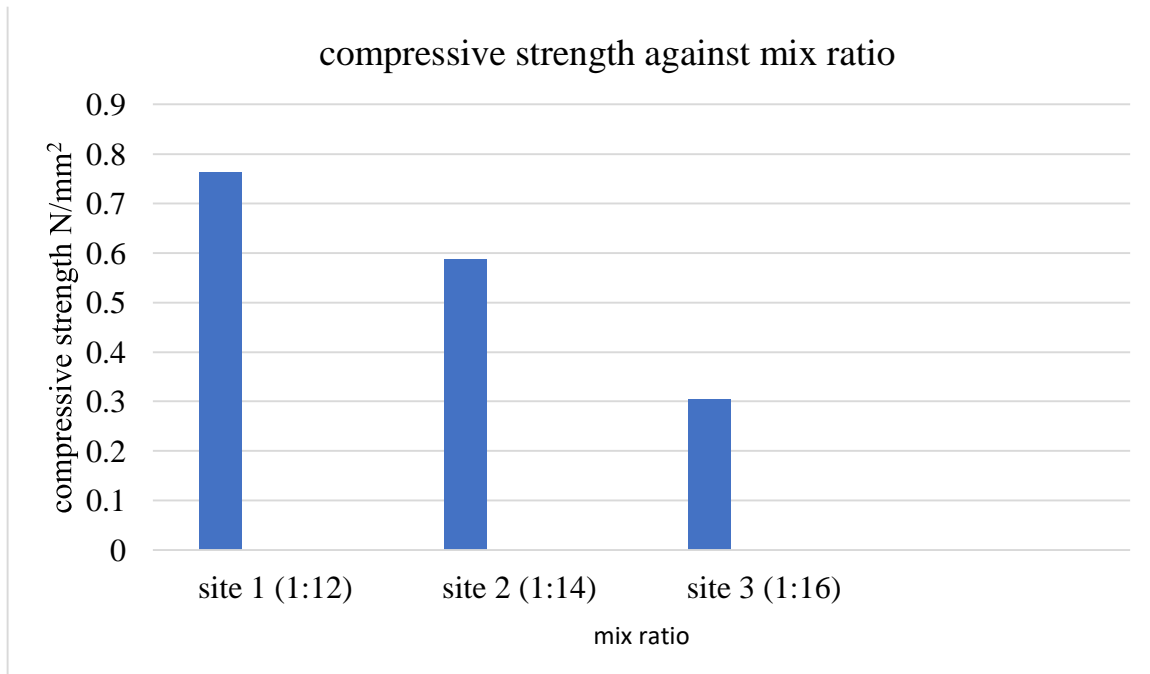


Fig 4.2: compressive strength of blocks obtained from site

4.7 COMPRESSIVE STRENGTH OF BLOCKS FROM LABOURATORY

Table3 and Figure 2 present the results of the compressive strengths of blocks with mix ratios 1:6 cured in the laboratory by spraying the blocks every morning and evening. The 28-day value is 3.058MPa. Again, these values are less than the 3.35 N/mm² at 28 days obtained in (Akeem, Ayodeji, & Aliu, 2012), It can be observed that improving the curing of the blocks by consistent watering also increased the strength of the commercial blocks by 98.28%. **Table 4:5: compressive strength obtained from labouratory (1:12,1:14 and 1:16)**

	Curing Age (days)	Weight of blocks (kg)	Density of blocks (kg/m²)	Average density of blocks	Crushing load (KN)	Compressive strength (C.S) (MPa)	Avg C.S
1:12	28	23.5	1850	1837	53.095	0.944	0.875
		23.5	1850		50.595	0.899	
		23.0	1811		44.025	0.783	
1:14	28	23.2	1827	1848	44.812	0.792	0.795
		23.5	1850		42.342	0.813	
		23.7	1866		43.416	0.781	
1:16	28	22.5	1772	1782	21.885	0.401	0.425
		22.7	1787		24.513	0.442	
		22.7	1787		22.814	0.428	

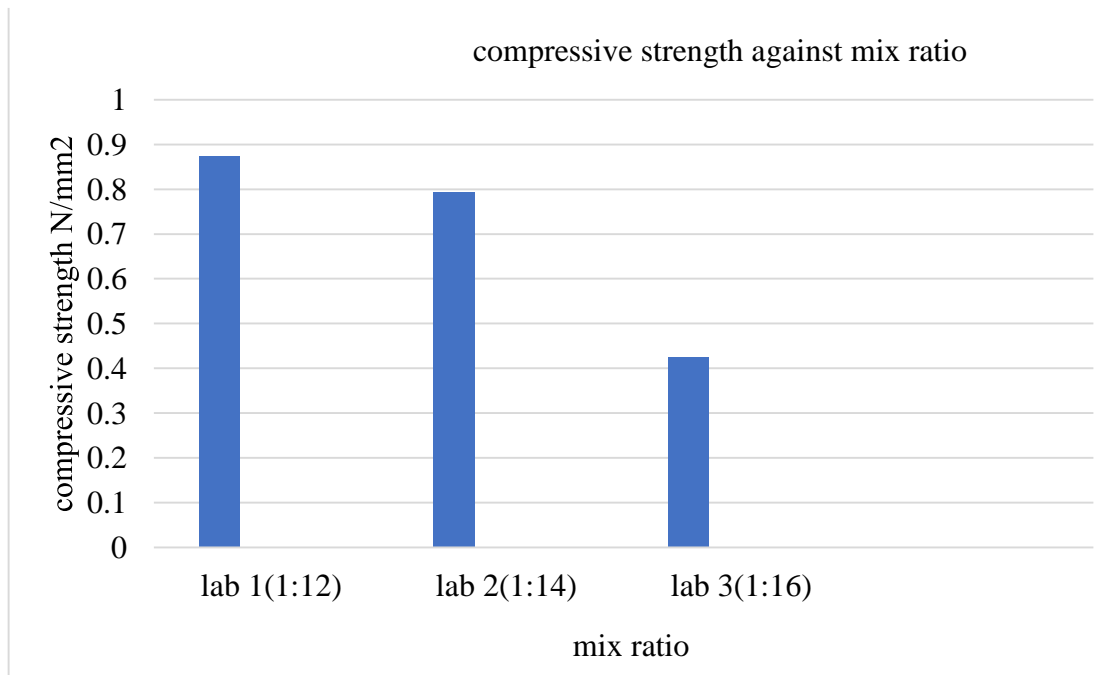


Fig 4.3 compressive strength obtained from laboratory (control) Table 4.5: compressive strength obtained from laboratory (1:6)

	Curing Age (days)	Weight of blocks (kg)	Density of blocks (kg/m²)	Average density of blocks	Crushing load (KN)	Compressive strength (C.S) (MPa)	Avg C.S
	28	24.5	1929	1916	184.487	3.286	3.058
		24.0	1929		163.597	2.908	
		24.5	1890		170.194	2.981	

fig 4.3 : compressive strength of blocks obtained from site and laboratory

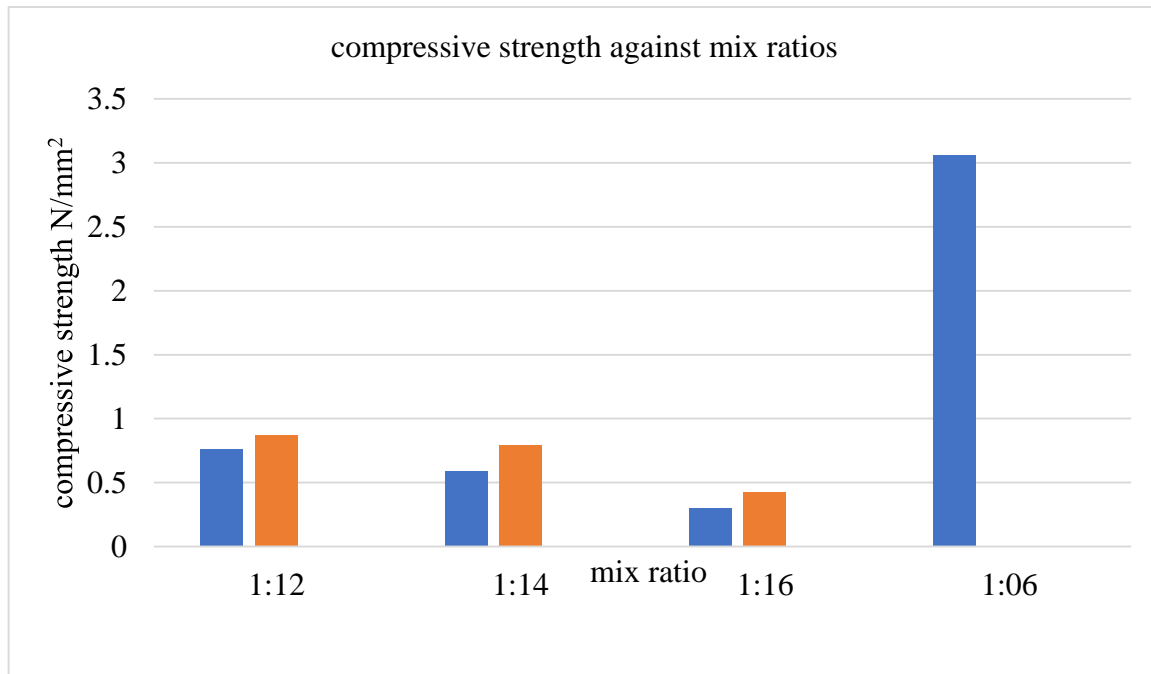


Fig 4.4 compressive strength for site and labouratory for all mix ratios

4.8 DISCUSSION

Section 4.1 presented the result of the sieve analysis, the result indicated that Okhuahe river sand, which was used in the production of the sandcrete blocks, was a uniformly graded sand (containing very fine grave particles) and possesses a specific gravity of 2.47. this shows that Okhuahe river sand is suitable for block production because from the particle size distribution; the fine aggregate had particles cutting across the full range of sand particles (fine to medium to coarse). It even contained particles in fine gravel range as indicated in the graph. Alutu and Omoregie 24, also confirmed result that Okhuahe River sand gave the maximum compressive strength when used in the production of sandcrete blocks.

From Fig 1, it can be seen that site 1, 1:12 mix ratio gives the highest compressive force and site 1 gives the least with 1:16 mix ratio.

From the information obtained above, we can clearly see that none of the producers complies with the allowable mix ratio standardized for sandcrete blocks. And it can also be seen that none of them follows the appropriate method of curing for the design period. And they start selling out the blocks from the third-fifth day of curing instead of minimum of one week (from enquiries). Considering the methods and procedure of the tests conducted and as can be seen from the graphs, it is important to make some important observations and conclusion on the nature and quality of the Sandcrete blocks produced in Benin metropolis. The strength of Sandcrete blocks produced in the site 1 at 28 days is higher than that of other site (2, 3,) in the development stages. However, this is much lower than the minimum value of 2.5 N/mm^2 specified by the Nigerian Industrial Standard. The strengths gotten from site has a maximum value of 0.763 N/mm^2 which was gotten from site 1 as compared with the minimum value of 2.50 N/mm^2 . The quality of the sandcrete blocks depend mainly on the quality of the constituent materials viz: cement, sand and water/cement ratio respectively.

When the values gotten from the site were compared to the one done with the same mix ratio but on a normal curing method of sprinkling water twice a day for 28 days and keeping it not directly under sunlight to dry off, it can be seen that the strength of the sandcrete blocks for the various mix ratios increased.

Comparing the values gotten from the actual way of curing blocks with the appropriate mix ratio (1:6), it can be seen that the compressive strength which was 3.058 N/mm^2 was more than the minimum strength required for sandcrete blocks 2.50 N/mm^2

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This research has shown that the available commercial sandcrete blocks in Benin Metropolis do not meet the minimum requirements for compressive strength set by the Nigerian Industrial Standard (NIS) and that of the British Standard Institution for masonry blocks.

The following conclusions are drawn from the study:

The producers are not actually adhering to the standard specification for mix ratio as is required for sandcrete blocks. The standard mix ratios are 1:6, whereas the block industries in Benin metropolis uses 1:12 and above.

They do not conform to the standard method and duration for curing as they do it haphazardly by spraying water with a hose twice a day for a period of three days or less. The study has also found that curing plays a vital role in improving on the compressive strengths of sandcrete blocks. It concludes that with improved curing and appropriate cement content, the sandcrete blocks produced in commercial block industries in Benin can be improved.

Commercial sandcrete blocks produced in Benin metropolis do not meet the standard required strength for commercial blocks, which. It is therefore recommended that workshops/seminars should be organized periodically to enlighten the producers of sandcrete blocks on importance of adhering to standard specifications and strict penalties should be meted out to erring producers by the Nigerian Industrial Standard Organization.

from the above experiment done on curing, it can be ascertained that curing should be properly done on sandcrete blocks to get the maximum strength. Sandcrete block should not be allowed to dry off under sun but be placed under a cool shade, i.e., not in direct contact with the sun and should be sprayed with sufficient amount of water twice every day for a period of at least 14-28 days

5.2 RECOMMENDATION

From the conclusions, the following recommendation can be made.

- 1 A curing duration minimum of 7 days and maximum of 28days should be adopted to ensure higher strength gain in sandcrete blocks before they are being used.
- 2 To enhance strength, a mix ratio of 1:6 should be adopted if it is feasible for production
- 3 Curing should be done properly by sprinkling water at least twice per day and should not be left under direct sunlight to dry off
- 4 It is highly recommended that for a high strength of sandcrete block, an appropriate mix ratio, material selection, curing practice and quality control is needed.

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APPENDIX

FIG 6.1- Compressive strength machine



FIG 6.2 – sandcrete block moulder





FIG 6.3 Operation of compressive strength machine