STRUCTURAL PERFORMANCE OF LATERITIC CONCRETE CONTAINING PALM KERNEL SHELL (PKS) AS A PARTIAL REPLACEMENT OF COARSE AGGREGATE

By

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ABSTRACT

Sand has traditionally been used as fine aggregate in structural concrete. It is usually imported from relatively distant places at high costs, and this increases the overall cost of making concrete and of providing housing in various Nigerian communities.

This study investigates the performance of 40% of laterite as fine aggregate in place of sand, and specifically seeks to determine whether lateritic concrete containing pks would satisfy the minimum compressive strength requirement of BS 8110 (1997) for use in reinforced concrete works, which is 25 N/mm.

Ordinary Portland Cement was used as binder. 40%Laterite was used as fine aggregate, while granite was replace by pks which varied from 0% to 50% at intervals of 10%.The mix design used for the concrete mix is 1:2:4 and the water /cement ratio used is0.5m.The compaction factor test was used to assess the workability of the fresh concrete .The compressive strengths and densities of cured concrete cubes of sizes, 150mm×150mm×150mm were evaluated at 7days, 14days, 21days, 28days,60days and 90days curing day in total taking the number of cubes to 126cubes . Increase in the percentage replacement of granite lowered compressive strength and workability.

The result shows that control had 10mm and 0% pks had 6mm,this reduction in slump is as a result of the 40% replacement of sand aggregate with laterite aggregate. The mix containing 10% pks had slump of 0mm(zero).This is the result of the replacement of granite aggregate with pks aggregate, which have a high water absorption rate. At 50% content shear slump took place and the test was repeated,again, shear slump occurred. It was also observed that the compressive strength of concrete increased rapidly with age until the 28th day after which strength developed or reduced gradually until the 90th day. The control concrete had the greatest compressive strength at all the curing ages ,the compressive strength of concrete at 28 days were in range of 8.71N/mm^2 to 24 N/mm^2 and those of 7 days varied from 4.65 N/mm^2 to 15.99 N/mm^2.

Compressive strength values of the normal weight concrete is about twice that of the palm kernel shell which is normal as PKS is lighter and workability is also reduce. Therefore it can be used to produce lightweight concrete like lintel and roads.

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This report is dedicated to God almighty, the giver of life and my maker, the fountain of wisdom, knowledge and understanding and to my late father Alhaji Tijani Opomulero may his soul continue to rest in perfect peace (AMIN).

CERTIFICATION

This is to certify that this project was prepared by Tijani Suaib Adekunle (CVE/12/0834) under my supervision in partial fulfillment of the requirement for the award of a bachelor of Engineering (B.Eng) degree in Civil Engineering, Federal University Oye Ekiti. Ekiti State

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LIST OF ABBREVIATION

PKS	PALM KERNEL SHELL
ASTM	AMERICAN SOCIETY FOR TESTING MATERIALS
BS	BRITISH STANDARD
CU	UNIFORMITY COEFFICIENT
CC	COEFFICIENT OF GRADATI

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CHAPTER ONE

1.0 INTRODUCTION

1.1 GENERAL BACKGROUND

1.1.1 Concrete

Concrete is a composite material composed of coarse aggregate bonded together with fluid cement that hardens over time. Most concretes used are lime -based concretes such as Portland cement. When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid mass that is easily molded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or super plasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete. Today, large concrete structures (for example, dams and multi-storey car parks) are usually made with reinforced concrete. Many types of concrete are available, distinguished by the proportions of the main ingredients below. In this way or by substitution for the cementitious and aggregate phases, the finished product can be tailored to its application. Strength, density, as well chemical and thermal resistance are variables.

Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite , along with finer materials such as sand. Cement, most commonly Portland cement, is associated with the general term "concrete."

1.1.2 Cement

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and many plasters. English masonry worker Joseph Aspdin patented Portland cement in 1824. It was named because of the similarity of its color to Portland limestone, quarried from the English Isle of Portland and used extensively in London architecture. It consists of a mixture of calcium silicates (alite , belite), aluminates and ferrites - compounds which combine calcium, silicon, aluminum and iron in forms which will react with water. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay and/or shale (a source of silicon, aluminum and iron) and grinding this product (called clinker) with a source of sulfate (most commonly gypsum).

In modern cement kilns many advanced features are used to lower the fuel consumption per ton of clinker produced. Cement kilns are extremely large, complex, and inherently dusty industrial installations, and have emissions which must be controlled. Of the various ingredients used to produce a given quantity of concrete, the cement is the most energetically expensive. Even complex and efficient kilns require 3.3 to 3.6 gigajoules of energy to produce a ton of clinker and then grind it into cement. Many kilns can be fueled with difficult-to-dispose-of wastes; the most common being used tires. The extremely high temperatures and long periods of time at those temperatures allows cement kilns to efficiently and completely burn even difficult- to-use fuels.

1.1.3 Water

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. A lower water-to-cement ratio yields a stronger, more durable concrete, whereas more water gives a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles and other components of the concrete to form a solid mass. Reaction:

Cement chemist notation : $C_3S + H \rightarrow C\text{-}S\text{-}H + CH$

Standard notation: $Ca_3SiO_5 + H_2O \rightarrow (CaO)\cdot(SiO_2)\cdot(H_2O)(gel) + Ca(OH)_2$

Balanced: $2Ca_3SiO_5 + 7H_2O \rightarrow 3(CaO)\cdot 2(SiO_2)\cdot 4(H_2O)(gel) + 3Ca(OH)_2$

(Approximately; the exact ratios of the CaO, SiO_2 and H_2O in C-S-H can vary)

1.1.4 Aggregate

Fine and coarse aggregates make up the bulk of a concrete mixture. Sand , natural gravel, and crushed stone are used mainly for this purpose. Recycled aggregates (from construction, demolition, and excavation waste) are increasingly used as partial replacements for natural aggregates, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted. The size distribution of the aggregate determines how much binder is required. Aggregate with a very even size distribution has the biggest gaps whereas adding aggregate with smaller particles tends to fill these gaps. The binder must fill the gaps between the aggregate as well as pasting the surfaces of the aggregate together, and is typically the most expensive component. Thus variation in sizes of the aggregate reduces the cost of concrete. The aggregate is nearly always stronger than the binder, so its use does not negatively affect the strength of the concrete. Redistribution of aggregates after compaction often creates in homogeneity due to the influence of vibration. This can lead tostrength gradients. Decorative stones such as quartzite, small river stones or crushed glass are sometimes added to the surface of concrete for a decorative "exposed aggregate" finish, popular among landscape designers.

1.1.5 Admixture

Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement and are added to the concrete at the time of batching/mixing. (See the section on Concrete Production, The common types of admixtures are as follows: Accelerators speed up the hydration (hardening) of the concrete. Typical materials used are CaCl 2, Ca(NO 3) 2 and NaNO 3. However, use of chlorides may cause corrosion in steel reinforcing and is prohibited in some countries, so that nitrates may be favored. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather. Retarders slow the hydration of concrete and are used in large or difficult pours where partial setting before the pour is complete is undesirable. Typical polyol retarders are sugar , sucrose , sodium gluconate, glucose, citric acid, and tartaric acid

. Air entraining agents add and entrain tiny air bubbles in the concrete, which reduces damage during freeze-thaw cycles, increasing durability. However, entrained air entails a trade off with strength, as each 1% of air may decrease compressive strength 5%. If too much air becomes trapped in the concrete as a result of the mixing process, Deformers can be used to encourage the air bubble to agglomerate, rise to the surface of the wet concrete and then disperse.

Plasticizers increase the workability of plastic or "fresh" concrete, allowing it be placed more easily, with less consolidating effort. A typical plasticizer is lignosulfonate. Plasticizers can be used to reduce the water content of a concrete while maintaining workability and are sometimes called water- reducers due to this use. Such treatment improves its strength and durability characteristics. Superplasticizers (also called high-range water-reducers) are a class of plasticizers that have fewer deleterious effects and can be used to increase workability more than is practical with traditional plasticizers. Compounds used as superplasticizers include sulfonated naphthalene formaldehyde condensate, sulfonated melamine formaldehyde condensate, acetone formaldehyde condensate and polycarboxylate ethers. Pigments can be used to change the color of concrete, for aesthetics. Corrosion inhibitors are used to minimize the corrosion of steel and steel bars in concrete. Bonding agents are used to create a bond between old and new concrete (typically a type of polymer) with wide temperature tolerance and corrosion resistance. Pumping aids improve pump ability, thicken the paste and reduce separation and bleeding.

1.2 REPLACEMENT OF COARSE AGGREGATE WITH PKS AND LATRITE WITH FINE AGGREGATE

Continuous increase in the cost of construction is one of the major challenges the construction industry is encountering and quality discharge of great number of developmental project, as such projects are dependent on some factors of production which is the cost of materials (Anthony, 2000). In line with this, Shetty (1999) affirmed that the prices of concrete elements primarily depends on the cost of material and labour. According to Falade, Ikponmwosa and Ojediran, (2010) the volume of concrete is composed of about 70-80% of coarse aggregate, which is to connote that the percentage is of considerable importance. The use of natural agricultural and industrial bye product has now become imperative as alternatives to the use of granite that causes noise pollution during manufacturing according to Falade et al, (2010).

1.2.1 Laterite

Laterite is a soil and rock type rich in iron and aluminum, and is commonly considered to have formed in hot and wet tropical areas. Nearly all laterite are of rusty-red coloration, because of high iron oxide content. They develop by intensive and long-lasting weathering of the underlying parent rock. Tropical weathering (laterization) is a prolonged process of chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils. The majority of the land area containing laterite is between the tropics of Cancer and Capricorn. Laterite has commonly been referred to as a soil type as well as being a rock type. This and further variation in the modes of conceptualizing about laterite (e.g. also as a complete weathering profile or theory about weathering) has led to calls for the term to be abandoned altogether. At least a few researchers specializing in regolith development have considered that hopeless confusion has evolved around the name. There is no likelihood, however, that the name will ever be abandoned; for material that looks highly similar to the Indian laterite occurs abundantly worldwide, and it is reasonable to call such material laterite.

Historically, laterite was cut into brick-like shapes and used in monument-building. After 1000 CE, construction at Angkor Wat and other southeast Asian sites changed to rectangular temple enclosures made of laterite, brick and stone. Since the mid-1970s, some 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, so the layers can function as aquifers in rural areas. Locally available laterites have been used in an acid solution, followed by precipitation to remove phosphorus and heavy metals at sewage-treatment facilities.

Laterites are a source of aluminum ore; the ore exists largely in clay minerals and the hydroxides, gibbsite, boehmite, and diaspore, which resembles the composition of bauxite. In Northern Ireland they once provided a major source of iron and aluminum ores. Laterite ores also were the early major source of nickel.

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 a brick; this highly compacted and cemented soil can easily be cut into brick-shaped blocks for building. The word laterite has been used for variably cemented, sesquioxide-rich soil horizons. A sesquioxide is an oxide with three atoms of oxygen and two metal atoms. It has also been used for any reddish soil at or near the Earth's surface.

Laterite covers are thick in the stable areas of the Western Ethiopian Shield, on cratons of the South American Plate, and on the Australian Shield. In Madhya Pradesh, India, the laterite which caps the plateau is 30 m (100 ft) thick. Laterite can be either soft and easily broken into smaller pieces, or firm and physically resistant. Basement rocks are buried under the thick weathered layer and rarely exposed.[3]:1 Lateritic soils form the uppermost part of the laterite cover

Lateritic soils are widely used as a construction material in Nigeria and other under-developed and developing countries of the world. The use of laterite in combination with river sand in particular have received much attention in Nigeria, laterite being a tropical soil that is abundantly available in the tropical belts of the world. This had attracted the interest of researchers both in the time past and in recent times. The efforts of these researchers have led to the production of laterized concrete. Laterized concrete is a concrete in which stable laterite replaces fie aggregate, basically sand. Results of investigations on laterized concrete as reported by most researchers have consistently shown that laterized concrete is inferior in compressive strength and durability when compared to conventional concrete. For this reason, laterized concrete has found little or no application in the Nigerian construction industry. Generally in the preparation of concrete, the addition of water to its dry constituents brings about chemical reaction between it and cement which is referred to as hydration thereby producing cement gel and Calcium Hydroxide ($Ca(OH)2$). From these products of hydration, $Ca(OH)2$ most readily react with($CO2$) to form Calcium Carbonate ($CaCO3$) with the rate of carbonation of concrete increasing with an increase in concentration of $CO2$. Carbonation could have some positive consequences because $CaCO3$ occupies greater volume than $Ca(OH)2$ which it replaces and in turn reduces the porosity of concrete since it is generally accepted that the durability of concrete is related to the characteristics of its pore structure. Proportions of mix, the method of compaction and other controls during placing, compaction and curing. The supply of sand is being threatened by a number of factors on one hand while its demand is increasing at alarming rate on the other hand. Increasing environmental consideration are among other factors besides being the only conventional fine aggregate that militate against supply of sand. It has been observed that based on the availability of laterite, a fine aggregate and laterite could either partially or wholly replace sand as fine aggregate. The criterion for concrete strength requirement is always based on the characteristic compressive strength obtained after 28-day curing. The compression strength of concrete is usually determined by performing compression test on standard sizes of concrete blocks (i.e., 150mm x 150mm x 150mm).The strength of concrete is affected partly by the relative proportion of cement and of the fie and coarse aggregates but the water-cement ratio is another important factor Carbon IV Oxide.

Plate 1.1: Packing of Laterite

1.2.2 Palm Kernel Shell (PKS)

Palm kernel shells are not common materials in the construction industry. This is either because they are not available in very large quantities as sand or gravel, or because their use for such has not been encouraged. For some time now, the Nigerian government has been clamoring for the use of local materials in the construction industry to limit costs of construction. The palm oil industry produces wastes such as palm kernel shells, palm oil fibers which are usually dumped in the open thereby impacting the environment negatively without any economic benefits. Palm kernel shells (PKS) are hard, carbonaceous, and organic by products of the processing of the palm oil fruit.

PKS consists of small size particles, medium size particles and large size particles in the range 0-5mm, 5-10mm and 10-15mm (Alengaram, Mahmud, Jumaat and Shiraz, 2010). Between 70 to 80 per cent out of the total volume of concrete is occupied by aggregate. With this large proportion of the concrete occupied by aggregate, it is expected for aggregate to have a profound influence on the concrete properties and its general performance. Aggregates are essential in making concrete into an engineering material.

Plate 1.2: Palm kernel shell

1.3 STATEMENT OF THE PROBLEM

Sustainability issues, investigation to what extent can waste materials be used as replacement for materials constituents, industrial waste.

Structural engineers face significant challenges in the 21st century and among them, global environmental challenges must be a priority for our profession. On a planet with finite natural resources and an ever-growing built environment, engineers of the future must consider the environmental, economic, and social sustainability of structural design. To achieve a more sustainable built environment, engineers must be involved at every stage of the process.

To address the broad issue of sustainability for structural engineers, it should be addressed in these two forms namely.

Global environmental impact: The trends in steel and concrete consumption worldwide illustrate the growing environmental impact of structural design. In particular, the emissions of greenhouse gases due to structural materials are a primary global concern that all structural engineers should consider.

Solutions for today: There are many steps that each structural engineer can take to mitigate the environmental impact of structural design. Furthermore, there is growing demand for engineers who are knowledgeable of environmental issues in construction. This section presents several options that are available today for engineers interested in reducing environmental impacts.

Global Environmental Impact

On a planet with finite natural resources, the human population is growing and the rate of resource consumption per person is growing. This cannot continue indefinitely. In 1974, a landmark study by an interdisciplinary research group at MIT illustrated the various global scenarios that may occur depending on a range of possible technological, economic, and social assumptions (Meadows et al. 1974). Almost all of the possible scenarios predicted a collapse of natural resources followed by a collapse of human populations and decreased quality of life. Recently, a 30-year update reconfirmed the key conclusions of this study and illustrated the grave challenges facing global society in the future (Meadows et al. 2004). Increasing greenhouse gas levels, rising global temperatures, rising sea levels, and dramatic resource depletion have all occurred at increasing rates in the last 30 years. The growing need to address these challenges has become more accepted in the last decade and civil engineers have begun to play an important role. Since the 1987 Brundtland report defined sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their own needs," the concept of sustainability has become an ethical standard and a goal for both government and industry (Brundtland 1987). Though civil engineers have not provided global leadership on this issue in recent decades, it is clear that the profession of civil engineering will play an integral role in achieving more sustainable development in the future (ASCE 2001). Over the last 200 hundred years, the definition of civil engineering has evolved from "directing the great sources of power in Nature for the use and convenience of Man" (Chrimes 1991) to a more recent definition that "Civil engineers are the custodians of the built and natural environment" (Agenda 2003). This shift illustrates the fundamental change in the relationship between engineers and the natural world

1.4 Aim and Objectives

The aim of this work is to determine the strength performance of lateritic concrete.

In order to achieve the stated aim, the following objectives are set.

1. To determine the effect of palm kernel shell(PKS) on the workability of a lateritic concrete
2. The effects of palm kernel shell(PKS) on density of lateritic concrete.
3. To determine the effect of palm kernel shell (PKS) on durability characteristics of lateritic concrete.
4. To determine the effect of palm kernel shell (PKS) on the microstructure of lateritic concrete.
5. To study the data obtained from the above so as to make appropriate recommendation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 WORK DONE ON PALM KERNEL SHELL (PKS) WITH CONCRETE

(william, 2014) This research work vividly shows that Palm kernel shell can be used for concrete production as lightweight aggregate and therefore can be used to produce lightweight concrete. The properties of Palm kernel shell fresh concrete is however excellent, it is very workable, consistent and easily placed. Hardened palm kernel shell concrete (lightweight concrete) developed sufficient strength that will help make it suitable for a wide range of uses. However the flexural and compressive strength values of the normal weight concrete is about twice that of the palm kernel shell which is normal as Palm kernel shell is lighter. The specific gravity of Palm kernel shell coarse aggregate is relatively low compared to the range of values for different coarse aggregate as a result of the high amount of voids within the particles. It can therefore be concluded that PKSC is useful as coarse aggregate where they are abundant in other to reduce the cost of building construction. Palm kernel shell concrete can also be partially replaced with course aggregate to get a desired strength in building construction projects. It can be concluded from the findings of Zarina Itam et al (2016) The Feasibility of Palm Kernel Shell as a Replacement for Coarse Aggregate in Lightweight Concrete;

1. The workability of fresh concrete mix decreases with the inclusion of palm kernel shell.
2. Water absorption for concrete containing Palm kernel shell increases but is still within standard ranges.
3. The inclusion of Palm kernel shell reduces the concrete strength, but the replacement of 50% Palm kernel shell gives acceptable values as it falls within the range of requirement for structural LWC components.

The work of Olutoge and Quadri (2012) Investigation of the Strength Properties of Palm Kernel Shell Ash Concrete concluded that Concrete strengths increases with curing age and decreases with increasing percentage of PKSA replacement in concrete. The use of Palm kernel shell Ash will minimize the environmental issues arising from the disposal of Palm kernel wastes. The use of palm kernel shell will reduce the volume of aggregate used in concrete, thereby reducing the cost of concrete production. The work of Peter Ndoke (2015), Performance of Palm Kernel Shells as a Partial replacement for Coarse Aggregate in Asphalt Concrete from the results obtained, it can be concluded that:

Palm kernel shells can be used as partial replacement for coarse aggregate up to 10% for heavily trafficked roads and 50% for light trafficked roads.

For the very lightly trafficked roads in the rural communities palm kernel shells can be used as full replacement for the coarse aggregates. This will go a long way into reducing construction and maintenance costs of these roads.

The quest by governments in developing countries, especially those in Africa south of the Sahara for use of locally available materials in infrastructure development will be met th the use of palm kernel shells as a road construction material.

The economic power of the rural dwellers will be enhanced if they are encouraged to plant palm trees from which these shells could be gotten.

It can be concluded from the findings of Festus et al (2016) Investigation of the Strength Properties of Palm Kernel Shell Ash Concrete the following conclusions can be arrived at

1. PKSA contains all the main chemical constituents of cement though in varying quantities compared to that of OPC; this means it will be a good replacement if the right Percentage is used.
2. The use of PKSA as a partial replacement for cement exhibits a lower water absorption rate and slower setting time of concrete.
3. Concrete strengths increases with curing age and decreases with increasing percentage of PKSA replacement in concrete.
4. The use of PKSA will reduce the volume of cement used in concrete, thereby reducing the cost of concrete production.

The use of PKSA will minimize the environmental issues arising from the disposal of Palm kernel wastes.

The work of owolabi (2012) Assessment of Palm Kernel Shells as Aggregate in Concrete and Laterite blocks tests on palm kernel shells revealed low specific gravity, high moisture content and water absorption rate. Concrete with crushed stone as coarse aggregate has higher strength than concrete with palm kernel shells as aggregate. This shows that palm kernel shells cannot be substituted for crushed stones as coarse aggregate in concrete except for aesthetic purposes. However, concrete with palm kernel shells as aggregate could be used for lightweight construction work. Laterite cubes reinforced with palm kernel shells are about 15% stronger than plain laterite cubes. However, it has been discovered that the proportion of kernel shells that would result in the maximum strength of laterite cubes is 25%, above which there could be a reduction in strength. This is because increase in quantity of kernel shells beyond the optimum value results in the reduction of the cohesive property of laterite. The strength of laterite cubes (whether plain or reinforced with kernel shells) compare favorably with the strength of sandcrete blocks popularly used in day to day building construction work as partitions; so laterite blocks are good substitutes for sandcrete blocks. It can be concluded from the findings of Daniel and Emmanuel (2012) Experimental Study on Palm Kernel Shells as Coarse Aggregates in Concrete that;

There exists a high potential for the use of palm kernel shells as aggregates in the manufacture of lightly reinforced concrete.

PKSC batched by volume replacement or weight replacement of coarse aggregate with palm kernel shells show similar trends in the variation of density, workability and strength with increase in percentage replacement

Loss of strength ,workability and density per increase in percentage replacement by PKS is higher for weight-batched concrete than for volume batched concrete

There are potential cost reductions in concrete production using palm kernel shells as partial replacement for crushed granite

Based on the results obtained, replacement of 8% crushed granite by palm kernels shell in volume batched concrete can be used in reinforced concrete construction whereas replacement of 13% if crushed granite in weight batched concrete can be used in reinforced concrete construction.

Palm kernel shell concrete batched by volume performed better than that batched by weight.

2.2 WORK DONE ON LATERITE

According to Tanveer Asif Zerdi et al (2016) Suitability of using laterite as Partial Replacement of Fine Aggregate in Concrete From the experimental investigation, the following conclusions are arrived at;

The development of compressive strength for normal mix concrete is giving the 21.74, 29.51, 32.07 N/mm 2 at 7, 21 and 28 days of curing respectively.

Similarly the compressive strength of laterite replaced concrete is giving 26.95, 29.41N/mm 2 at 15, 30 percentage replacement of laterite respectively.

If we compare the values of the two types of concretes studied shows that the incorporation of laterite sand by replacing normal shahpur sand is decreasing the compressive strength of concrete, but this decrement is not very large, hence authors feels that the replacement of laterite sand is a break through to the prevailing crisis of availability of river bedded sand. Hence authors recommends to utilize laterite sand in the manufacturing the concrete.

Introduction of laterite content into the concrete matrix is found to reduce the workability of the mix. This is due to fiesse of laterite which ultimately increases the total surface area of concrete and consequently, more water is required to wet the surface of aggregate.

It can also be concluded from the findings of Asiedul and Agbenyega (2014) Suitability of Laterite fines as a Partial Replacement for Sand in the production of sandcrete bricks that

1. The use of laterite fines as a partial replacement has a significant influence on the engineering properties of bricks.
2. Even though, the densities and compressive strength characteristics of the bricks were found to be inferior to bricks with only natural sand and cement (control bricks), they were found to be suitable for both load and non-load bearing masonry units after 28 days curing age.
3. Although, composite bricks are recommended for both load bearing and non-load bearing wall construction, they should be well rendered to ensure protection from moisture ingress especially when used for external walls or below ground level.
4. Bricks with laterite fines replacing the natural sand can satisfactorily perform as a masonry unit when the laterite fines content does not exceed 30%.

The work of olubisi A. ige (2013) performance of lateritic concrete under environmental harsh condition. The influence of high temperature, chemical and alternating wet and dry condition on the compressive strength of laterized concrete has been investigated. It was found that for laterized concrete mix 1:2:4 and curing age of 28 days, with laterite fine aggregate ratio variation as a factor, 20% replacement of fine aggregate by laterite had a reasonable compressive strength for temperature applications up to 100°C whereas plain concrete and other percentage replacement suffered a reduction in compressive strength as the temperature increases. The reason for this could be due to some other inherent salts present in the laterite which may experience a breakdown in their internal structure when subjected to temperatures above 100°C, thus leading to a reduction in the compressive strength of the laterized concrete, on the other hand, the increase in compressive strength for 20% replacement at temperature range of 100°C could be due to a gradual build up in the bond of the inherent salts present in the laterite which thus lead to a high bearing capacity of the laterized concrete.

Another conclusion drawn from the result of this study when laterized concrete is subjected to alternate wetting and drying, compressive strengths were as low as 9.30N/mm^2. It implies that laterized concrete depreciates with time under the prevailing conditions (rainy and dry season) in the tropic. Similarly, when the same laterized concrete is subjected to magnesium sulphate (Mg_2SO_4), compressive strengths were as high as 14.22N/mm^2. It implies that laterized concrete increases in strength when exposed to various metallic salts solution.

.Optimum compressive strengths could be obtained at 20% laterized-fine aggregate ratio at temperature of 50 – 100°C. It is thereby recommended that for any concrete works in which laterite was to be used as a replacement or substitute for fine on coarse aggregate, the laterite should be carefully subjected to various test to ensure the suitability of the laterite for concrete strength. Also, the laterized concrete should not be exposed to constant rainy and dry season as it could result in reduction of its compressive strength. Otherwise, it could be subjected or exposed to magnesium sulphate salt (Mg_2SO_4) or any other metallic salt which may improve its compressive strength.

According to Theophilus (2015), an investigation into structural strengths of laterized concrete. it can be concluded that: the workability of LATCON increases while the percentage of water absorption by the concrete decreases with increase in replacement level of sand by laterite; 40% of laterite and 60% of sand is classified as falling into Zone 2 (region as evidenced of grading): the strengths of laterite concrete generally increased with age but decreases with increase in the replacement level of sand by laterite; LATCON with maximum of 40% replacement levels of sand by laterite attained the design strength of 20.48 N/mm2 for C20, but was 15.36% lower than the design of 25 N/mm^2 for C25 at 28-day hydration period; for class C20 it is proposed that the mix proportion be modified to 1:0.8:1.2:4 (cement: laterite: sand: coarse aggregate) instead of the usual 1:2:4 (cement: sand: coarse aggregate) and correspondingly 1:0.8:1.2:2 instead of 1:2:2 for C25: and for C20 and C25 LATCON the following expressions are proposed:
Ft (C20) = 0.2093 (f_{cu}) 0.5259

$R_2 = 0.8946$

Ft (C25) = 0.4961(fcu)0.2945

$R_2 = 0.947$

According to L. O. Ettu et.al (2013) The Suitability of using laterite as sole fine aggregate in structural concrete, laterite could be used as sole fine aggregate for making structural concrete. Such laterized concrete would be especially useful for concrete elements under mild conditions of exposure that are reasonably protected from the effects of harsh weather. We recommend using a combination of traditional concrete and laterized concrete for more sensitive structures; in which case traditional concrete could be used in casting members under moderate and harsher conditions of exposure such as foundations and other members in continuous contact with water, and laterized concrete used for members under mild conditions of exposure. Also, since laterized concrete has a lower unit weight than traditional concrete, it would be more suitable for use in Nigerian communities with problematic soils that have poor or unreliable bearing capacities. Moreover, the prevalence of laterite in most communities also means the use of laterized concrete would greatly contribute toward the provision of low cost housing units for the rapidly increasing populace in major urban cities such as Owerri in Imo State of Nigeria. The resultant burrow pits could be well utilized for sanitary landfills and recovered for other convenient uses at the maturation of the landfills

CHAPTER THREE

3.0 METHODOLOGY

3.1 THEORETICAL BACKGROUND

Standardized value of coarse aggregate is 20mm , in the packing theory the coarse aggregate having 20mm diameter will have a particular number a container will contain at a time but since we are replacing the coarse aggregate with palm kernel shell which has a lesser diameter then the number of materials the container will take will be more and these in turn will increase the parking density, then the effect of these packing is studied and known if it will ultimately affect the structural performance of the concrete.

The packing of an aggregate for concrete is the degree of how good the solid particles of the aggregate measured in terms of 'packing density', which is defined as the ratio of the solid volume of the aggregate particles to the bulk volume occupied by the aggregate.

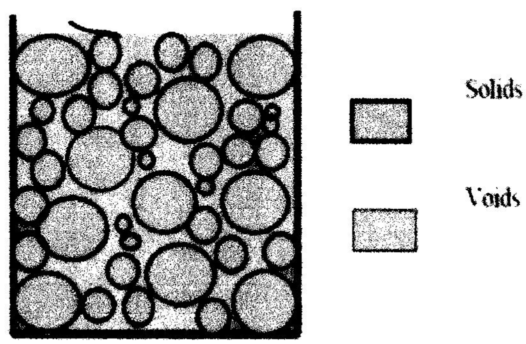


Figure 3.1: Packing Density

From the packing density 'voids ratio', that is the ratio of the volume of voids between the aggregate particles to the bulk volume occupied by the aggregate. Particle packing models are based on the concept that voids between larger particles would be filled by smaller particles thereby reducing the volume of voids or increasing the packing density. Thus the important property regarding packing of multi particle system is the packing density .The packing density of a multi particle system.

3.2 MATERIAL ESTIMATION

For 1 batch

Material estimation of cubes of $0.15 \times 0.15 \times 0.15 = 0.003375m^3$

Density of concrete = 2400Kn

For 3 cubes density(γ)=$m \div v$ = m= γv = 2400×0.012

= 28.8kg

For mix ratio 1:2:4

Cement = $\frac{1}{7} \times 28.8 = 4.11kg$

Sand = $\frac{2}{7} \times 28.8 = 8.23kg$

Granite = $\frac{4}{7} \times 28.8 = 16.46kg$

Material estimation of cubes of $0.10 \times 0.10 \times 0.10 = 0.001m^3$

Density of cement = 2400Kn

For 2 cubes density (γ) = $m \div v$ = m= γv = 2400×0.002

= 4.8kg

For 1 cube = 2.4kg

For mix ratio 1:2:4

Cement = $\frac{1}{7} \times 4.8 = 0.68kg$

Sand = $\frac{2}{7} \times 4.8 = 1.37kg$

Granite = $\frac{4}{7} \times 4.8 = 2.74kg$

TABLE 3.1 MATERIAL ESTIMATION

Mix	Cement	Fine aggregate		Coarse aggregate	
		Laterite	Sand	PKS	Granite
0	4.11	0	8.23	0	16.46
0	4.79	2.88	6.72	0	19.20
10	4.79	2.88	6.72	1.92	17.28
20	4.79	2.88	6.72	3.84	15.36
30	4.45	2.67	6.24	5.35	12.48
40	4.45	2.67	6.24	7.13	10.70
50	4.45	2.67	6.24	8.92	8.92

3.3 Experimental investigations

I. The Preliminary investigation
II. The Main investigation

3.3.1 Preliminary investigations

The preliminary investigation carried out on the aggregates, sand, laterite and palm kennel were density, specific gravity, porosity, moisture content, water absorption, crushing test, and mechanical analysis

3.3.1.1 Density

Density is elementary physical property of matter. For a homogeneous object it is the density (ρ) defined as the ratio of its mass (m) to its volume (V)
$\rho = mV$ Kg m^{-3}

Experimental procedure:

Accuracy of herein described method for density determination of liquid and/or solid matter relies on precise measurements of weight and volume. Since it is important to determine weight of empty pycnometer in its dry state, we do so at the beginning.

1. Determine the weight of empty, dry pycnometer

2. Fill about 1/3 of pycnometer volume with objects made of examined material and measure the weight m_1.
3. Add water such that pycnometer as well as capillary hole in the stopper is filled with water. Dry the spare water that leaks through the capillary hole with a filter paper and measure total weight m_2.
4. Empty pycnometer filled with distilled water only. Use the filter paper to dry the spare water again and measure the weight (m_3).
5. Empty pycnometer. Rinse it once with a liquid whose density you are going to determine next. Fill pycnometer with the liquid as previously and measure the weight m_4.
6. Clean pycnometer carefully after finishing the experiment. Rinse it with distilled water and let dry.
7. Measure the laboratory temperature t, which determines the temperature of examined liquids and solid objects.
8. Calculate the weight of water $mH_2O = m_3 - m_0$, weight of measured liquid $mL = m_4 - m_0$ and determine density of liquid.

3.3.1.2 Porosity

The amount of empty space in a rock or other earth substance; this empty space is known as pore space. Porosity is how much water a substance can hold. Porosity is usually stated as a percentage of the material's total volume

Procedure for measuring porosity

1. Measure out 100 mL of water in the graduated cylinder.
2. Pour the 100 mL of water in one of the cups and use the marker to mark the level.
3. Pour the water back into the graduated cylinder.
4. Fill the same cup with sand up to the mark you drew.
5. Pour the 100 mL of water slowly into the sand. Stop when the water level just reaches the top of the sand.
6. Record the amount of water left in the graduated cylinder in the right column.
7. Calculate the pore space by subtracting the amount left in the graduated cylinder from the original 100mL.
8. Repeat steps 4-7 with the pea gravel and yard soil.

9. Calculate the %porosity and record in the table. Use this formula: $POROSITY\ \frac{PORE\ SPACE\ VOUME}{TOTAL\ VOLUME} \times 100$

3.3.1.3 Water Absorption

This test helps to determine the water absorption of coarse aggregates. For this test a sample not less than 2000g should be used. The apparatus used for this test are :-

Wire basket – perforated, electroplated or plastic coated with wire hangers for suspending it from the balance, Water-tight container for suspending the basket, Dry soft absorbent cloth – 75cm x 45cm (2 nos.), Shallow tray of minimum 650 sq.cm area, Air-tight container of a capacity similar to the basket and Oven.

Procedure to determine water absorption of Aggregates

The sample should be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 and 32oC.

After immersion, the entrapped air should be removed by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample should remain immersed for a period of 24 + ½ hrs afterwards.

The basket and aggregates should then be removed from the water, allowed to drain for a few minutes, after which the aggregates should be gently emptied from the basket on to one of the dry clothes and gently surface-dried with the cloth , transferring it to a second dry cloth when the first would remove no further moisture. The aggregates should be spread on the second cloth and exposed to the atmosphere away from direct sunlight till it appears to be completely surface-dry. The aggregates should be weighed (Weight 'A').

The aggregates should then be placed in an oven at a temperature of 100 to 110°C for 24hrs. It should then be removed from the oven, cooled and weighed (Weight 'B').

3.3.1.4 Sieve Analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

The apparatus used are

1. A set of IS Sieves of sizes – 80mm, 63mm, 50mm, 40mm,31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm and 75µm.
2. Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample.

The weight of sample available should not be less than the weight given below:-

The sample for sieving should be prepared from the larger sample either by quartering or by means of a sample divider.

Procedure to determine particle size distribution of Aggregates

I. The test sample is dried to a constant weight at a temperature of 110 + 5°C and weighed.
II. The sample is sieved by using a set of IS Sieves.
III. On completion of sieving, the material on each sieve is weighed.
IV. Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.
V. Fineness modulus is obtained by adding cumulative percentage of aggregates retained on each sieve and dividing the sum by 100.

Reporting of Results

The results should be calculated and reported as:

i. The cumulative percentage by weight of the total sample
ii. The percentages by weight of the total sample passing through one sieve and retained on the next smaller sieve, to the nearest 0.1 percent. The results of the sieve analysis may be recorded graphically on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller than the specified diameter as ordinate.

3.3.1.5 Aggregate Impact Value

This test is done to determine the aggregate impact value of coarse aggregates. The apparatus used for determining aggregate impact value of coarse aggregates is Impact testing machine conforming to IS: 2386 (Part IV)- 1963, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm, A cylindrical metal measure of 75mm dia. and 50mm depth, A tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Oven.

Preparation of Sample

The test sample should conform to the following grading:

Passing through 12.5mm IS Sieve – 100%

Retention on 10mm IS Sieve – 100%

The sample should be oven-dried for 4hrs. at a temperature of 100 to 110oC and cooled.

The measure should be about one-third full with the prepared aggregates and tamped with 25 strokes of the tamping rod.

A further similar quantity of aggregates should be added and a further tamping of 25 strokes given. The measure should finally be filled to overflow, tamped 25 times and the surplus aggregates struck off, using a tamping rod as a straight edge. The net weight of the aggregates in the measure should be determined to the nearest gram (Weight 'A').

Procedure to determine Aggregate Impact Value

i. The cup of the impact testing machine should be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by 25 strokes of the tamping rod.
ii. The hammer should be raised to 380mm above the upper surface of the aggregates in the cup and allowed to fall freely onto the aggregates. The test sample should be subjected to a total of 15 such blows, each being delivered at an interval of not less than one second.

Reporting of Results

i. The sample should be removed and sieved through a 2.36mm IS Sieve. The fraction passing through should be weighed (Weight 'B'). The fraction retained on the sieve should also be weighed (Weight 'C') and if the total weight (B+C) is less than the initial weight (A) by more than one gram, the result should be discarded and a fresh test done.

ii. The ratio of the weight of the fines formed to the total sample weight should be expressed as a percentage.

Aggregate impact value = (B/A) x 100%

Two such tests should be carried out and the mean of the results should be reported

3.3.1.6 Moisture Content

This test is used to determine the water content of a material by drying a sample to constant mass at a specified temperature. The water content of a given soil is defined as the ratio, expressed as a percentage, of the mass of the pore water to the mass of the solid material (or "solids").

Apparatus

1. Weighing device: A balance or scale sensitive to 0.1 % of the mass of the test sample, and having a capacity equal to, or greater than, the wet mass of the sample to be tested.
2. Drying device: An oven or other suitable thermostatically controlled heating chamber capable of maintaining a temperature of 110 ± 5°C.
3. Containers: Any pan or other container that will not be affected by the drying temperature, and is suitable for retaining the test sample without loss while permitting the water to evaporate.

Test Procedure

Prepare a representative portion of the material to be tested.

1. Determine the mass of the test sample and record this mass as the "wet mass"
2. Dry to constant mass at 110 ± 5°C.
3. Remove the sample from the drying device
4. Determine the mass of the test sample and record this weight as the "dry mass" and cool to room temperature.

3.3.1.7 Specific Gravity

This lab is performed to determine the specific gravity of soil by using a pycnometer. Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to t he mass of the same volume of gas-free distilled water at a stated temperature.

Standard Reference:

ASTM D 854-00 – Standard Test for Specific Gravity of Soil Solids by Water Pycnometer.

Significance:

The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil.

Equipment:

Pycnometer, Balance, Vacuum pump, Funnel, Spoon

Test Procedure:

1. Determine and record the weight of the empty clean and dry pycnometer, WP.
2. Place 125g of a dry soil sample (passed through the sieve No. 10) in the pycnometer. Determine and record the weight of the pycnometer containing the dry soil, WPS.
3. Add distilled water to fill about half to three-fourth of the pycnometer. Soak the sample for 10 minutes.
4. Apply a partial vacuum to the contents for 10 minutes longer, to remove the entrapped air.
5. Stop the vacuum and carefully remove the vacuum line from pycnometer.
6. Fill the pycnometer with distilled (water to the mark), clean the exterior surface of the pycnometer with a clean, dry cloth. Determine the weight of the pycnometer and contents, WB.
7. Empty the pycnometer and clean it. Then fill it with distilled water only (to the mark). Clean the exterior surface of the pycnometer with a clean, dry cloth. Determine the weight of the pycnometer and distilled water, WA.
8. Empty the pycnometer and clean it.

Data Analysis:

Calculate the specific gravity of the soil solids using the following formula:

$$Specific\ Gravity, G_s = \frac{W_0}{W_0 + (W_A - W_B)}$$

Where:

W_0 = weight of sample of oven-dry soil,

g= W_{PS}- W_P

W_A = weight of pycnometer filled with water

W_B = weight of pycnometer filled with water and soil

3.3.1.8 Aggregate Crushing Value

The aggregate crushing value give relative measure of aggregate to crushing under a gradually applied compressive load. Crushing value is a measure of the strength of the aggregate .The aggregate should therefore have minimum crushing value.

Apparatus

1. A 15cm diameter open ended steel cylinder with plunger and base plate ,of the general form and dimension
2. A straight metal tampering rod of circular cross-section 16mm diameter and 45 to 60cm long, rounded at one end.
3. A balance of capacity 3k, readable and accurate up to 1g
4. IS Sieve of sizes 12.5,10 and 2.36mm
5. A compressive testing machine capable of applying a load of 40 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minute .The machine may be used with or without a spherical seating.
6. For measuring the sample,cylinder metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions;
   Diameter 11.5cm
   Height 18.0cm

PROCEDURE

The test sample; it consist of aggregate size 12.5mm-10.0mm (minimum3kg).

The aggregates should be dried by heating at100-110C for a period of 4 hours and cooled.

1. Sieve the material through 12.5mm and 10.0mm IS sieve. The aggregate passing through 12.5mm sieve and retained on 10.0mm sieve comprise the test material.
2. The cylinder of the test shall put in position on the base-plate and the test sample added in thirds, each third being subjected to 25stroke with tampering rod.
3. The surface of the aggregate shall be carefully leveled.
4. The plunger is inserted so that it rests horizontally on this surface ,care being taken to ensure that the plunger does not jam in the cylinder
5. The apparatus with the test sample and plunger in position ,shall then be placed between the plates of the testing machine.
6. The load is applied at a uniform rate as possible so that the total load is reached in 10minutes.The total load shall be 40 tonnes.
7. The load shall be released and the whole of the material is removed from the cylinder and sieved on 2.36mmIS Sieve
8. The fraction passing the sieve shall be weighed and recorded.

3.3.1.9 Los Angeles Abrasion Value

The principle of Los Angeles abrasion test is to produce the abrasion action by use of standard steel balls which when mixed with the aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates .The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value

APPARATUS

1. Los Angeles Machine: It consist of a hollow steel cylinder, closed at both the ends with an internal diameter of 700mm and length 500mm and capable of rotating about its horizontal axis. A removable steel shaft projecting radially 88 mm into cylinder and extending full length (i.e 500mm) is mounted firmly on the interior of cylinder. The shelf is placed at a distance 1250mm minimum from the opening in the direction of rotation.

2. Abrasion charge: Cast iron or steel balls, approximately 48mm in diameter and each weighing between 390 to 445g;6 to 12 balls are required.
3. Sieve: The 1.70mm IS sieve
4. Balance of capacity 5 kg or 10kg.
5. Draying oven
6. Miscellaneous like tray

PROCEDURE

Test sample: it consist of clean aggregates dried in oven at 105-110c and are coarser than 1.70mm sieve size. The sample should conform to any of the grading

3.3.2 Main investigations

Casting of concrete (lateritic) replacing coarse aggregate with palm kernel shell from 0-50 percent and curing for 7, 14, 21, 28, 60 and 90 days and test for the following

3.3.2.1 Sorpitivity

The sorpitivity test is a simple and rapid test to determine the tendency of concrete to absorb water by capillary suction. The test was developed by Hall (1981) and is based on Darcy's law of unsaturated flow.

Test Specimens

Test specimens for compressive strength and change in mass test were 100× 100× 100mm cubes of control concrete and geopolymer concrete each. 3 specimens for each test were prepared compressive strength and change in mass to take average result of the specimen

Test Procedure

The samples were pre-conditioned for 7 days in hot air oven at 105 C. The sides of the specimen were sealed in order to achieve unidirectional flow. Locally available wax and resin with 50:50 proportions was used as sealant. Weights of the specimen after sealing were taken as initial weight. The initial mass of the sample was taken and at time 0 it was immersed to a depth of 5-10 mm in the water. At selected times (typically 1, 2, 3, 4, 5, 9, 12, 16, 20 and 25 minutes) the sample was removed from the water, the stop watch stopped, excess water blotted off with a damp paper towel or cloth and the sample weighed. It was then replaced in water and stop watch was started again.

The gain in mass per unit area over the density of water is plotted versus the square root of the elapsed time. The slope of the line of best fit of these points (ignoring the origin) is reported as the average result of the specimen.

3.3.2.2 Cube Casting

The wooden moulds of dimension 150mm x150mm x 150mm was used, with an engine oil which is rub at the inner surface of the mould so as to give a lubricating effect between the mould and the concrete after it has harden for easy removal. The mould is put at a leveled and smooth surface so as to give the cubes a smooth base. Concrete was poured into the moulds in three layers in such a way that each pouring will be approximately equivalent with the height of the mould divided into three. Then each layer poured is compacted using a tamping rod so as to give properly locking of the concrete and also to reduce the honeycomb due to improper compaction, using the tamping rod each layers of the concrete are given 25 blows each, equally distributed throughout the surface of the layer, the equally distributed blows are done for every layer. At the last layer the concrete is poured above the height of the mould before compacting it so as to provide a sufficient level of concrete, excess concrete is then scrape off from the surface using a hand trowel, so as to give a proper levelling with the top of the mould. The surface of the casted cube is then smoothening to provide a smooth surface. The proportion of the PKS present in the concrete and the date of casting is then inscribed on the concrete. The cubes are then removed after twenty-four hours to be cured for different day intervals. The casting of test specimens is shown below

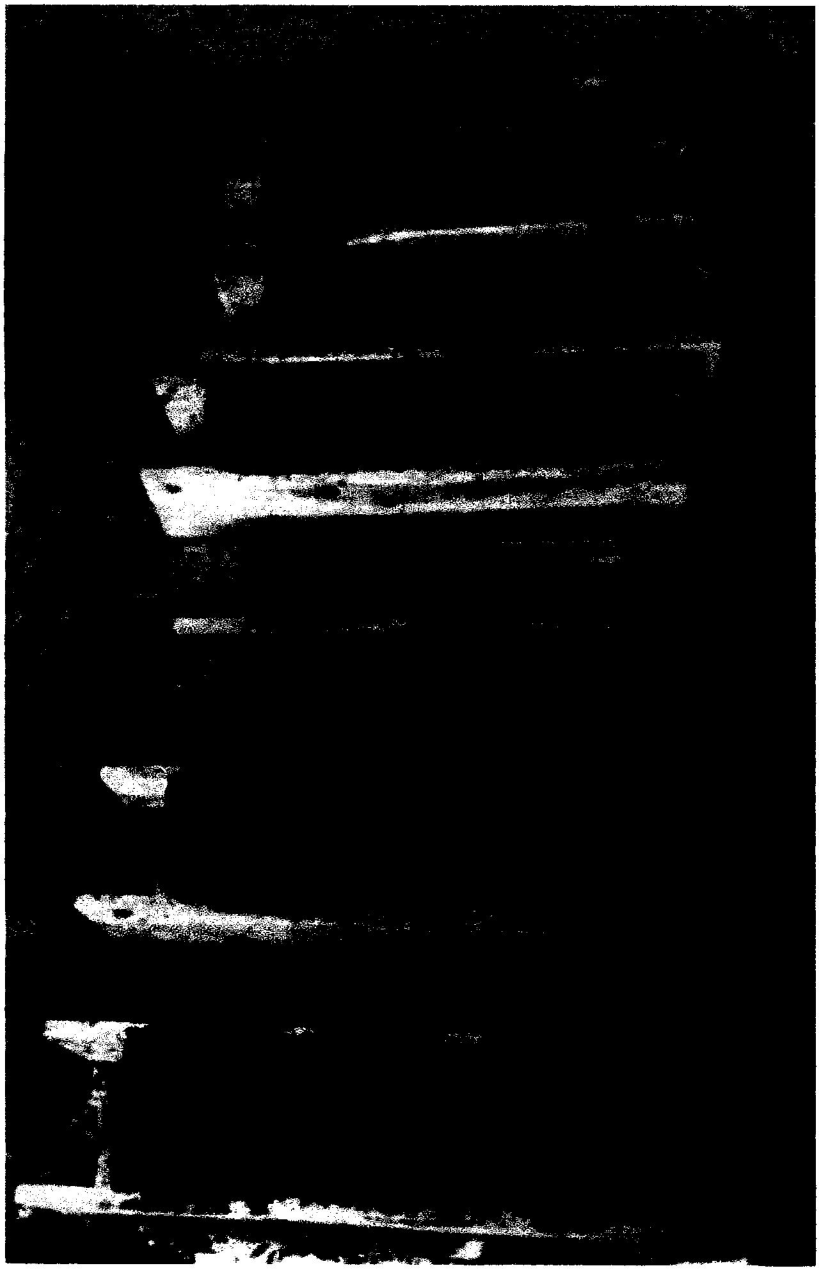


PLATE 3 CUBE CASTED

3.3.2.3 Workability Of The Concrete

The slump test for concrete was carried out following the standards given in BS 1881: 102. The concrete slump test is an empirical test that measures the workability of fresh concrete. This test is carried out with a mould called slump cone whose top diameter is 10 cm, bottom diameter is 20 cm and height is 30 cm.

1. Place the slump mould on a smooth flat and non-absorbent surface.

2. Mix the dry ingredients of the concrete thoroughly till a uniform colour is obtained and then add the required quantity of water in it.

3. Place the mixed concrete in the mould to about one-fourth of its height.

4. Compact the concrete 25 times with the help of a tamping rod uniformly all over the area.

5. Place the mixed concrete in the mould to about half of its height and compact it again.

6. Similarly, place the concrete upto its three-fourth height and then up to its top. Compact each layer 25 times with the help of tamping rod uniformly. For the second and subsequent layers, the tamping rod should penetrate into underlying layer.

7. Strike off the top surface of mould with a trowel or tamping rod so that the mould is filled to its top.

8. Remove the mould immediately, ensuring its movement in vertical direction.

9. When the settlement of concrete stops, measure the subsidence of the concrete in millimeters which is the required slump of the concrete.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 PRELIMINARY TEST RESULT AND DISCUSSION

4.1.1 Density

The density for granite, sand, laterite, and PKS are 1.66, 1.8, 1.46, 0.66 respectively, this result shows that sand and granite are denser than laterite and palm kernel shell (PKS)

4.1.2 Porosity

After testing the porosity of materials of the following result were obtained for the aggregate using the formula

$$\text{Porosity} = \frac{\square_2 - \square_3}{\square_2} \times 100$$

The result for sand, granite, laterite, PKS, are 25,1.52,11.36,5.88 respectively.it is concluded from the result that the porosity of sand is the highest followed by that of laterite and subsequently by palm kernel shell and the last is that of granite.

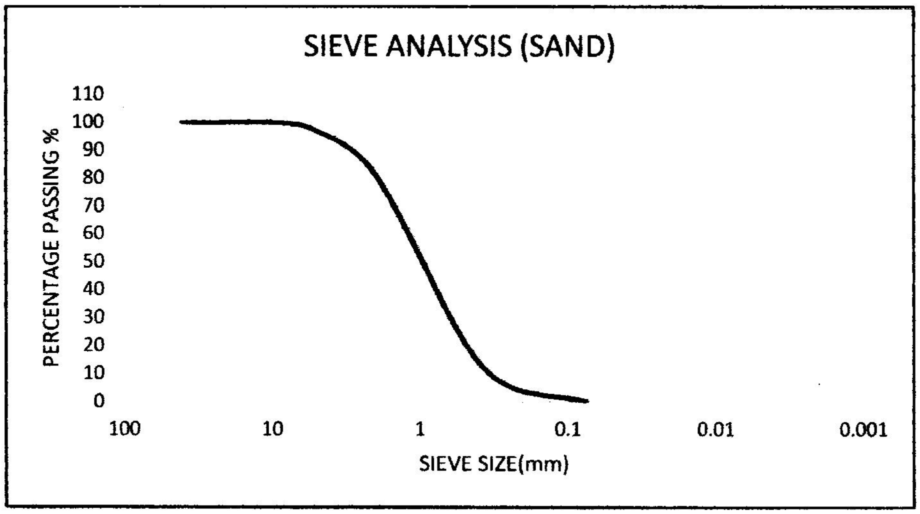
4.1.3 Sieve Analysis

Table 4.1 SIEVE ANALYSIS TABLE

FOR SAND

Sieve opening	Weight of sieve(g)	Weight of sieve + soil	Weight of soil retained(g)	Percentage of soil retained	Cumulative percentage retained	Percentage finer
40	325	325	0	0	0	100
20	320	320	0	0	0	100
10	285	285	0	0	0	100
5	315	345	30	3	3	97
2	330	485	155	15.5	18.5	81.5
0.5	255	815	560	56	74.5	21.5

0.25	270	470	200	20	94.5	5.5
0.075	245	293	50	5	99.5	0.50
Pan	200	205	5	0.5	100	0



From the graph, the percents finer of 10%, 30%, and 60%, which are respectively, the diameters D_{10}, D_{30}, and D_{60} are: D_{10},

$D_{10} = 0.3$

$D_{30} = 0.6$

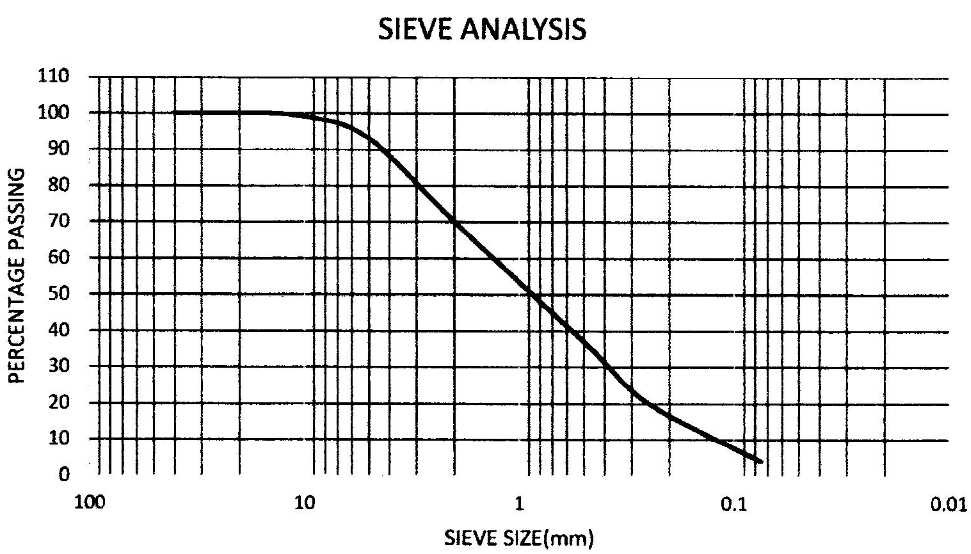
$D_{60} = 1.30$

Uniformity Coefficient (C_u) $= \frac{D_{60}}{D_{10}} = \frac{1.30}{0.3} = 4.33$

Coefficient of Gradation (C_c) $= \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{0.6^2}{1.30 \times 0.3} = 0.92$

FOR LATERITE

Sieve opening	Weight of sieve(g)	Weight of sieve + soil	Weight of soil retained(g)	Percentage of soil retained	Cumulative percentage retained	Percentage finer
40	325	325	0	0	0	100
20	325	325	0	0	0	100
10	280	285	5	1	1	99
5	295	325	30	6	7	93
2	335	430	95	29	30	70
0.5	255	415	160	30	63	37
0.25	255	345	90	18	80	20
0.075	250	280	30	16	96	4
pan	200	220	20		100	0



From the graph, the percents finer of 10%, 30%, and 60%, which are respectively, the diameters D_{10}, D_{30}, and D_{60} are:

D_{10} = 0.17

$D_{30} = 0.40$

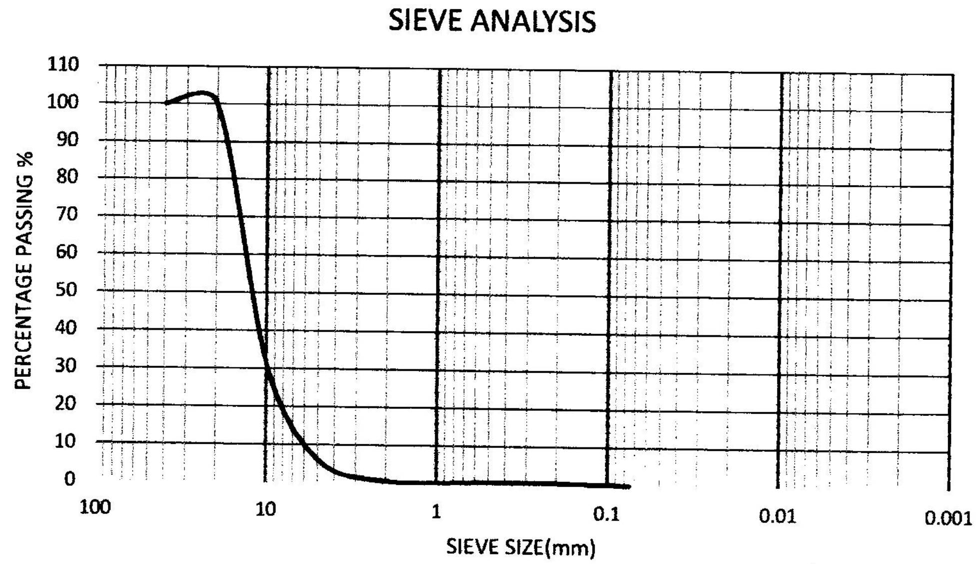
$D_{60} = 1.50$

Uniformity Coefficient $(C_u) = \frac{D_{60}}{D_{10}} = \frac{1.50}{0.17} = 8.8$

Coefficient of Gradation $(C_c) = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{0.40^2}{1.50 \times 0.17} = 0.6$

FOR PALM KERNEL SHELL

Sieve opening	Weight of sieve(g)	Weight of sieve + soil	Weight of soil retained(g)	Percentage of soil retained	Cumulative percentage retained	Percentage finer
40	325	325	0	0	0	100
20	320	320	0	0	0	100
10	285	975	695	69	69	31
5	315	565	250	25	94	6
2	330	385	55	5.5	99.5	0.50
0.5	255	255	0	0	99.5	0.50
0.25	270	270	0	0	99.5	0.50
0.075	245	250	5	0.5	100	0
Pan	200	200	0	0	100	0



From the graph, the percent finer of 10%, 30%, and 60%, which are respectively, the diameters D_{10}, D_{30}, and D_{60} are:

$D_{10} = 6$

$D_{30} = 10$

$D_{60} = 10.3$

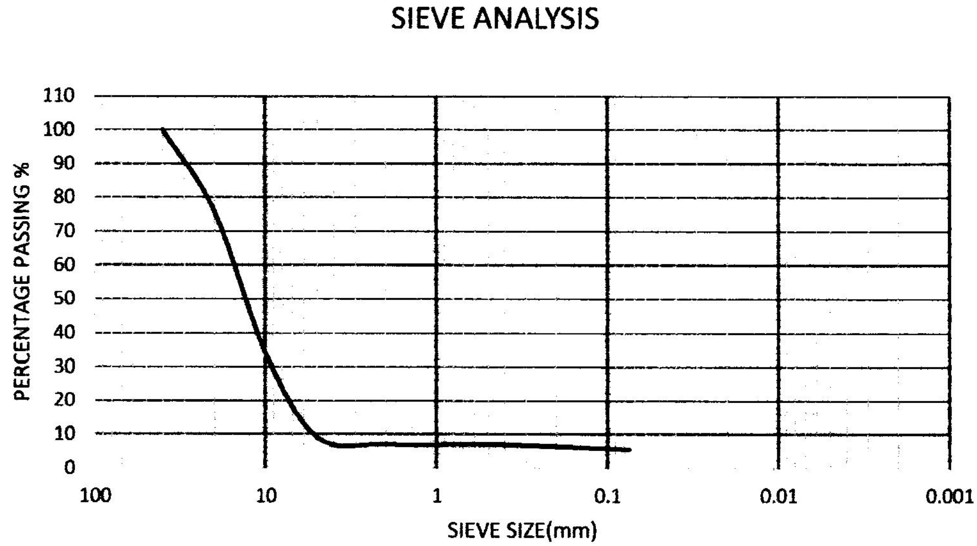
Uniformity Coefficient $(C_u) = \frac{D_{60}}{D_{10}} = \frac{10.3}{6} = 1.7$

Coefficient of Gradation $(C_c) = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{10^2}{10.3 \times 6} = 1.62$

FOR GRANITE

Sieve opening	Weight of sieve(g)	Weight of sieve + soil	Weight of soil retained(g)	Percentage of soil retained	Cumulative percentage retained	Percentage finer
40	325	325	0	0	0	100
20	320	560	240	24	24	76
10	285	775	490	45	69	34
5	315	535	220	22	91	9

2	330	400	70	2	93	7
0.5	255	255	0	0	93	7
0.25	270	275	5	0.50	93.5	6.50
0.075	245	255	10	1	94.5	5.50
Pan	200	205	5	5.5	100	0



From the graph, the percents finer of 10%, 30%, and 60%, which are respectively, the diameters D_{10}, D_{30}, and D_{60} are:

$\mathbf{D_{10} = 5.3}$

$\mathbf{D_{30} = 9}$

$\mathbf{D_{60} = 10.6}$

Uniformity Coefficient $(C_u) = \frac{D_{60}}{D_{10}} = \frac{10.6}{5.3} = 2$

Coefficient of Gradation $(C_c) = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{9^2}{10.6 \times 5.3} = 1.4$

4.1.4 Moisture

MOISTURE CONTENT TABLE

SAND

CAN NO	A	B
CAN WEIGHT(W_1)	23.75	19.60
CAN WEIGHT + SAMPLE(W_2)	57.95	61.15
CAN WEIGHT + DRY SAMPLE (W_3)	57.23	61.13
MOISTURE CONTENT	2.15	0.05

AVERAGE MOISTURE CONTENT = $\frac{2.15 + 0.05}{2} = 1.1$

LATERITE

CAN NO	A	B
CAN WEIGHT(W1)	26.62	18.25
CAN WEIGHT + SAMPLE(W2)	67.18	52.81
CAN WEIGHT + DRY SAMPLE (W3)	66.04	51.67
MOISTURE CONTENT	2.89	3.41

AVERAGE MOISTURE CONTENT = $\frac{2.89 + 3.41}{2} = 3.15$

PKS

CAN NO	A	B
CAN WEIGHT(W1)	20.02	13.30
CAN WEIGHT+ SAMPLE(W2)	51.15	44.83

CAN WEIGHT + DRY SAMPLE (W3)	50.98	44.43
MOISTURE CONTENT	0.549	0.642

AVERAGE MOISTURE CONTENT = $\frac{0.549 + 0.642}{2}$ = 0.60

GRANITE

TRIAL	A	B
W1	24.84	23.57
W2	60.42	65.47
W3	101.84	100.83
W4	77.70	75.45

CAN NO	A	B
CAN WEIGHT(W1)	19.76	26.45
CAN WEIGHT+ SAMPLE(W2)	74.28	87.37
CAN WEIGHT + DRY SAMPLE (W3)	74.29	87.37
MOISTURE CONTENT	0.018	0

AVERAGE MOISTURE CONTENT = $\frac{0.018 + 0}{2}$ = 0.01

4.1.5 Specific Gravity Table

SAND

LATERITE

TRIAL	A	B
W1	26.47	24.68
W2	54.80	56.63

W3	93.56	94.40
W4	79.32	76.10

PKS

TRIAL	A	B
W1	889.08	388.85
W2	450.56	441.43
W3	655.53	658.54
W4	647.74	640.90

GRANITE

TRIAL	A	B
W1	387.03	395.12
W2	541.99	584.65
W3	742.95	766.65
W4	639.80	648.83

4.1.6 Aggregate Crushing Value(ACV)

Like the AAV test this shows the result of aggregate under gradual compressive load and it was done only for the coarse aggregate which include the granite and PKS and the result gotten from test is as follows

For Granite: 14.65

For PKS: 3.122

These result shows the quantity of aggregate passing through the 2.36mm sieve and shows that granite crush more under this test than the PKS

4.1.7 Aggregate Abrassion Test

The aggregate abrasion test is a measure of degradation of mineral aggregates of standard grading resulting from a combination of action including abrasion or attrition, impact and grinding in a rotating steel drum containing a specified number of steel spheres. As the drum rotates, a shelf plate picks up the sample and the steel sphere, carrying them around until they are dropped to the opposite side of the drum, causing an impact-crushing effect. The contents then roll within the drum with an abrading and grinding action until the shelf plate impacts and the cycle is repeated. After the prescribed number of revolutions, the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as percent loss.

This test is carried out only the aggregate i.e PKS and Granite and the result gotten is as follow

For granite:2.0

For PKS:16.3

These result shows that palm kernel shell degrade more under stress than the granite.

4.1.8 Aggregate Impact Test

After the impact test on the granite and palm kernel shell (aggregate) the result obtain is as follow

Palm kernel shell =0.61

Granite = 0.98

For each test portion, the total mass of fine passing the 2.36mm sieve (Mf)to the nearest 0.1g

From:Mf = Mf – Mr

Where:

Mf = mass of test portion before testing (g)

Mr = mass retained on 2.36mm sieve after testing (g)

(b) for each test portion, the aggregate impact value (AIV) to the nearest 0.1 from:

AIV = (Mf/Mr)*100

(c) The mean of the value obtain in (b) for each of the two test samples to the nearest 0.1

4.2 MAIN INVESTIGATION TEST

4.2.1 Sorptivity

The sorptivity obtained for the concrete cubes for 28 and 90 days with 0% PKS, 10% PKS, 20% PKS, 30% PKS, 40% PKS and 50%

It is observed that concrete containing 0% PKS had the lowest sorptivity while concrete containing 50% PKS had the highest sorptivity.

The result obtained showed that the sorptivity of concrete increased proportionally with increase in PKS content of concrete, this can be related to the fact that increase in PKS reduced the bulk density of concrete and in the study of sorptivity in concrete by (Hall & Yau, 1987), it was reported that sorptivity of concrete varied with the mix, water-cement ratio, density of concrete, porosity and the compaction of concrete, they observed that sorptivity increased with increase in porosity, water-cement ratio, it also increased with decrease in bulk density of concrete.

(Cannan, 2003) In his research combined effects of mineral admixtures and curing conditions on the sorptivity coefficient of concrete, observed that as the compressive strength of concrete increased, the sorptivity reduced under different curing condition.

(EsamElawady et al., 2014) investigated Strength, permeability and sorptivity of concrete and their relation with concrete durability. They concluded that curing by water, air or moisture is critical to sorptivity than strength, that is, the concrete sorptivity is highly sensitive to curing rather than its compressive strength.

Table 4.2: Sorptivity test result for concrete specimens

Pks % in concrete	SORPTIVITY (MM/MIN$^{0.5}$)	
	28 DAYS	90 DAYS
0	0.222	0.222
10	0.267	0.312
20	0.367	0.319
30	0.370	0.325
40	0.388	0.327
50	0.412	0.415

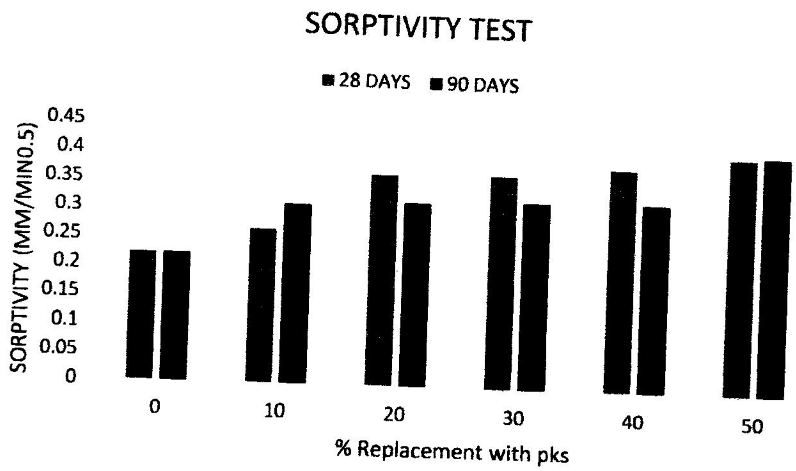


Figure4.2: Sorptivity test result

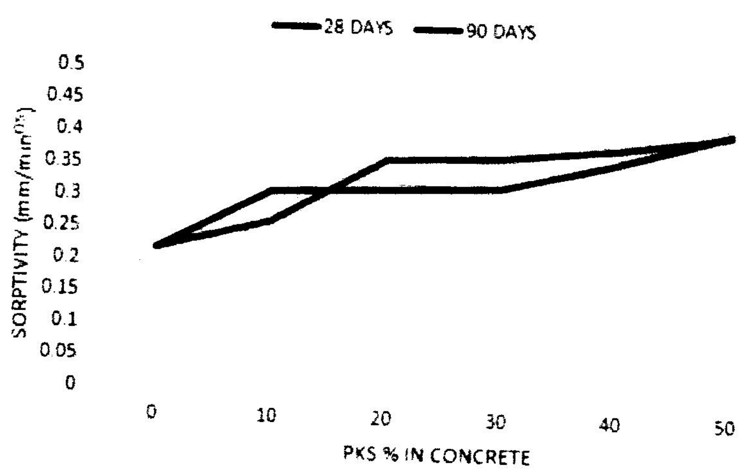


Figure 4.3 Sorptivity test graph

4.2.2 Workability Test

The fresh concrete which may be expected to give the best results must possess the property of workability. This most important property of fresh concrete is considered to be the sum total of qualities like plasticity, mobility, slump and compatibility. Workability, in simplest language, is the ease with which freshly prepared concrete can be transported and placed for the job and compacted to a dense mass. Obviously, such a concrete should be a homogeneous mix having the desired consistency. It should be capable of spreading, easily and uniformly without inducing any segregation of the aggregates(shittu2016). This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability.

The result shows that control had 10mm and 0% pks had 6mm,this reduction in slump is as a result of the 40% replacement of sand aggregate with laterite aggregate.The mix containing 10% pks had slump of 0mm(zero).This is the result of the replacement of granite aggregate with pks aggregate,which have a high water absorption rate. At 50% content shear slump took place and the test was repeated,again, shear slump occurred.(Nevile & Brook,2008) stated that the reoccurrence of shear slump cohesive in the mix. This can be that since normal aggregate is denser than PKS aggregate, and the replacement is by weight, the specific surface increases as the PKS content increases. This implies that more cement paste and water is required for the lubrication of the aggregate, hence reducing the entire fluidity of the mix, thereby reducing the height of the slump. Similar findings have been obtained by Daneshmand and Saadatin (2011) agreeing with the fact that the workability of concrete decreases with the increment of PKS replacement percentage, causing the reduction of height of slump.The degree of workability is very low with slump of 10mm which fall within the range 0-25mm and This concrete is suitable for roads vibrated by power operated machine and must be compacted in certain cases with hand operated machine.

Table 4.3 workability test result

Slump mix	Height of cone (mm)	Height of concrete (mm)	Slump height (mm)	Workability
Control	300	290	10	Very low
0%	300	294	6	Very low
10%	300	300	0	Very low

20%	300	300	0	Very low
30%	300	300	0	Very low
40%	300	300	0	Very low
50%	300	300	0	Very low

PLATE 4: Fresh Concrete Slump

4.2.3 Compressive Strength of Concrete

The relationship between the compressive strength with age is shown in the figure4.5. It was observed that the compressive strength of concrete increased rapidly with age until the 28th day after which strength developed or reduced gradually until the 90th day. Generally, the control concrete had the greatest compressive strength at all the curing ages, as shown in figure 4.5 the compressive strength of concrete at 28 days were in range of 7.12 N/mm^2 to 24 N/mm^2 and those of 7 days varied from 4.65 N/mm^2 to 15.99 N/mm^2.

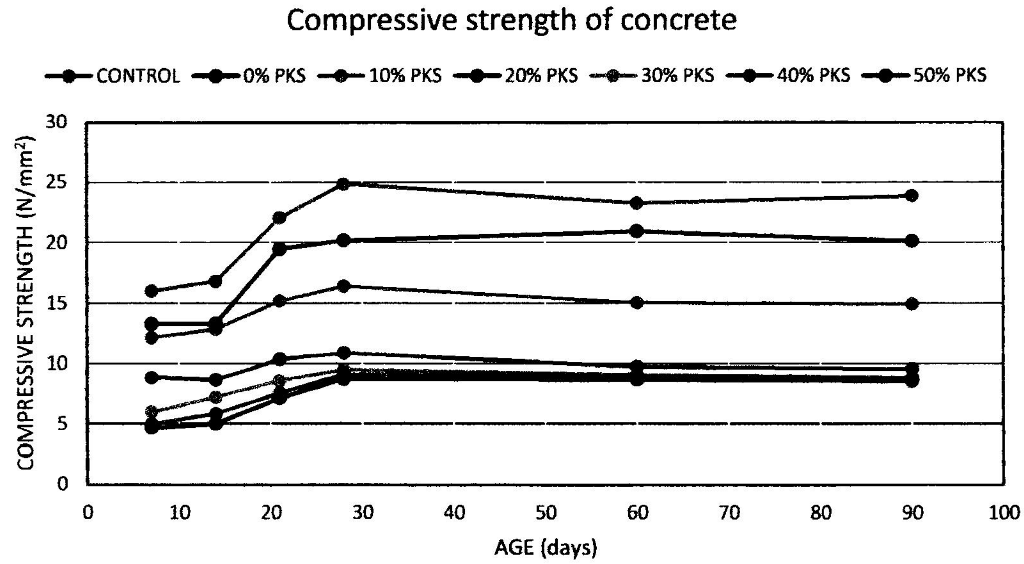


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Figure 4.4: Compressive strength of concrete at different curing ages and PKS content

Table 4.4: Compressive strength of concrete

S/N	AVERAGE COMPRESSIVE STRENGTH OF CONCRETE (N/mm^2)					
	7 DAYS	14 DAYS	21 DAYS	28 DAYS	60 DAYS	90 DAYS
CONTROL	15.99	16.77	22.03	24.82	23.22	23.81
0 PKS	13.25	13.29	19.45	20.16	20.89	20.10
10 PKS	12.11	12.81	15.17	16.39	15.01	14.89
20 PKS	8.28	8.60	10.34	10.84	9.72	9.52
30 PKS	5.96	7.18	8.54	9.49	9.01	8.79
40 PKS	4.97	5.82	7.53	9.06	8.85	8.62
50 PKS	4.65	5.00	7.12	8.71	8.63	8.53

From the figure 4.6, it was observed that the compressive strength of concrete reduced gradually as the percentage of PKS in concrete increased, this decrease in compressive strength may be due to several reasons not limited to; decrease in content of natural coarse aggregate, increase in laterite content in the concrete, reduction in bond strength between the aggregates with the introduction of PKS aggregate and particle size of the PKS aggregate.

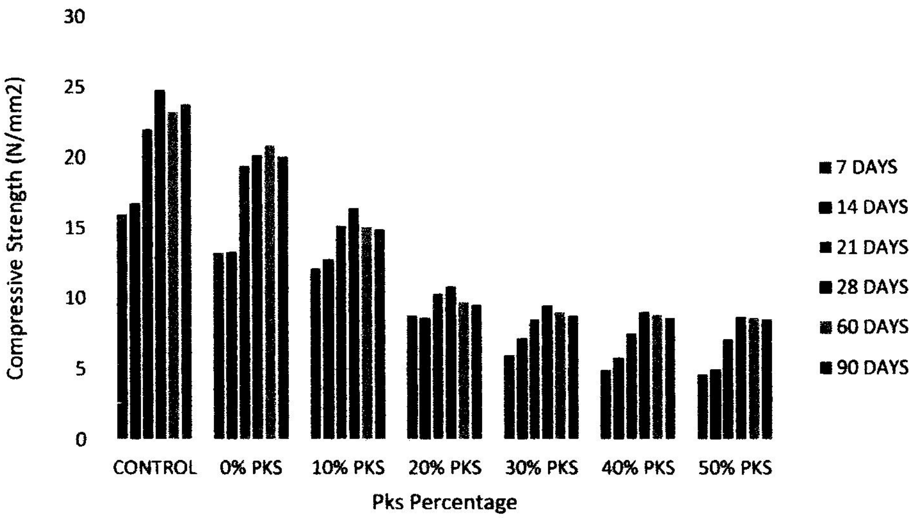

Figure 4.5: Comparison of concrete compressive strength at different PKS content and curing ages

As a result of the low water - cement ratio of concrete mix, the strength development during the first 7 days could be attributed to the higher hydration rate and thus strength of the cement paste. Beyond 7 days, the strength of the cement paste in the PKS concrete begins to approach the strength of the aggregates which limits further increase in compressive strength (Okpala, 1990). (Alex, 2015) Stated that it was more likely that rather than strength of PKS aggregates, strength at higher curing periods will depend on the PKS-cement paste bond, as the hydration of cement paste will have run its course.

(ASTM C330, 1999) Recommends a minimum compressive strength of 17 N/mm^2 for structural LWC at 28-days. While (BS 8110, 1997), recommends a minimum compressive strength of 15 N/mm^2. The 28^{th} day compressive strength of concrete produced, had higher than the minimum required strength recommended by BS 8110 at 10% PKS content and 0% PKS content for ASTM C330. This shows that PKS cannot be used to replace granite in producing LWC for structural applications. This contradicted the findings of (Alex, 2015) who reported a higher than minimum required compressive strength for both ASTM C330 and BS 8110, which was suitable for producing LWC for structural applications.

The PKS aggregates were parabolic, circular or semicircular, flaky and elongated and these are controlling factors for compressive strength (Chen et al., 1999). The flaky and elongated shape of the PKS resulted in greater demand for cement-sand paste for a given mix as the total surface area of aggregate to be coated with the paste increased (Gupta & Gupta, 2004). The result is that corresponding concretes will have lower workability, be harsh, and be of lower strength where the cement paste is not sufficient to lubricate the aggregates for the necessary bonding (Alex, 2015).

Alex in his research shear strength properties of structural lightweight reinforced concrete beams and two-way slabs using palm kernel shell coarse aggregates, studied the failure of PKS concrete cubes and he observed that failure is been caused by a weak bond between the PKS and the cement matrix. Failure was observed to be along the smooth convex surface of the PKS aggregates.

(Mahmud et al., 2009) reported that failure of PKS concrete in compression was as a result of the failure of the PKS aggregates. (Mannan & Ganapathy, 2002) Indicated that failure of PKS concrete at 90 days is controlled more by the strength of PKS-cement paste bond than by the strength of PKS aggregate itself.

(Alex, 2015) Suggested that the strength of PKS concrete depends on the strength of the mortar, and the interfacial bond between the PKS and the cement matrix at least at early stages of hydration.

4.2.4 Micro Structure

The figures below show the microscopic image of the concrete samples analysed using scanning electron microscope (SEM) in the back scattered electron mode with an accelerating voltage of 16.0 Kev. The back scattered Intensity was set to the same parameter for each sample, at display magnification of 25. Table 4.9 shows the elemental composition of each of the concrete samples.

The SEM analysis of 0% PKS concrete is shown in the figure below;

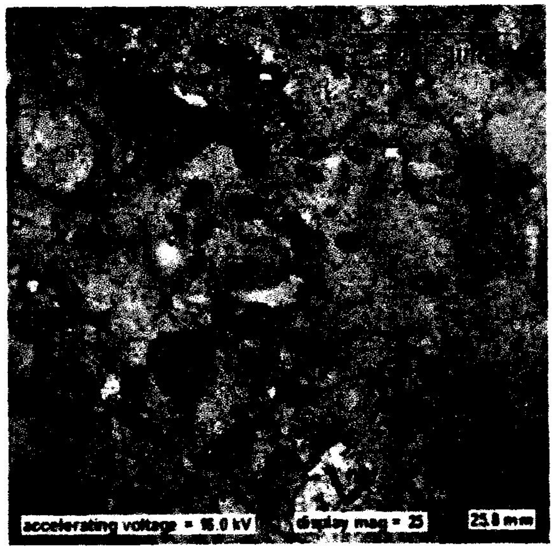

Figure 4.6: SEM image of concrete sample with 0% PKS

At display magnification of 25, the distribution of large particle of granite aggregate and several small particles of sand can be seen in a matrix of the cement paste.

The figure below shows the EDX result of the concrete sample.

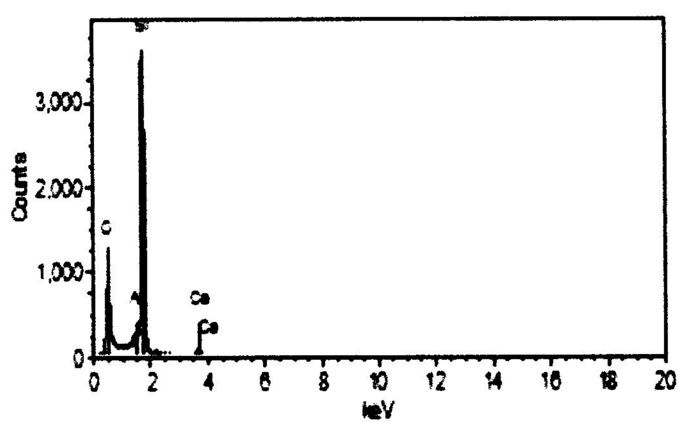

Figure 4.7: EDX analysis of concrete sample with 0% PKS

From figure 4.8, it is found that the elements present in the concrete sample are calcium, alumina, silica, oxides e.t.c. The calcium reacts with alumina and oxides and produces tri calcium aluminate, which is the reason for early setting.

The SEM analysis of 20% PKS concrete is shown in the figure below;

Figure 4.8: SEM image of concrete sample with 20% PKS

PKS fibres and sand particles can be seen in the matrix of cement paste. From figure4.9 it can be seen that the fibres in the PKS affects the bonding between the binding medium and the aggegate particles, this promotes the formation of cracking in the concrete sample.

The figure below shows the result of the EDX analysis of the concrete sample.

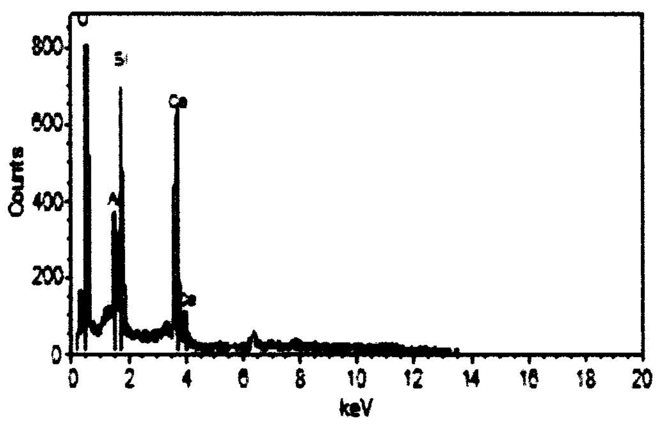

Figure 4.9: EDX analysis of concrete sample with 20% PKS

From figure 4.10 and table 4.9, it is evident that the concrete sample contains calcium, alumina, silica, oxides e.t.c. The calcium reacts with alumina and oxides and produces tri calcium aluminate, which is the reason for early setting.

The SEM analysis of 50% PKS concrete is shown in the figure below;

Figure 4.10: SEM image of concrete sample with 50% PKS

The poor interlocking between the aggregate particles (coarse and fine) and the cement paste, resulted in the pores which can be seen in figure 4.11. Pores result in the cracking of the concrete once loaded.

(Nicolas et al., 2001) in their research, Experimental analysis of compaction of concrete and mortar reported that when concrete is subjected to high confinement compressive stresses, the non-linear response of concrete is not only the result of microcracking and microcrack sliding but also the consequence of material crushing.

The figure below shows the EDX result of the concrete sample.

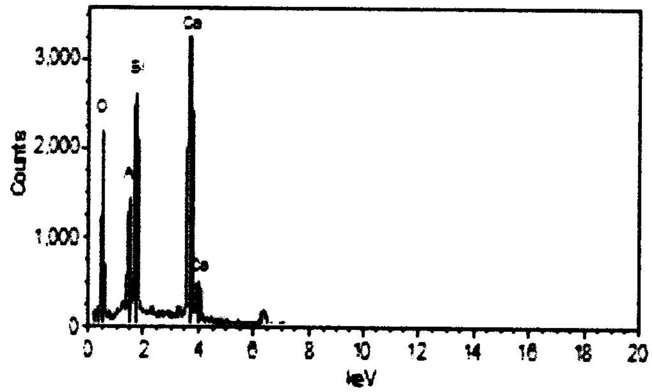

Figure 4.11: EDX analysis of concrete sample with 50% PKS

From figure 4.12 and the Table 4.9, it is evident that the concrete sample contains calcium, alumina, silica, oxides e.t.c. The calcium reacts with alumina and oxides and produces tri calcium aluminate, which is the reason for early setting.

The SEM analysis and their corresponding EDX result of concrete containing 10%, 30%, and 40% PKS are shown in figure (4.13, 4.14, 4.15, 4.16, 4.17 and 4.18) from the result it can be seen that the homogeneity between PKS and the matrix decreased with increase in the PKS content.

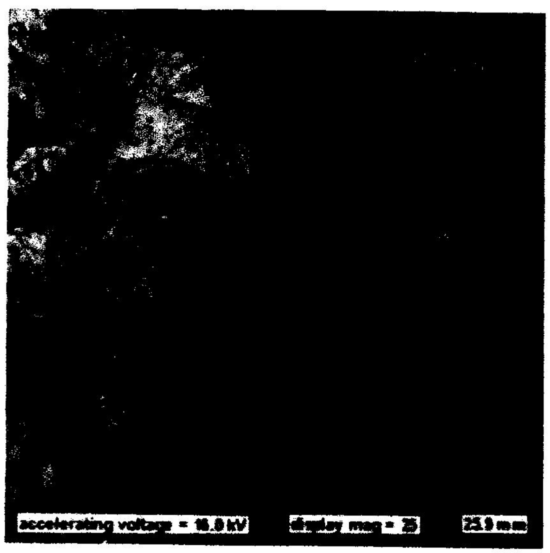

Figure 4.12: SEM image of concrete sample with 10% PKS

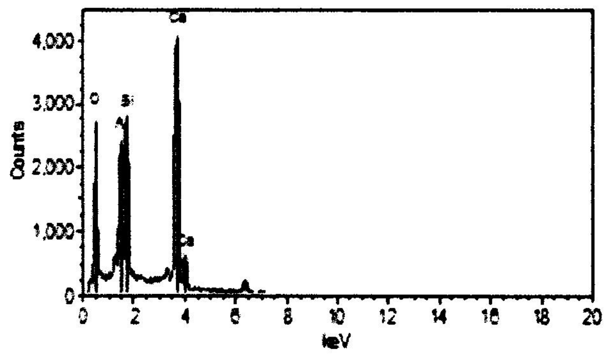

Figure 4.13: EDX analysis of concrete sample with 10% PKS

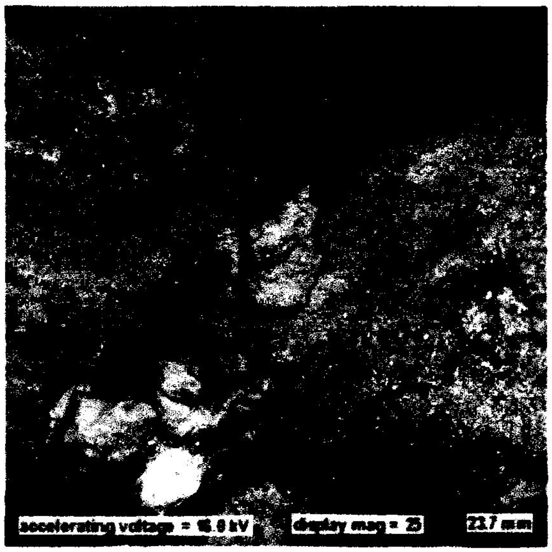

Figure 4.14: SEM image of concrete sample with 30% PKS

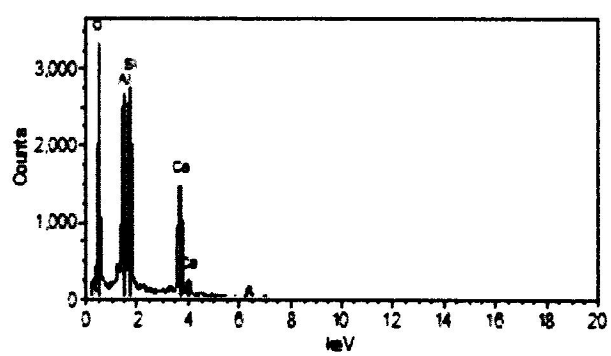

Figure 4.15: EDX analysis of concrete sample with 30% PKS

Figure 4.16: SEM image of concrete sample with 40% PKS

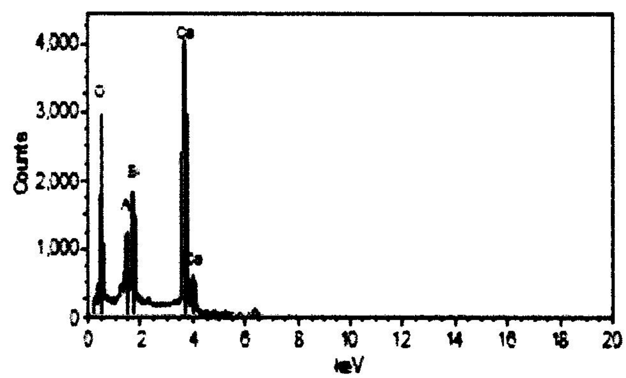

Figure 4.17: EDX analysis of concrete sample with 40% PKS

Table 4.5: Elemental composition of the concrete samples

	0% PKS CONCRETE	10% PKS CONCRETE	20% PKS CONCRETE	30% PKS CONCRETE	40% PKS CONCRETE	50% PKS CONCRETE
ELEMENTS	Normalized K-Ratio rounded to first decimal	Normalized K-Ratio rounded to first decimal	Normalized K-Ratio rounded to first decimal	Normalized K-Ratio rounded to first decimal	Normalized K-Ratio rounded to first decimal	Normalized K-Ratio rounded to first decimal
Na	0.0	0.0	0.0	0.0	0.0	0.0
Al	0.0	3.6	3.1	1.2	1.2	7.7
Si	51.7	8.8	13.0	4.1	6.2	18.9
S	0.7	0.3	0.2	0.0	0.2	0.5
Cl	0.3	0.1	0.0	0.0	0.1	0.0
K	0.0	2.3	1.8	2.2	2.0	1.3
Ca	2.7	30.9	27.7	37.9	36.1	17.5
Ti	0.3	0.4	0.3	0.3	0.3	0.5
Cr	0.3	0.1	0.0	0.0	0.0	0.3
Mn	0.0	0.1	0.3	0.0	0.0	0.0
Fe	0.1	3.8	5.2	0.5	2.0	5.8
Ni	0.4	0.0	1.5	0.0	0.0	0.1
Cu	0.6	0.0	0.0	0.1	0.2	0.0
Zn	0.0	0.5	0.0	0.0	0.0	0.4
Br	10.5	7.0	5.7	2.8	5.9	19.6
Sr	0.0	0.7	0.0	0.0	0.0	0.4
Zr	7.2	0.3	0.4	0.1	0.0	0.9
Ag	1.1	0.3	0.7	0.6	0.5	0.4
Sn	1.0	12.9	10.7	16.8	14.8	7.2
Sb	2.0	23.7	21.8	30.0	27.0	14.2
Ba	0.0	1.6	3.1	2.2	2.2	1.7

La	0.2	0.2	1.5	0.3	0.3	0.2
Ce	0.2	0.0	0.0	0.0	0.0	0.0
W	0.0	0.0	0.0	0.0	0.8	0.0
Au	7.7	0.0	0.0	0.0	0.0	0.5
Hg	10.0	1.6	2.2	0.2	0.3	1.7
Pb	2.9	0.7	0.6	0.4	0.0	0.2
Bi	0.0	0.0	0.0	0.0	0.0	0.0

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The construction sector is a very importance activity around the world. It is linked to the infrastructure of a country and provides great employment and income generation due to the huge amount of resources applied, being a development index of a country. It represents the creation of long-term investments in diverse companies in industry, service and agriculture areas. Thus, concrete is one of the most consumed products in the world, turning it very important to construction. Fundamentally, binder, coarse and fine aggregates, additives and water form concrete and it has as main property the compressive strength. The use of laterite fines as a partial replacement has a significant influence on the engineering properties of concrete.

PKSC is useful as coarse aggregate where they are abundant in other to reduce the cost of building construction. palm kernel shell concrete can also be partially replaced with course aggregate to get a desired strength in building construction projects..

Based on investigation the following conclusion can be drawn

The workability of fresh concrete mix decreases with the inclusion of Pks

1. The use of laterite in the production of concrete will reduce the cost in construction
2. It also concluded that 40% replacement of laterite could be optimum level for the production of concrete because of the strength.
3. Compressive strength of the concrete decreased with replacement of granite with pks.
4. Compressive strength values of the normal weight concrete is about twice that of the palm kernel shell which is normal as PKS is lighter. Therefore used to produce lightweight concrete
5. The use of palm kernel in the production of concrete will help to clean environment of potentially hazardous wastes.

5.2 Recommendation

1. It is recommended that laterite content should not exceed 40% of fine aggregate.

2.It is recommended that the PKS content in concrete should be within the range of 10% -20% replacement of granite

3.Its concluded that pks and latrite can be use in civil engineering work for light weight concrete

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APPENDIX

Appendix A

DENSITY

	Values
Mass of solid	365.19
Volume	220

For Sand

	Values
Mass of solid	500
Volume	280

For Laterite

	Values
Mass of solid	435.87
Volume	300

For PKS

	Values
Mass of solid	218
Volume	330

Appendix B

POROSITY

Sand

Porosity	**Volume**
V_2	**440**
V_3	**330**

Granite

Porosity	**Volume**
V_2	**440**
V_3	**335**

Laterite

Porosity	**Volume**
V_2	**440**
V_3	**390**

PKS

Porosity	**Volume**
V_2	**440**
V_3	**417**

Porosity $= \frac{V_2 - V_3}{V_2} \times 100$

For sand

$$\text{Porosity} = \frac{440-330}{440} \times 100 = 25$$

For Laterite

$$\text{Porosity} = \frac{440-390}{440} \times 100 = 11.36$$

For Granite

$$\text{Porosity} = \frac{440-435}{440} \times 100 = 1.52$$

For PKS

$$\text{Porosity} = \frac{440-417}{440} \times 100 = 5.88$$