THE EFFECTS OF PARTIAL REPLACEMENT

OF

SHARP SAND WITH LATERITE IN BLOCK PRODUCTION.

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CERTIFICATION

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DEDICATION

This project work is dedicated to GOD-TALK AND DO, whose I am and belong to and whom I serve, my eternal and earthly father who has revealed his fatherhood in me since my earthly father forsook me; to JESUS CHRIST who is my lord and personal savior; and to the HOLY SPIRIT who is my comforter and teacher according to his manifestation in my life.

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With tears of joy and deep sense of adoration, I return all glory and honor to God who has been by my side and kept all my days of little begging to my years in school. I join the saints both in heaven and in earth in worship and reverence to your holiness and incorruptible name.

I wish to appreciate my able supervisor, Engr. Prof. Aginam, Chukwurah Henry, who has helped with wise counsels and corrections that has made this research work a success.

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I wish to thank my loving and assisting course mates especially Chimdiuto for their wonderful company.

May God bless you all, Amen.

ABSTRACT

This research works seek to find out the effects of partial replacement of sharp sand with laterite in block production in Awka Anambra State, Nigeria. Lateralized Sandcrete blocks were made with lateritic soil replacing the conventional fine aggregate (local river sand) in steps of 2.5% up 12.5%. %. Their compressive strengths were determined to check for conformity with standard sandcrete block as specified in the Nigerian National Building Code (2006) with a view to determine the acceptable percentage replacements. Solid sandcrete blocks were produced with fine aggregate (sharp sand and laterite) and cement in the ratio 1:6 by mass. Two and halve percent (2.5%) of the conventional fine aggregate (sharp sand) was replaced with the lateritic soil and then 5%, 7.5%, 10%, and 12.5%. Four (4) blocks at each percentage replacement of the conventional fine aggregate with the lateritic soil content were produced, cured weighed and tested for the 7th day, 14th day, 21th day and 28th day compressive strength and the average values of the values are taken as actual parameters. For control, four blocks were molded without replacement, that is, with 100% conventional sand. They were prepared to have water/cement ratio that will ease molding as this is to simulate site conditions. They were cured by sprinkling with water for 28 days and crushing test was performed on the samples to determine their compressive strengths. The compressive average strength of the control (0%), 2.5%, %, 7.5%, 10%, and 12.5% percentage replacements are recorded to be 10.6 N/mm^2, 8.8 N/mm^2, 8.5 N/mm^2, 7.5 N/mm^2, 6.9 N/mm^2, and 5.7 N/mm^2 respectively. The values and graph showed that there is an approximate linear decrease in compressive strength with increasing sand replacement with laterite. The minimum compressive strength of blocks for walling units is 1.7 N/mm^2 as specified in the Nigerian National Building Code (2006). Hence compressive strength results have gotten show conformity with standard comprehensive strength for sandcrete block as specified in the Nigerian National Building Code (2006). The lowest compressive strength recorded is 5.7 N/mm^2 at 12.5% percentage replacement which is 4 N/mm^2 (235.2%) greater than the allowable minimum compressive strength, therefore Laterite sandcrete blocks of the mix ratio of 1:6 and percentage replacements 2.5%, 5%, 7.5%, 10% and 12.5% are good for walling unit. These percentage replacements can be recommended to the block making industries within Awka and its environment with a view to encouraging utilization, though it is encouraged to confirm the percentage before embarking on mass block production.

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CHAPTER ONE

INTRODUCTION

1.1 The Background of Study

Building materials and their method of use are important factors to be considered in building construction. One of these building materials is Sharp sand which is the most popular choice and conveniently used fine aggregate in used in block production. It remains the best choice for block production in terms of strength measurement but it is becoming rarely available and as well becoming more uneconomical. Moreover, it has been said that the consumption of sharp sand as fine aggregate in block and concrete construction in this generation is over one billion tons per year, but such overuse of the material has led to environmental concerns; the depleting securable sand deposits and a concomitant increase in the price of material. The rapid extraction of sand from river beds causes problem like erosion and lowering of the water table, sinking of the bridge piers, change in river courses leading to flood, deepening of the river bed, loss of vegetation on the bank of the rivers. One way to improve this situation is to provide an available and low-cost but functional local material to replace sharp sand. Research is ongoing on the materials that could be used as a partial or complete replacement to sharp sand in block production.

One of such local material that is being researched is lateritic soil. Lateritic soil has been one of the major building materials in Nigeria for a long time. The main reason lies on the fact that it is readily available, environmentally friendly and the cost of procuring it is relatively low. Lateritic soil possesses other advantages which makes it potentially a very good and appropriate material for construction, especially for the construction of rural structures in the developing countries. These merits include little or no specialized skilled labour required for sandcrete-latrite block production and for its use in other construction works; and laterized concrete structures have potentially sufficient strength compared with that of normal concrete (Lasisi and Ogunjimi,1984).

This study is part of the continuing effort to investigate the use of lateritic soils in construction industries. **Specifically, this research work focused on the effects of partial replacement of sand with laterite (within Anambra state) in block production especially on the compressive strength.**

Laterite is derived from the latin word “later” which is essentially the product of tropical weathering usually found in areas where natural drainage is impeded (Amu, O.O., Ogunniyi, S.A.

and Oladeji, O.O (2011); Lasisi and Osunade, 1984). From an engineering point of view, late rite or lateritic soil is a product with red, reddish brown and dark brown colour, with or without nodules, ability to self- harden, concretions, and generally (but not exclusively) found below hardened ferruginous crusts or hard plan (Ola, 1983). Lasisi and Ogunjide (1984) assert that the degree of laterization is estimated by the silica sesquioxides ratio (SiO_2/ (Fe_2O_3 + Al_2O_3)). Silica- Sesquioxide (S-S) ratio less than 1.33 are indicative of laterites, those between 1.33 and 2.00 are lateritic soils and those greater than 2.00 are non-lateritic types. According to Akintorinwa, O. J., Ojo, J. S. and Olorunfemi, M. O. (2012)), lateritic soil abounds locally and its use is mainly limited to civil engineering works like road construction and land fill operations. It is less utilised in the building industry except in filling works. In lieu of the abundance of lateritic soils and its availability, its optimum use in building production could positively affect the cost of buildings leading to the production of more affordable housing units (Joshua and Lawal, 2011).

However, the use of laterite in the building production is not yet generally accepted because there are no sufficient technical data on it, hence limiting its wider application in building construction work (Udoeyo, F.F., Udeme, H.I., Obasi, O.O. (2006)). Studies are currently going on in the use of lateritic soil in concrete production where laterite is made to partly or wholly replace conventional fine aggregate in the production of concrete known as laterized concrete; and in the production of brick units such as Compressed Laterized Brick (CLB) usually stabilised with cement. Presently, these applications are mostly limited to buildings in rural areas and low income housing projects which are mostly situated at satellite areas (outskirts) of Central Business Areas (CBA's).

1.2 Aim and Objectives of Study

The aim:

To investigate the effects of partial replacement of sharp sand with lateritic soil in the production of blocks.

The objective:

To determine the compressive strength of laterized sandcrete blocks, to check for conformity with standard sandcrete block as specified in the Nigerian National Building Code (2006) with a view to determine the acceptable percentage replacements.

1.3 The Scope of Study

The scope of study of the determination of the effects of partial replacement of sharp sand with laterite on the density and compressive strength of blocks. Other effects as the volume of water need for a consistent mix, color change, permeability and porosity and the static modulus of elasticity are also considered.

The cost analysis at the time of this study was conducted on the basis of percentage cost of a trip of sand and laterite.

1.5 Relevance of Study

From findings, the closest construction element with laterite as part of its masonry is a compressed laterized bricks stabilized usually with cement or lime.

The use of the brick is either in the rural area or ion the low cost housing project, and unfortunately despite the establishment of about twenty bricks manufacturing plants in Nigeria since 1976 and low cost of locally produced bricks, their application in building construction industry has not gained much popularity except in very few occasions where government took the initiative to deliberately utilize stabilized compressed lateritic and clay soil like the case of ACO HITECH in lugbe, Abuja and few others.

Hence the need to create awareness over the possibility of using laterite as a partial replacement of sand in block production is of paramount importance in engineering works. This research work I believe strongly will add to already done work on this topic.

CHAPTER TWO

LITERATURE REVIEW

2.1 Laterite as An Engineering Material

Laterite derived from the Latin word “later” is essentially the product of tropical weathering. It is usually found in hot and wet tropical areas where natural drainage is impeded (lasisi and asunade, 1984).

From and engineering view point, laterite or lateritic soil is a product of tropical weathering with red, reddish brown and dark brown color, with or without nodules or concretion and generally [but not exclusively] found below hardened ferruginous crusts or hard (Ota, 1983). According to Osunade, 2002. The term laterite was used to describe a ferruginous, vesicular, unstratified and porous material with yellow ochre caused by its high iron content occurring abundantly in Malabar in India. It was locally used in making bricks for buildings and hence the laterite from the word later meaning bricks, although laterite is a material that has been used in building construction industry in Nigeria for a very long time especially in the rural areas. There are adequate data to fully understand the characteristic strength behavior of this abundant material. There is a need to improve on the indigenous technology on the practical usefulness of laterite soils in building and allied industries. A lot of research activities are now being carried out on lateritic soils. Earlier published works on laterized concrete seems to have been a study in which the strength properties of normal concrete were compared with those of laterized concrete (Adepegba, 1975).

According to Balogun and Adepegba, 1982 when sand is mixed with laterite fines the most suitable mix for structural application is 1:1. 5:3 [Cement: Sand plus laterite fines: Gravel] with a water cement ratio of 0.65, provided that the laterite content is kept below 50 percent (50%). It has also been established by (lasisi and osunade, 1984) that the finer the grain size of lateritic soils, the higher the comprehensive strength of the unstabilized cubes we made from such soils. They have also reported that the possible formation processes form a factor in the strength determination and that the comprehensive strength of lateritic soils is dependent on the source from which they were collected.

In a study on the effect of mix proportion and reinforcement size on the anchorage bond stress of laterized concrete specimens, the richer, in terms of cement content, the mix proportion, the higher the anchorage bond stress of laterize concrete (Osunade and Babalola, 1991). Also. The anchorage bond stress between plain round steel reinforcement and laterized cement increases with increase in the size of reinforcement used.

In Minna (Niger State capital) and surrounding towns, there exists abundant laterite soil and this course if harnessed well, will lead to production of low-cost laterite-cement blocks.

However, laterite bricks have been produced by Nigerian building and Road Research Institute (NBRRI) and used for the construction of a Bungalow. From the study, NBRRI proposed the following specifications as requirement for laterite bricks: bulk density of 1810kg/m^3, water absorption of 12.5%, compressive strength of 1.65N/mm^2 and durability of 6.9% with maximum cement content fixed at 5%. Good laterite bricks were produced from different sites in kano, Nigeria when laterite was stabilized to 3 to 7% and the study showed that particle size distribution, cement content, compacted efforts and method of curing adopted are factors which affect the strength of bricks.

According to Olugbenga A and Abiodun O, 2007, laterite has been used in the construction of shelter from time immemorial, and approximately 30% of world's present population still lives in laterite structures, that is, over 200 million people of the world still live in laterite-built houses.

Laterite is often used to describe the clinkered siliconized clay material. Amu, O.O., Ogunniyi, S.A. and Oladeji, O.O (2011) it could be described as material with no reasonable constant properties while Villar-Cocina, E., Valencia-Morales E, Gonza´lez-Rodrı´guez, R. and Herna´ndez-Ruı´z, J (2003)) described it as a red friable clay surface, a very hard homogenous vescular massive clinker-like material with a framework of red hydrated ferric oxides of vescular infill of soft aluminum oxides of yellowish color.

Villar- Cocina *et al.*, (2003) opined that mechanical stability is an important factor that should be considered in the use of lateritic materials. On the other hand, mechanical instability may manifest in form of remoulding and recasting and breakdown of cementation and structure.

The mechanical instability can affect engineering properties of laterite, such as particle size, Atterberg's limits, moisture content, grain size among others which in turns affect the strength of laterized products according to Middendorf, B., Mickley, J., Martirena, J.F., Day R.L.(2003). These properties can however be improved through stabilization in order to improve the characteristics and strength.

O'Flaherty (2002), Villar Cocina *et al.*, (2003) and Amu *et al.*, (2011) described soil stabilization as any treatment applied to a soil to improve its strength. Different methods have been used in laterite stabilization in recent years, mechanical and chemical stabilization being the two most popular methods in operation all over the world. Laterite stabilization using mechanical approach involves blending of different grades of soils to obtain a desired standard. Chemical stabilization on the other hand, is the use of silicon friendly material in blending of natural clay with chemical agents such as pozzolana, soda ash, fly ash cement among others. It is against the antecedents that this study researched into laterite stabilization with a view to reducing production cost

2.2 Definition of Soil

Soil in its traditional meaning is the natural medium for the growth of land plants, whether or not it has developed discernible soil horizons. It is also defined or refers to the non-water surface of the earth, however, what a soil scientist calls **soil**, a geologist may call **fragmented rocks or overburden**, an engineer may also call **earth or rocks**, and an economist may call **land**.

An engineering definition of soil is **"all the fragmented mineral material at or near the surface of the earth, the moon, or other planetary body, plus the air, water, organic matter and other substances which maybe included therein"** (Spangler and Handy, 1982,). This is the same definition for regolith.

Man's job on the earth is predominantly on land (soil), both economical and otherwise activities of man are on it,

Soil means several things to several disciplines, but for the purpose of this work, the engineering definition of the soil as defined above shall be adopted.

2.3 The Composition of Soil

While a nearly infinite variety of substances may be found in soils, they are categorized into four basic components:

i. Minerals
ii. Organic matter
iii. Air
iv. Water

Most introductory soil textbooks describe the ideal soil (ideal for the growth of most plants) as being composed 45% minerals, 25% water, 25% air and 5% organic matter. In reality, the percentages of the four components vary tremendously. Looking at the soil air and water, they are found in the pore spaces between the solid soil particles. The ratio of water-filled pore space to air-filled pore space often changes seasonally, weekly and even daily depending on water additions through precipitation, through flow, groundwater discharge and flooding. The volume of pore water space itself can be altered one way or the other by several processes.

2.3.1 soil minerals

Almost any mineral that exist may be found in some soil, somewhere. The broad and deep subject area of soil mineralogy can barely be touched upon here.

However, the minerals would be elementarily discussed; the mineral portion of soil is divided into three particle-size classes, namely

i. Sand
ii. Silt
iii. Clay (note: sand, silt, and clay are collectively referred to as the fine earth fraction of soil. They are less than 2mm diameter. Larger soil particles are referred to as rock fragments, and have their own size classes (pebbles, cobbles and boulders).

The particle size classes are classified as follows:

Table 2.1: Particle size classification

Particle name	**Size range**
Sand	2mm-0.05mm
Silt	0.05mm-0.002mm
Clay	<0.002mm

Mineralogically, sand and silt are just small particles of rocks, and are largely inert. Clay particles are mineralogical different from sand and silt. Clay minerals form at or near earth's surface, in soil or in water. Most clay belongs to a class of minerals called phyllosilicates.

There are many different phyllosilicate clay minerals. Two that are mainly found useful are kaolinite and member of smectile group of clay of montmorillonite.

Kaolinite does not shrink and swell when dried or wet, which makes it ideal for making bricks and pottery. It also has much commercial usefulness.

2.3.2 Soil Organic Matter

Soil Organic Matter **(SOM)** is a complex mixture of substances that can be highly variable in its chemical content. It ranges from freshly deposited plant and animal parts to the residual humus-stable organic compounds that are relatively resistant to further rapid decomposition. The elemental composition of **SOM** includes Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus and Sulphur. Nitrogen, Phosphorus and Sulphur are plant nutrients that are slowly released during decomposition and are then available to plants, as well as other organism.

The presence of this minerals affects to a greater extent, the compressive characteristic strength, for instance, sand contains mainly silica in the form of quartz which is a very hard material, hence, this accounts to the high compressive strength obtained when sand are mixed with cement in comparison with laterite which contains less silica.

2.4 Soil Formation

A number of conceptual models of soil formation have been postulated over the years. The two that have been keys in our basic understanding of soils and soil formation are those of **(Hans J, 1941 and Roy W.S, 1959)**.

The five factors that affect soil formation according to **Hans, 1941 and Roy W.S, 1959 are:**

i. Parent material
ii. Organisms
iii. Climate
iv. Relief
v. Time

These five factors affect the soil formation by their surrounding properties and the type of soil that is formed at particular areas of the earth.

2.5 Soil Types

There are different types of soil and each type exhibits certain properties. Each type of soil has a specific texture, color, water holding capacity etc. Soil are classified in many ways, but for the purpose of this research, the types are to be considered, nevertheless, it is majorly classified into two, **vernacular system** and **scientific system**, while Vernacular system is developed by land users, scientific system can be categorized by the development of the soil.

Classification helps to understand the soil properties and this enables us to conclude on a type of soil, whether it is good for farming, gardening or building construction.

Therefore, depending on the size of the particles in the soil, it can be classified into the following types:

i. Sandy Soil
ii. Silt Soil
iii. Clay Soil
iv. Loamy Soil
v. Peaty Soil
vi. Chalky Soil

2.6 Sandy Soil

To check if soil is sandy, moisten a small sample of soil and try to make ball using your palms. If the soil is sandy, then no dirt balls will form and the soil will crumble and fall through the fingers.

This soil type has the biggest particles and the bigger size of the particles in a soil, the better the aeration and drainage of the soil. Sandy soil is formed by the disintegration and weathering of rocks such as **limestone, granite, quartz and shale.**

The presence of silica (In form of quartz) accounts for high compressive strength experienced when sharp sand is mixed with cement.

2.7 Mineralogical Composition of Sand

The composition of sand is highly variable, depending of the local rock sources and conditions, but the most common constituents of sand(sharp) in inland continental setting and non-tropical coastal settings is **silica (silica dioxide SO_2)** usually in the form of **quartz**, this compound account for high compressive strength easily attained by sand Crete blocks.

However, from observations made, source of sand collection in this case beaches determine the chemical composition of that sand for example, sand from **Pismo Beach California** is composed primarily of **quartz, chert, igneous rock and shell** fragments differs from sand from **Kalalau Beach, Hawaii.**

However, the silica content of sand usually in form of quartz in inland continental settings and non-tropical coastal setting have been attributed to the chemical inertness and considerable hardness, is the most common **mineral** resistant to weathering.

2.8 Laterite Soil

Laterite is soil type rich in **iron and aluminum**, formed in **hot and wet** tropical areas. Nearly all laterite is rusty red because of **iron oxides**. They develop by intensive and long-lasting weathering of the parent rocks. Tropical weathering (**laterization**) is a prolonged process of chemical weathering which produced a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils. The majority of the Land areas with laterite was or is between the tropical of Cancer and Capricorn (also known as Northern tropics, is the curve of latitude on the earth that marks the most northerly position at which the sun may appear directly overhead the zenith). This event occurs once per year. Since the mid1970s trial sections of bituminous surfaced low volume roads have used laterite in place of stone as a base course. Thick laterite layers are porous and slightly permeable.

Francis Buchanan Hamilton first described and named a laterite formation in Southern India in 1807. He named it laterite from the Latin word later which means bricks; this rock can easily be cut into bricks shaped blocks for building. The word laterite has been used for variably cemented sesquioxides rich soil horizons. A sesquioxide is an oxide with three atoms of oxygen, two metal atoms. It is also any reddish soil at or near the earth's surface.

Laterite are formed from the leaching of parent sedimentary rocks [sandstones, clays, limestone] s, metamorphic rocks [schist, gneisses, migmatities], igneous rocks [granites, basalts, gabbros, peridotites] and mineralized proto ores, which leaves the more insoluble ions predominantly **iron and aluminum**.

2.9 Lateritic Soil Components

The mineralogical and chemical composition of laterites are dependent on their parent rocks. Laterites consist mainly of **quartz and oxides of titanium zircon, iron, tin, aluminum and manganese** which remain during the course of weathering. The chemical affects the strength characteristics of laterite in engineering works.

2.10 Engineering Importance of Lateritic Soil

Lateritic soils with suitable CBR values atterbergs results have been found useful in several engineering works namely road constructions, production of bricks, blocks etc. It has been found suitable for road constructions where it is used as a stone base against the stone base course which is very expensive. About **30 percent of world's population** still live in houses used with laterite soil and have been used in building several low-cost buildings in some States in Nigeria. Laterite soil are generally reddish in color, but is however important to differentiate laterite soil from red soils. Four major differences between laterites and red soils are

Table 2.2: Major difference between Red soil and Laterite soil

	RED SOIL	LATERITE SOIL
i.	Red soil is formed due to weathering of igneous and metamorphic rocks.	It is formed by the leaching process in the heavy rainfall areas of the tropic.
ii.	It is highly porous and less fertile but where it is deep, it is fertile.	It is less fertile, only grass grows on it in abundance.
iii.	It is less crystalline.	It is crystalline.
iv.	It is red in color due to presence of iron in it.	It is red in color due to little clay, iron and much gravel of red sand-stone.

The crystalline characteristic of lateritic soil makes it more useful in engineering works.

2.11 Local Laterite to Replace Sand and Granite

Weathered soils are composed mostly of iron and aluminum oxide and when dominated with iron oxide, they are called **LATERITE**. When aluminum oxide dominates, they are usually yellow or grey and are known as bauxite, (Gidigasu, 1976).

In an effort to find a suitable and cheap alternative building material to the existing ones for low cost houses, laterite was introduced into the aggregates of concrete. Laterite has featured in building construction works for a very long time in Nigeria. The majority of the houses in rural areas in use today were built from lateritic soils.

The practice varies depending on the location and related local problems and physical properties of the lateritic soils. (Ola, 1985) found stabilization of laterite with cement, lime, bitumen, etc, to be effective means of improving engineering properties of lateritic soils for road construction, rural infrastructures and low-cost housing.

Laterite deposits occur extremely in **Australia, Asia, and South America and in Africa**. They are generally used to produce bricks for dwelling houses in these areas because of their **relative cheapness**. Location of clay deposits in Nigeria. However, laterites usually contain **a good quantity of clay particles**

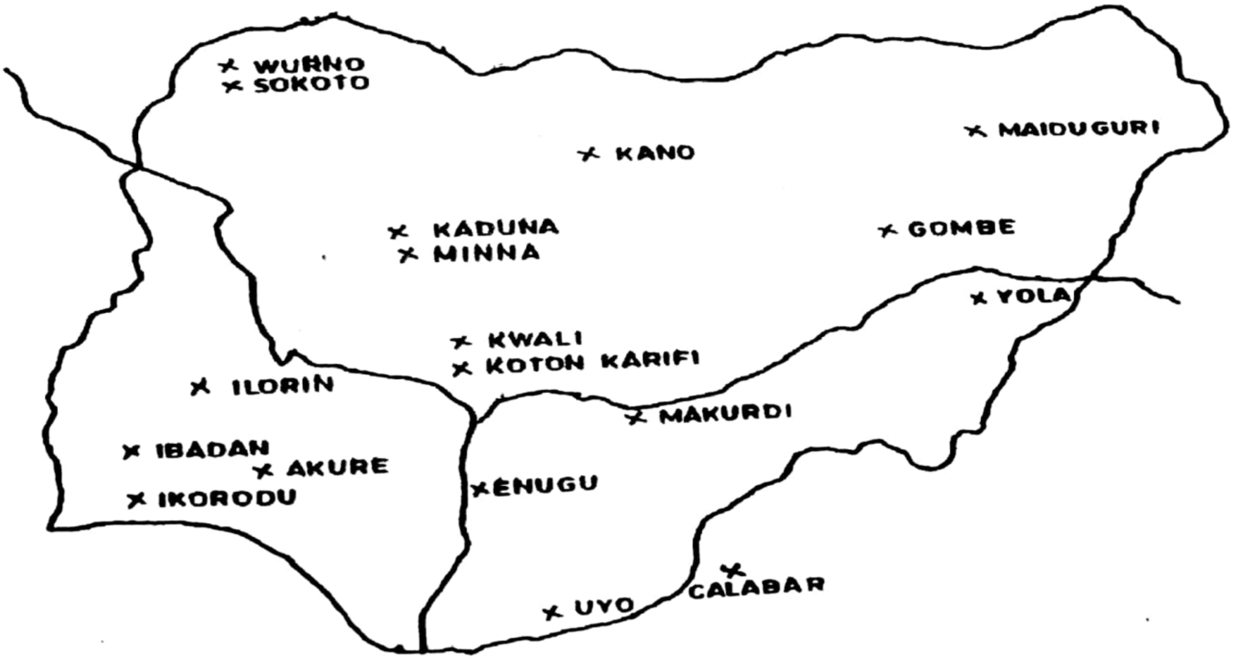

Figure 2.1: Major Location of Clay Deposits in Nigeria

2.12 Types of Fine Laterites

Laterite is highly weathered material, rich in secondary oxides of iron, aluminum or both and is found mainly in tropical and subtropical regions. There are two types: fine laterite and rock or quarry laterite. For engineering purpose, (Gidigasu, 1974) has identified two types of fine laterites: “sensitive” and “stable” laterites.

The sensitive laterite, which are unsuitable for engineering purposes, are generally found in regions of recent volcanic activity, and evaluation of their properties is unreliable. The stable laterites suitable for structural works are amendable to standard laboratory tests. A systematic survey of clay deposits by the Nigeria Geological Survey Department is given in Figure 1 and their preferred use, suggested in Table 6.

Laterized concrete is therefore defined as concrete in which stable laterite fine replaces fine aggregate (i.e. sand). (Late Prof. Adepegba D.A of Department of Civil Engineering University of Lagos was one of the pioneering researchers in Nigeria on this new concrete material. (Adepegba, 1975) recommended that laterites containing 40 percent or less of clay content for laterized concrete. Higher clay content could make the laterized concrete unmalleable, resulting in high water-cement ratio and consequently low compressive strength.

Resistance to high temperature, modulus of elasticity and compressive and tensile strength of laterized concrete mixes (1:2:4; 1:$\frac{1}{2}$:3 and 1:1:2 by weight were compared with that of normal concrete by (Adepegba, 1977). He concluded that, for high strength and workability only 25% of sand in concrete should be substituted with lateritic fine while the mix ratio should be 1:1$\frac{1}{2}$:3 (cement: sand/laterite: granite) with a water/cement ratio of o.65.

(Lasisi and Osunade, 1984) studied the effect of grain size and optimum moisture content on the cement-stabilized and unstabilized lateritic soil and concluded that investigation on the physical and strength characteristics of varying grades of laterized concrete with fine, the results showed that:

i. For the same mix proportion, percentage laterite content and water/cement ratio, the density of laterized concrete reduces gently with age from 28 days but stabilizes at about 70 days.
ii. Due to the higher fine aggregate/cement ratio in the 1:2:4 mix compared to 2:3:6, more water would be expected in 1:2:4 mix for the same laterite/sand content. For the same mix ratio, the rate of strength gain with increases in laterite content increases as the water/cement ratio increases.
iii. The maximum cube strength of laterized concrete was attained around 50-56 days for different mixes and water/cement ratios depending on the % laterite content. The reduced strength at 70 designs are based.
iv. For 0 and 25% laterized concrete, rate of gain in strength with age is inversely proportional to the w/c ratio whereas for 50%, 75% and 100% laterite substitute the rate of strength gain is directly proportional. This may be due to the necessity of additional

water for workable mix for higher % laterite substitution in view of the highet absorbent nature of clay (about 44%) in laterite.

v. The strength in normal concrete (0% laterized concrete) is only about 10% higher than the corresponding 25% laterized concrete.

The results showed that, a mix proportion of 1:2:4 with up to 50% substitution of fine aggregate with laterite and water-cement ratio of between 0.50 and 0.60 is recommended for structural elements in housing development. The resultant cube strength is not less than 30N/mm^2 at 70 days. This shows about the same strength as the corresponding normal concrete (0% laterite) at the same age.

In order to compliment the findings on the short-term (not more than 28 days) strength characteristics of laterized concrete, (Salau and Balogun, 1998) and (Salau, 2002) studied respectively the shrinkage and creep deformation of laterized concrete short columns. Note that creep ia a property of concrete members by which they continue to deform over considerable length of time at constant stress or load, while shrinkage is a deformation and volume change of concrete members under the influences of a different nature, even without external loading. The general findings, on the long-term durability, being that instantaneous modulus of elasticity and compressive strength of laterized concrete with 25% laterite content of fine aggregate compared favorably with those of normal concrete of similar mix proportion by weight and water/cement ratio. The mix ratio of 1:1$^{1/}{}_{2}$:3 (cement: sand/laterite: granite) by weight was also suggested.

Much works have been done on laterized concrete including the long-term resistance for it to have been used in building, however, no code of practice on laterized concrete to encourage users. Laterized concrete was pioneered in Nigeria more than 30years ago. However, its introduction into the construction industry has been delayed also because we still have sharp sand and granite/gravel to use but these are not cost effective. The adage still comes true that "Necessity is the mother of invention". The researchers are getting tired of working and development of substitute of imported structural engineering material without the practical application, that is, support from organized private sector, the government and the public at large.

2.13 Engineering Importance of Sharp Sand

Sharp sand is a mix of ungraded, coarse sands often with small [sharp] rock chipsin it.Good for ballast, concreting, block making, filling of foundations, road or embankment filling in water logged areas.

The coercive nature of sharp sand has made it the best kind of sand to be used for concrete, in road embankment in area like Lagos State Nigeria where the water table are found to be very found to be very shallow and hence needs a soil of zero plasticity to be able to curtail it. The importance of sharp sand to engineering works cannot be over emphasized. Sharp sand has little or zero expansive properties; these very properties made it the best kind of sand for filling in foundation, road embankment among others.

2.14 Effects of Climatic Changes on Soil

The availability of sharp sand as ingredients in engineering works is adversely affected by climate. Sharp sand is readily available and comparatively cheaper in rainy season when the volume of water oceans, rivers and beaches is on the increase while the reverse is the case during dry season, investigation into the lack of sand mostly experienced in some area revealed that the availability of sharp sand in the beach is adversely affected by climate change. The increase in price of a tipper of sharp sand during dry season as a result of insufficiency experienced in the supply of the commodity. This phenomenon is not associated with lateritic soils that are readily available seasonally and comparatively cheaper in price per tipper.

This factor also affects the water absorption rate, hardening and setting of molded blocks, the spent on purchasing of water for both molding processes and subsequent curing. These factors are however minimized during rainy season, thus climatic changes affect the cost of production and construction of building.

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Research Methodology

For the purpose of this research study, both primary and secondary method of data collection was employed. The primary sources of data include the formal and informal interview. The secondary method of data collection includes the use of scholarly journal, books, magazines and researcher's logical reasoning. The above-mentioned sources of data game me a wide range of views as regard the subject matter.

3.2 Sample and Sample Collection.

In or to carry out the laboratory investigation of the effects of partial replacement of sharp sand with laterite in block production, both sharp sand and late rite samples were collected by method of disturbed sampling for the purpose of analysis and classification.

Sharp sand samples were collected from Omabala river in Nando Anambra east local government area in Anambra state.

Laterite samples were collected from a borrowed pit Ugwuoba, Enugu state**.**

Table 3.1 Specific Gravity

River sand	**Laterite**
3.15	**2.75**

Fig 3.1

The specific gravity both samples as shown in fig 3.1, fall within the range specified by Nigerian National Building Code (2006).

3.3 Other Materials and Machine Used

The other materials used were Dangote cement, bore-hole water suitable for drinking sourced from civil engineering concrete laboratory, unizik awka.

The choice of Dangote cement in preference to other cement products lies on its strength and reliability amongst the locally produced cement in Nigeria (Yahaya, 2009). The mix ratio of the laterized sandcrete block was 1:6 by volume, that is, one part of cement to six parts of fine aggregate (combination of sand and lateritic soil). As this ratio (1:6, cement to sand) is the recommended standard for the production of sandcrete by the Nigerian National Building Code (2006). The specific gravity of the cement is 2.61 which falls within the range specified by Nigerian National Building Code (2006).

Mould for block is a cubic mold of size 150mm x 150mm x 150mm and the mass of 8.1kg.

Weighing balance was also used to weigh each specimen before crushing.

The machine used in this work was the HFI compression machine and for the compressive tests. These compressive strength values were compared with the 28-day strength requirements of a standard sandcrete block as specified in the National Building Code (2006) and the lateritic soil replacement that still falls within the standard sandcrete block requirement was taken as a permissible replacement.

3.4 Test Methodology

Solid sandcrete blocks were produced with fine aggregate (sharp sand and laterite) and cement in the ratio 1:6 by mass. Two and halve percent (2.5%) of the conventional fine aggregate (sharp sand) was replaced with the lateritic soil and then 5%, 7.5%, 10%, and 12.5%. Four (4) blocks at each percentage replacement of the conventional fine aggregate with the lateritic soil content were produced, cured weighed and tested for the 7th day, 14th day, 21th day and 28th day compressive strength and the average values of the values are taken as actual parameters. For control, four blocks were molded without replacement, that is, with 100% conventional sand. They were prepared to have water/cement ratio that will ease molding as this is to simulate site conditions. They were cured by sprinkling with water for 28 days and crushing test was performed on the samples to determine their compressive strengths. All precautions necessary at each step of the test were taken.

Careful observation of changes in some physical properties were done during molding and curing: Such observations are water volume for consistency of mix, Color changes, Porosity and permeability and Water absorption properties and are recorded in chapter four of this work.

Fig 3.1: Mixing materials and block moulding.

Fig 3.2: Moulded blocks in the process of curing.

Fig 3.3: crushing of blocks using the compressive strength machine.

3.5 The Economic Evaluation of The Project

In all the engineering projects worldwide, there have been undying quests for alternatives which will satisfy the standard requirement without compromising the functionality and quality to already known conventional method or practice. The need to identify a workable alternative is much keyed to achieving the **vision 10:2020** of the federal government of Nigeria and Africa as a whole.

However it is important to find a certified alternative to already known standards in block making industries in Nigeria, since clock is an indispensable building material which has an ever increasing demand over time, a certified alternative in the industries would reduce cost of construction and reduces the overdependence on the sandcrete block for our building projects.

It is “sine que none” that an engineer embarking on any project considers and reconsiders the alternatives and the cost implication, benefits and justification for such projects. These measures would help the client and engineer in reducing cost of production and speedy the completion of the work and meeting the targets of project within a reasonable time space. The indispensability of block walls in building industries cannot be overemphasized. Virtually all the buildings in this part of the world are built with block walls and this singular factor has made block an evenly increasing demanding building materials and there is forecasted to be on a progressive note since reproduction is a constant phenomenon and almost all these buildings are constructed using sandcrete blocks produced from the use of time aggregates, this of course increased the cost of one sandcrete blocks.

Therefore the economic evaluation this research work is aiming at is evaluating per annual cost of laterite materials in block making business as against the known conventional methods. The evaluation will at its best bring to light the implication of these materials (laterite and sharp sand). Their availability with respect to climatic conditions and other tangible factors that will be reviewed to validate the usefulness of laterite in blocking making industries and its economic implication.

3.6 Why Engineering Economy

The need for engineering economy is primarily motivated by the work engineers do in performing analysis, synthesis and coming to a conclusion as they work on the projects of all sizes.

Simply put engineering economy is at the heart of making decisions and proffering alternatives which would produce a viable project for sustainable development. These decisions centers on the fundamental elements such as cash flow of money, time and interest rates accruable from such projects (Leland blank, P.E and Anthony tarquin P.E). Proper decisions are vital to choosing one alternative over another. Decisions however are a function and product of person's educated choice of how best to invest funds also called capital. Since the amount of capital is usually restricted, just as the available cash to an individual is usually limited. Thus to judiciously utilize this capital in any project requires a holistic decision approach to available alternatives. The decision on how to invest capital will invariably change the future hopefully for better that is, it will be value adding.

Fundamentally, engineering economy involves formulating, estimating and evaluating the economic outcomes when alternatives to accomplish a defined purpose are available. It is also a collection of mathematical techniques that simplifies the economic evaluation and comparison.

3.7 Definition of Alternatives

This is a choice between two mutually exclusive possibilities. It can also be explained as an approach different from already known approaches but is able to save as a substitute for the known approaches. Availability of **workable alternative** in any engineering works makes room for choice in any project.

3.8 Economic Evaluation of The Cost of Sharp Sand and Laterite.

For the purpose of economic analysis on the cost effect of partial replacement of sharp sand with laterite in block production, the cost of sharp sand and laterite have be gotten from their respective source site where they are sold. The cost has been recorded and has been analyzed in chapter four of this research work.

CHAPTER FOUR

RESULT AND DISCUSSION

In this chapter, various test conducted on the specimen and results will be discussed in this chapter. The present study aims to investigate the for the effects of partial replacement (2.5%, 5%, 7.5%, 10%, 12.5%) of sharp sand with late rite in the blocks produced with the samples. All the test methods were done as described in chapter three of this report.

4.1 Block Moulding

It was observed during the process of making the blocks that the volume of water needed to produce the control mix and the 2.5% replacement had to gradually increase as the percentage replacements with laterite increases to attain a consistency that could make the blocks. Otherwise, the fresh sandcrete (mortar) would not discharge from the mould and every further discharge attempt resulted to the fresh sandcrete shattering out of the mould thereby loosing the desired shape of the blocks.

In the moulding process, it has been discovered that at each stage of the percentage replacement done, the mix for the blocks attains a consistency that could make the block(without shattering out of mould) but not without gradual increase in gradually increase in volume of water needed as the percentage replacements with laterite increases.

Hence such increase in volume of water needed for mouldability as the percentage replacements with laterite increases could be as a result of the absorption property of lateritic soil: interaction of dry laterite with water. Laterite absorbs and retains volume of water more to achieve adhesion than same volume of sharp sand, even though such volume increase is insignificant and negligible.

4.2 Observation Durind Curing

Water absorption properties: During curing, it has been observed that the water absorption properties increase with increase in percentage replacement of sharp sand with laterite in the sandcrete-laterite block.

Porosity and permeability: careful observation with naked eye shows that the porosity ad permeability of the sandcrete-laterite blocks increase with increase in the percentage replacements with laterite.

Colour changes: the colour of control is ash but the colour the sandcrete-laterite block becomes more reddish as the percentage replacements with laterite increases.

4.3 Density of Blocks

Density is a function of weight and volume of a substance.

$$\textbf{DENSITY} = \frac{W}{V}$$

Where

W= Weight (kg)

V= Block Cube volume (cm^3)

Table 4.1, **Percentage Displacement, Weight and Density.**

Percentage replacement (%)	**WEIGHT(kg)** Before crushing Times.				**AVERAGE WEIGHT (kg)**	**CUBE VOLUME, V (cm^3)**	**W/V = DENSITY** (x 10^{-3} kg/ cm^3)
	7 days	14 days	21 days	28 days			
Control,0%	7.94	7.91	7.88	7.81	7.85	3375	2.3259
2.5%	7.89	7.84	7.43	7.71	7.71	3375	2.2844
5%	7.98	7.33	7.29	7.10	7.42	3375	2.1985
7.5%	6.74	7.95	7.88	7.00	7.39	3375	2.1896
10%	7.27	7.61	7.41.	7.15	7.36	3375	2.1807
12.5%	6.96	7.05	6.73	7.65	7.09	3375	2.1007

The graph of Percentage replacement against Density is plotted as shown in **fig 4.1**

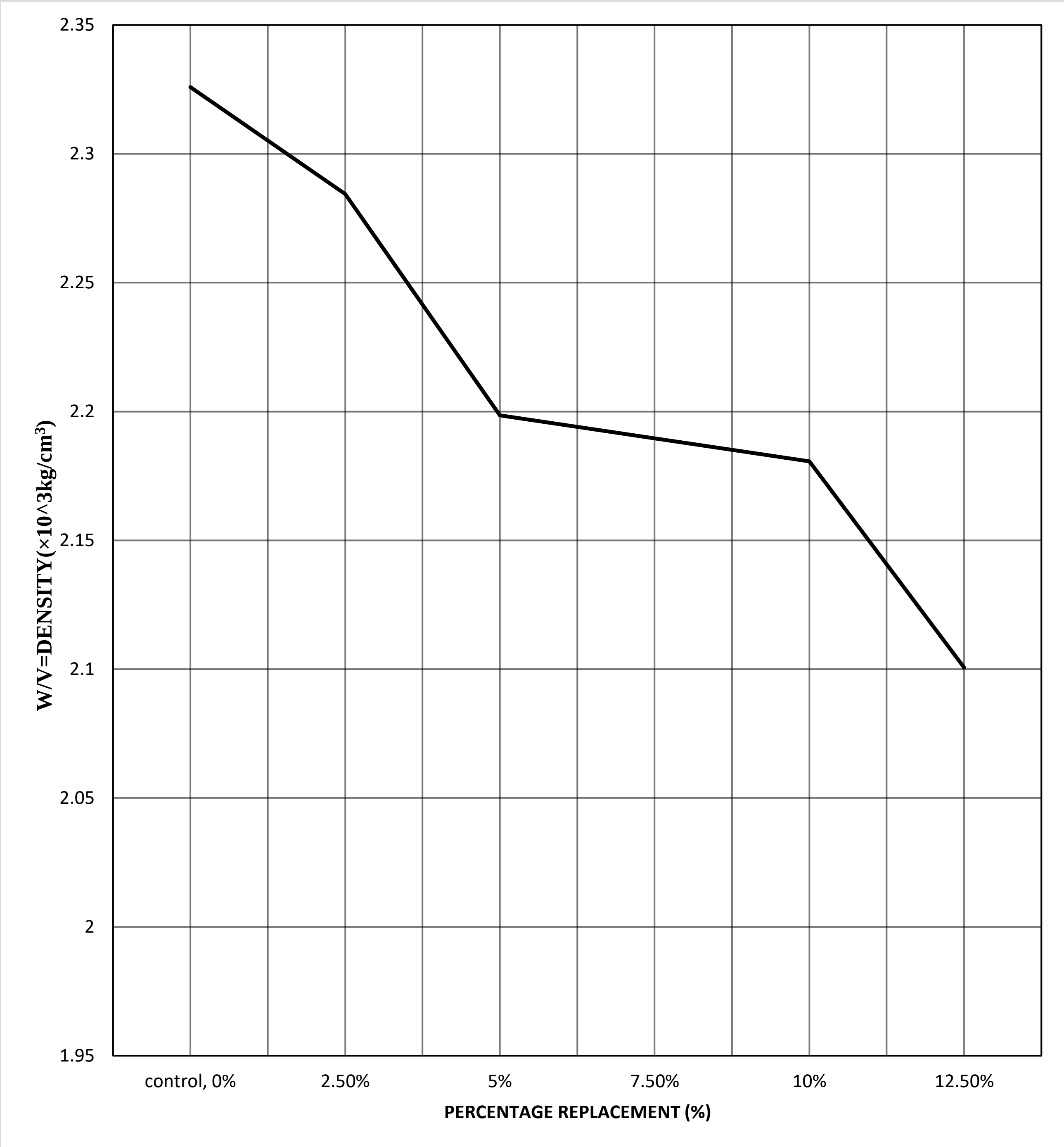

Fig 4.1. The variation of density of the sandcrete-laterite block with the percentage replacement of sand with lateritic soil.

From the graph **fig 4. t**he variation of density of the sandcrete-laterite block with the percentage replacement of sand with lateritic soil, it is seen that the density of blocks decreases as the percentage replacement increases. This is attributed to the lower specific gravity of lateritic material compared to sand. That is to say that that lateritic soils are lighter than sand. The good thing about the reduction in the weight and density as the percentage replacement increases is that, blocks of good strength and least density is the most preferred for walling units in multiple storey buildings since it will reduce overall imposed wall load of the structure.

4.4 Compressive Strength

Compressive strength was assessed at the ages of 3, 7, 14, 28 days of curing on 150 mm by 150mm by 150mm cube mortar specimens, as per means of compression testing machine at standard loading rate. The machine automatically stops when failure occurs and then displays the failure load.

Calculation

The measured compressive strength of the cubes was calculated by dividing the maximum load applied to the cubes during the test by the cross-sectional area, calculated from the mean dimensions of the sections and was expressed to the nearest 0.5/mm2.

$$\text{Compressive strength, } f_c = \frac{P}{A}$$

Where P = maximum crushing load (N)

A = the cross-sectional area of cubic block in mm^2

And the cross sectional area, A = 150mmx150mm=22500 mm^2

Here the compressive strength in **N/mm^2**, for each specimen is gotten directly from the compressive strength machine.

Table 4.2, **The percentage replacement and compressive strength**

Percentage replacement (%)	**COMPRESSIVE STRENGTH (N/MM2) (N/MM3)** Before crushing Times.				**AVERAGE COMPRESSIVE STRENGTH (N/mm^2)**
	7 days	14 days	21 days	28 days	
Control,0%	7.5	9.9	11.7	13.5	10.6
2.5%	6.2	9.4	9.6	10.2	8.8
5%	6.0	8.8	9.2	10.0	8.5
7.5%	5.9	7.0	8.4	9.0	7.5
10%	4.7	6.9	7.4	8.8	6.9
12.5%	4.2	4.9	6.6	7.1	5.7

The graph of percentage replacement against the compressive strength each of the crushing days is plotted as seen in fig 4.2(a). And the graph of percentage replacement against the average compressive strength is plotted as shown in fig 4.2(b).

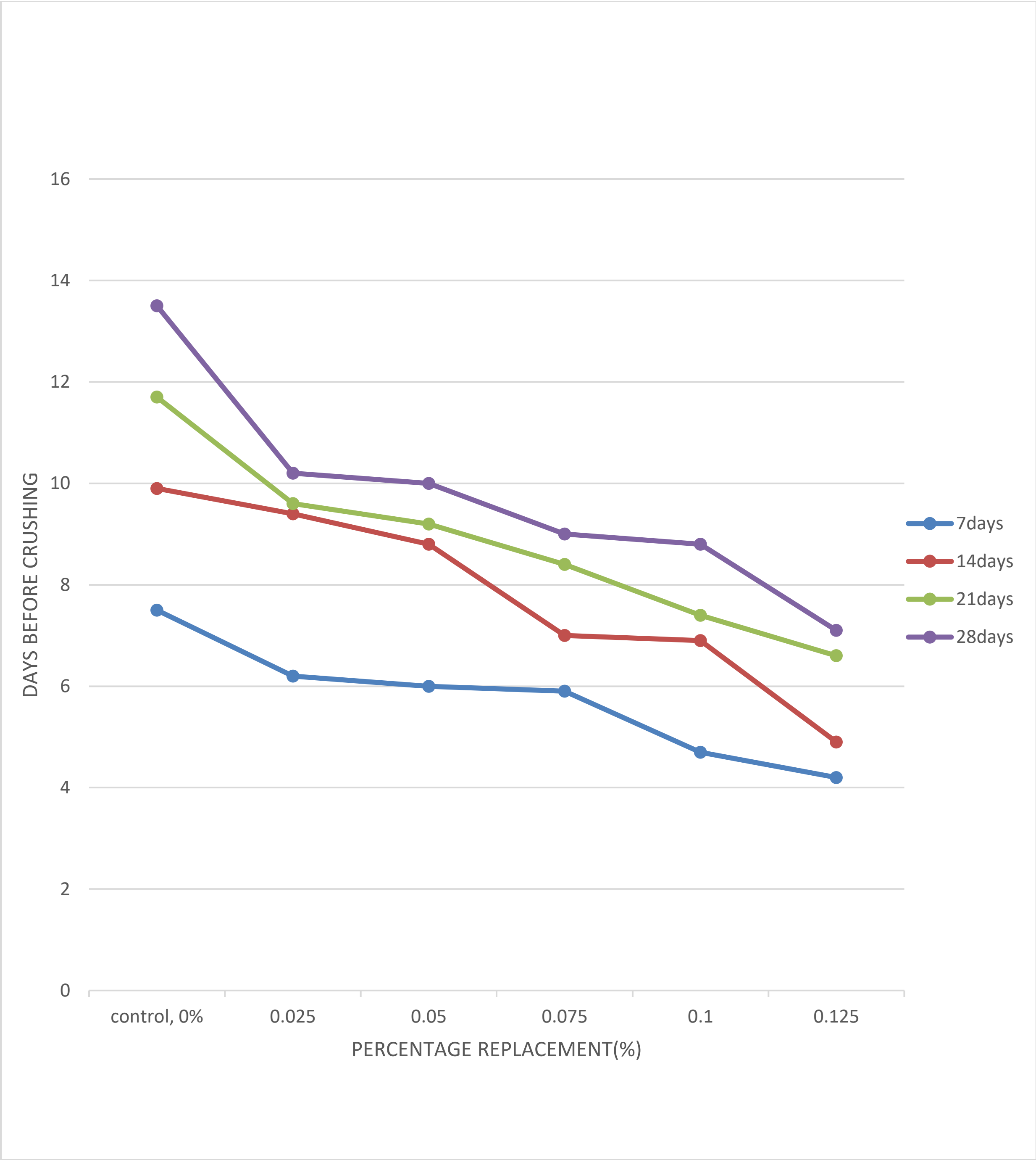

Fig 4.2(a) The graph of percentage replacement against the compressive strength each of the crushing day.

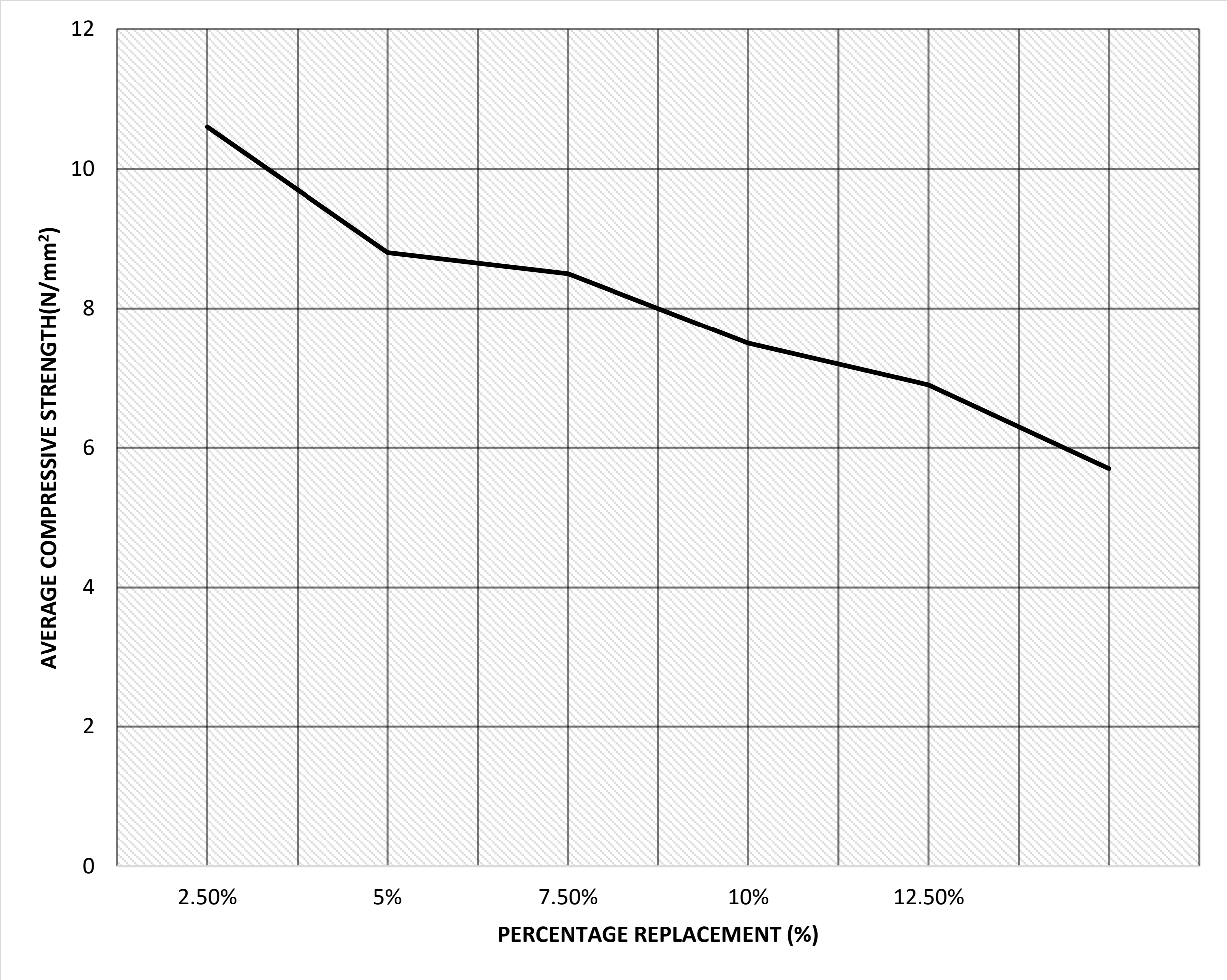

Fig 4.2(b) The graph of percentage replacement against the average compressive strength

From table 4.2, it is observed that for each of the percentage replacement, the compressive strength increases as the curing days increase. These follow the principle that curing improves the strength of blocks.

From fig 4.2(a): For each day of crushing, it is seen that compressive strength decrease with increasing percentage replacement. Similarly, in fig 4.2(b), it was observed that the average compressive strength curve is approximately linear and negative with increasing percentage replacement with lateritic soil. Such result is a proof that sandcrete blocks have higher compressive strength than lateritic blocks of similar mix.

In summary it has been seen that the greater the percentage replacement with the lateritic soil, the lighter the blocks produced and the lower the compressive strength of the sandcrete-laterite blocks.

4.5 STatic Modulus of Elasticity, Ec.

Static modulus is a function of compressive strength and density of each block. It is calculated using the equation below:

Ec **= 1.7 ρ^2 fc $^{0.33}$ *10^{-6}**

Were Ec = Static **modulus in Pa**

ρ = Density in Kg

fc=compressive strength in N/mm^2

Table 4.3, Percentage replacement and modulus of static elasticity of blocks

PERCENTAGE REPLACEMENT(%)	**W/V = DENSITY** (x 10^{-3} kg/ cm^2)	**AVERAGE COMPRESSIVE STRENGTH (**N/mm^2**)**	**STATIC MODULUS OF ELASTICITY,Ec X 10^{-11} (Pa)**
Control,0%	2.3259	10.6	**2.0043**
2.5%	2.2844	8.8	**1.8183**
5%	2.1985	8.5	**1.6649**
7.5%	2.1896	7.5	**1.5847**
10%	2.1807	6.9	**1.5291**
12.5%	2.1007	5.7	**1.3323**

The graph of percentage replacement against modulus of elasticity in fig 4.3

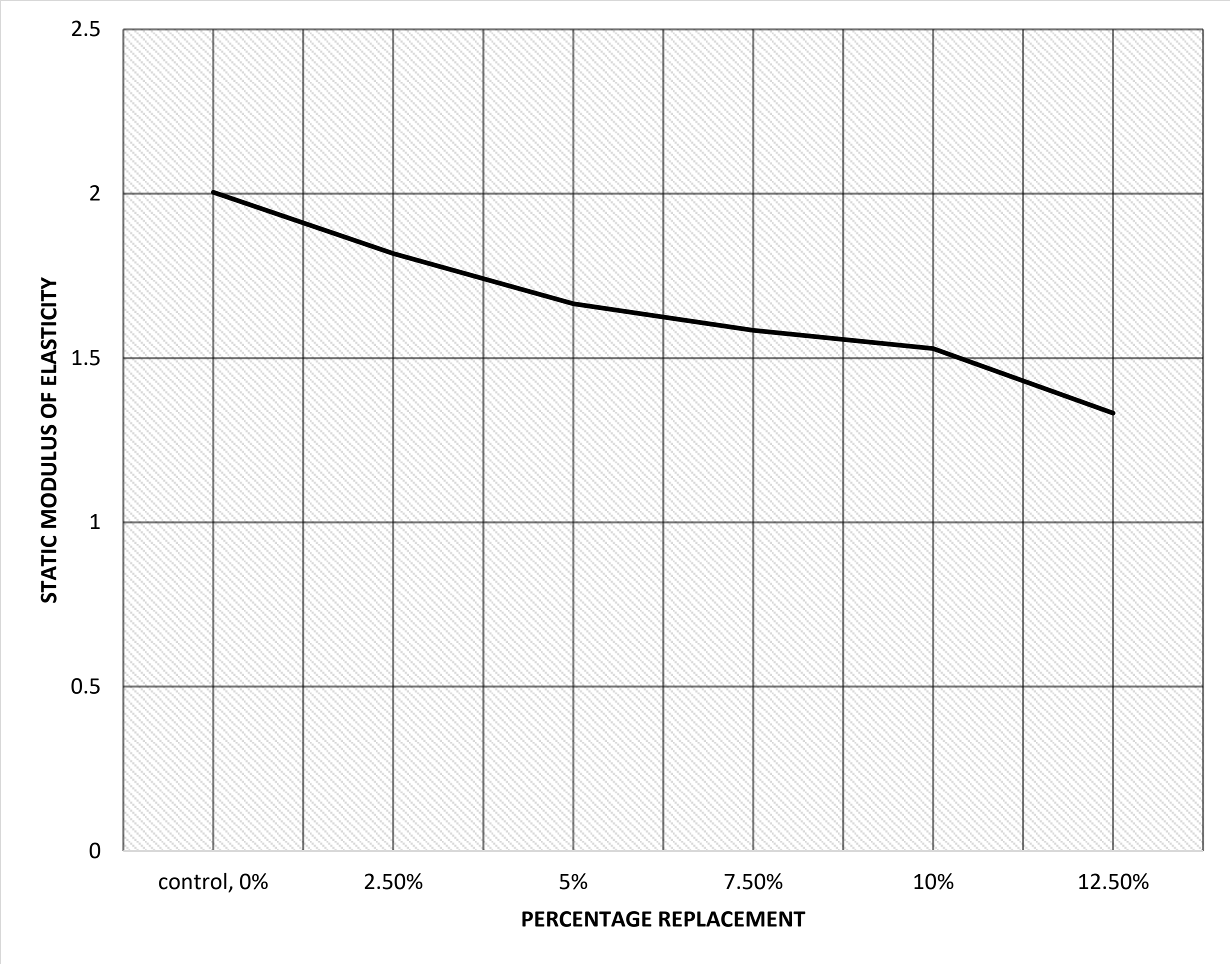

Fig 4.3 The graph of percentage replacement against the average compressive strength

From the curve at fig 4.3, it is seen that at the 0% replacement, the static modulus is 2.0043 X 10^{-11} Pa and then it gradually decreases to 1.3323 X 10^{-11} Pa at 12.5%. The static modulus has a down ward trend with the increase in inclusion of laterite. As the percentage replacement increases the static modulus decrease.

Meanwhile static modulus decreases as a result of decrease in compressive strength and density.

4.6 Economic Analysis and Effect of Partial Replacement of Sharp Sand with Laterite in Block Production.

The cost analysis at the time of this study was conducted on the basis of percentage cost of a trip of sand and laterite needed for a block production project. This is based on the assumption that the same volume of sand and that of sand partially replaced with laterite will produce the same number of blocks provided that they are of the same mix and both have acceptable strength. The percentage replacement of a given volume of sand with laterite causes a change in the overall cost of project since sharp sand is lighter than laterite.

Evaluation of alternative in the cost of alternative trucks of (a) fine sharp sand and (b)that of a tipper of sharp sand mixed of a known percentage of laterite for a given block project that will need 30 tonnes of either alternative to make same number of block is shown as follows:

Alternative A: 30 tonnes truck of sharp sand.

Alternative B: 30 tonnes truck of Sharp sand with partially replaced 10% laterite (90% sharp and 10% laterite).

Both alternatives give acceptable result of compressive strength according to strength requirements of a standard sandcrete block as specified in the National Building Code (2006). The material quantity for analysis = 10 tyre truck contains 30 tones which is about 19.7 cubic meter.

<u>Alternative A: A truck of 30 tonnes of sharp sand.</u>

Cost price 30 tonnes of sands = #180,000.

Cost price of 100% of 30 tonnes of sands = 1.0 x 180000 = #180,000.

Cost price of alternative A = #**180,000**

<u>Altrnative B: A truck of 30 tonnes of Sharp sand with partially replaced 10% laterite (90% sharp and 10% laterite).</u>

Cost price of 90% of 30 tonnes of sands = #162,000

Cost price 30 tonnes of laterite = #34,000.

Cost price of 100% of 30 tonnes laterite= 1.0 x 34000 = #34000

Cost price of 10% of 30 tonnes laterite = #3400

Total cost of alternative B = Cost price of 90% of 30 tonnes of sands + Cost price of 10% of 30 tonnes laterite = 162,000 + 3400 = #**165400**

Table 4.4 Summary of Alternative Analysis

ALTERNATIVES	**Alternative A: 30 tonnes truck of sharp sand.**	**Alternative B: 30 tonnes truck of Sharp sand with partially replaced 10% laterite (90% sharp and 10% laterite).**
TOTAL COST	#180,000	#165,400

The percentage cost difference in the alternatives =

$$\frac{(180,000 - 165,400)}{18,000} \times 100 = 8.1\%$$

This implies that the cost Alternative is 8.1% less than cost of Alternative A for the project.

From the above economic analysis and result, it is obvious that **Alternative B: 30 tonnes truck of Sharp sand with partially replaced 10% laterite (90% sharp and 10% laterite)** is more economical than **Alternative A: 30 tonnes truck of sharp sand.** Hence, it is a good and advisable to use of alternative B since it is standard and also reduces the cost of the overall project. Lateralized sandcrete blocks made with cement are more economical than sandcrete blocks of similar mix. It is not difficult to show that the higher the percentage replacement the more economical the cost of sandcrete-laterite blocks becomes

4.7 Comparison Between the Recommended Standard (Minimum Compressive Strength of Blocks) For the Production Of Sandcrete By The Nigerian National Building Code (2006) And The Compressive Strength Of Laterized Sancrete Block

Table 4.5: Comparison between the recommended standard (minimum compressive strength of blocks) for the production of sandcrete by the Nigerian National Building Code (2006) and the Compressive strength(N/mm^2) of the lateralized sandcrete blocks.

Percentage Replacement	Compressive strength**(N/mm^2)**	Minimum required compressive**(N/mm^2)**	Difference in compressive strength

Control,0%	10.6	1.7	8.9
2.5%	8.8	1.7	7.1
5%	8.5	1.7	6.8
7.5%	7.5	1.7	5.8
10%	6.9	1.7	5.2
12.5%	5.7	1.7	4

The table 4.5 shows that for each of the percentage replacement, the Compressive strength (N/mm^2) of the lateralized sandcrete blocks is above the recommended standard (minimum compressive strength of blocks) for the production of sandcrete by the Nigerian National Building Code (2006). Meanwhile such percentage replacements that produce laterized sandcrete blocks whose compressive strength are above 1.7 N/mm^2(the minimum required standard) are acceptable for walling units.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Tests have been done on the effects of partial replacement of sharp sand with laterite in block production and: block moulding, curing, density test and compressive strength determination. From the tests and results the following conclusions are note worth:

Lateralized sandcrete blocks made with cement have densities lower than sandcrete blocks of similar mix.

Lateralized sandcrete blocks made with cement have compressive strength lower than sandcrete blocks of similar mix.

Lateralized sandcrete blocks made with cement have static modulus of elasticity lower than sandcrete blocks of similar mix

Lateralized sandcrete blocks made with cement are more economical than sandcrete blocks of similar mix and the higher the percentage replacement the more economical it becomes.

Laterized sancrete blocks of the mix ratio of 1:6 and percentage replacements 2.5%, 5%, 7.5%, 10% and 12.5% are good for walling unit considering their compressive strength and the recommended standard (mimimum compressive strength of blocks) for the production of sandcrete by the Nigerian National Building Code (2006).

5.2 Recommendation

The study recommends that block moulding Industries that uses the source of both the sharp sand and laterite that was tested in this study, need to adhere strictly adhere to standard practice by incorporating lateritic soil not greater than 12.5% of the fine aggregate used in their block production as a way of reducing the production cost as well as a corresponding reduction in the market price of sandcrete blocks.

Further test should be done to check percentage replacements that are greater than 12.5% which are suitable for block production and to also find out the percentage beyond which partial replacement of sharp sand with laterite is unallowable for block making.

Furthermore, an investigation should be done on the use of laterite as an alternative to sharp sand in block production since such will be more economical than partial replacement if such lateritic blocks conform to the recommended standard (minimum compressive strength of blocks) for the production of sandcrete by the Nigerian National Building Code (2006).

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