PRODUCTION OF LIGHT WEIGHT CONCRETE BY PARTIALLY REPLACING FINE AGGREGATE WITH CRUSHED PALM KERNEL SHELL

NDUCHE UGOCHUKWU JOHNPAUL

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CERTIFICATION

This is to certify that this project "Production of Lightweight concrete by partially replacing fine aggregate with crushed palm kernel shell" is the original work of Nduche Ugochukwu Johnpaul (with registration number NAU/2017224048) done in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.Eng.) Degree in the Department of Civil Engineering, Nnamdi Azikiwe University,Awka. It is further certified that its content have not been submitted previously, in whole or part for any Degree or Diploma of this or any other University or Institution.

Nduche Ugochukwu Johnpaul _______________ ________________

(Student) Date Signature

APPROVAL

Nduche Ugochukwu Johnpaul, an Undergraduate of the department of Civil Engineering, Nnamdi Azikiwe University, Awka has satisfactorily completed the requirements for the award of Bachelor of Engineering (B.Eng)Degree. To the best of our Knowledge the work embodied in this project is original.
However, we affirm that Nduche Ugochukwu Johnpaul bears full responsibility for the contents of this work.

Engr. Dr. B.O. Adinna	________________	____________________
(Supervisor)	Date	Signature
Engr.Prof. C.A.Ezeagu	________________	____________________
(HOD, Civil Engineering)	Date	Signature
Engr.Prof.D.O.Onwuka	________________	____________________
(External Examiner)	Date	Signature

DEDICATION

With a heart full of praises I dedicate this work to the Almighty God for his mercy upon me.

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ABSTRACT

The suitability of palm kernel shell as a partial replacement of fine aggregate in concrete was researched to verify if concrete made with palm kernel shells meet some minimum standard prescribed for strength and density. Based on British standard classification of fine aggregate as aggregates passing the number 4 sieve of 4.75mm size or slightly higher sizes depending on local requirement, crushed palm kernel shells of particle diameter not greater than 5.0mm was used to replace river sand as fine aggregate in the following percentages: 0%, 10%, 20%, and 30%. For each mix proportion, three concrete cubes were cast and tested for compressive strength and density at 7, 14 and 28 days curing duration. The specific gravity of all the concrete ingredients were determined and used in preparing the concrete mix proportion. Sieve analysis of the different materials was also carried out in order to grade the fine aggregates used for the research as well as to determine their fineness modulus. The crushed palm kernel shell used was obtained by grinding palm kernel shells into fine sizes using grains' grinding machine. Afterwards, it was sieved through 5mm sieve and use for the research. Mix ratio of 1:2:4 was adopted with water-cement ratio of 0.60. The project in conclusion was a success as it took into consideration the economic status quo of the population. This paper is to create awareness about the usefulness of palm kernel shell as a construction material in the construction environment.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Concrete is the most used material in the construction industry. This is obtained from the mixture of binding materials, Fine and coarse aggregates, chemical admixtures and water. This has been considered as the cheapest and most readily available material with high resistance to water which can be formed easily when it is fresh. (Maghfouri et al. (2017)

Concrete is a composite static material containing of aggregates, water and cement. Concrete has been created a long time ago for constructing various structures around the world, such as, buildings, bridges, dams and etc. Nowadays, some countries are undergoing rapid infrastructure development, thus increase the demand of concrete.

As an example, the mass rapid transit project that are being construct in Malaysia required to use mass volume of concrete. The cost of concrete at these days are currently so high probably because of the increasing of demand. Besides, the strength of concrete is important to avoid the natural disasters, such as, earthquake, tsunami, tornadoes and flooding which may cause the people to get hurt or death. So, to overcome this problem, the cheap locally available waste material need to be adopt.

Nowadays, the construction industries have been searching the alternatives product that can help to minimize the cost of concrete. There are some waste material that have been identified which can help to reduce the volume of materials in concrete, such as, coconut shells, egg shells, and etc. Among of the waste material that have been identified, there are known to have good characteristic in increase the strength of the concrete which results in reducing the amount of waste and materials in concrete. Oil palm is truly a golden crop of

Malaysia. Oil palm is grown for its oils. As vegetable oil seed crop, the oil palm is an efficient converter of solar energy into biomass.

Besides being a prolific producer of palm and kernel oil, it also generates a number of residues and by product. The residues of oil palm industry are from the field and mill. Palm kernel shells are one of the wastes from palm oil industry, which have long been used as fuel in boiler to produce steam and electricity for mill processes. Palm kernel shell is the hard shell of the oil palm fruit seed that is broken to take out the kernel used for extracting palm oil. Thus, it is the by-products of palm oil processing during which the palm oil is extracted.

1.2 Problem Statement

For thousands of years, sand and gravel have been used in the construction of roads and buildings. Today, demand for sand and gravel continues to increase. Mining operation, in conjunction with cognizant resource agencies, must work to ensure that sand mining is conducted in a responsible manner. Excessive in stream sand and gravel mining causes the degradation of rivers and lowers the stream bottom, which may lead to bank erosion. Besides, depletion of sand in the stream bed and along coastal areas causes the deepening of rivers and estuaries, thus enlargement of river mouths and coastal inlets. In addition, sand mining also lead to increase of sea level, saline-water intrusion from thenearby sea, and loss to the system. To overcome this problem, this study will studied the feasibility of using the palm kernel shell as a partial replacement of fine aggregates to reduce the problems.

1.3 Objectives of Study

1. To compare the strength of fine aggregate concrete and crushed palm kernel shell concrete and their compressive strength determined in the laboratory.
2. To reduce the cost of concreting in building works.

3. To show the cost effectiveness of using kernel shells.
4. To study the effect of replacing natural aggregate with kernel shells on weight of concrete and find the optimum replacement of natural aggregate with kernel shells.

1.4 Scope of Study

The study is limited to the following;

1. To develop a suitable mix design of concrete with kernel shell as aggregate.
2. To determine the compressive strength of the concrete using compressive strength testing machine
3. To determine the crushing strength
4. To determine the workability of the concrete by concrete slump test
5. To determine the workability of concrete mix of given proportions by compaction factor test.
6. The percentage of palm kernel shell that will be replace fine aggregate at 10%, 20% and 30% replacement by volume of fine aggregate

1.5 Significance of Study

This research will be carried out to examine the feasibility of using the palm kernel shell as a partial replacement of fine aggregates in concrete. This research also determine the workability, compressive strength and flexural strength of concrete when replaced with 10%, 20% and 30% of palm kernel shell as a fine aggregates in concrete in order to reduce the demand of sand and the effect of sand mining to ecosystem

CHAPTER TWO
LITREATURE REVIEW

2.1 Introduction

There have been a number of advances in new concrete technology in the past ten years. There have been advancements made in almost all areas of concrete production including materials, recycling, mixture proportioning, durability, and environmental quality. However, many of these innovations have not been adopted by the concrete industry or concrete users. There is always some resistance to change and it is usually based on cost considerations and lack of familiarity with the new technology (Martin Dawson, 2010)

Mehta and Monteiro (2006) reported that light-weight concrete with a slump value of 50-75mm was similar to a normal concrete with 100-125mm adequate for site use. The slump value of M37.5 was 50mm, which shows the workability of palm kernel shell concrete is still acceptable, Abdullah (1984) achieved slump in the range of 0-260mm with a compressive strength of 15Mpa when oil palm kernel shell was used in the production of concrete. The aim of this research was to investigate the compressive strength of concrete by incorporating palm kernel shell as artificial aggregates. This is achieved by determining the physical properties of the proposed aggregates, design mix proportion for the palm kernel shell concrete based on the result of physical properties and to investigate compressive strength at different proportions of palm kernel shell. Advance knowledge in Civil Engineering and building has exposed the world to the use of concrete as a construction material. Concrete is composed of cement, fine aggregate, coarse aggregate, water and sometimes admixtures.

Concrete is a widely used construction material in Civil Engineering projects throughout the world for its excellent resistance to water, ease with which it can be formed into a variety of shapes and sizes. It is usually the cheapest and most readily available for the job (Mehta and Monteiro, 2006). From the various kinds of concrete, lightweight concrete (LWC) is one of the most interesting subjects to researchers because of its advantages such as the savings on reinforcements, formwork and scaffolding, foundations costs as well as the savings derived from the reduced cost of transportation and erection. Furthermore better fire resistance, heat insulation, sound absorption, frost resistance, superior anti-condensation properties and increased damping are other advantages of lightweight concrete (CEB/FIP, 1977). The most popular way of achieving lightweight concrete production is by using lightweight aggregate (LWA) (Polat and others, 2010). Lightweight aggregate is not a new invention in concrete technology. It has been used since ancient times. The fact that some of those structures are still in good condition validates the durability of concrete (Chandra and Berntsson, 2002). The construction industry is changing drastically with changes in conventional building materials like bricks and stones to the newer materials like fiber, reinforced plastics, aluminum and new varieties of bricks, cement, glass and steel. The list of new materials in the construction industry is in exhaustive. These materials hold the key to the economy of the building and construction industry (Ata et al., 2006).

An alternative lightweight aggregate in tropical countries that have a palm oil industry is palm kernel shells (PKS). Its use as a lightweight aggregate in producing lightweight concrete was researched early in 1985 by Salam and Abdullah in Malaysia. The palm oil industry is important in many countries such as Nigeria, Malaysia and Indonesia because of the high availability of palm trees in the regions. In Nigeria, the palm oil tree generally grows in the rain forest region, close to the coastal areas and adjacent to some inland water ways (Encarta, 2005).High performance concrete usually contains recycled materials and thereby reduces the need to dispose of these materials. Some of these materials include fly ash, ground granulated blast furnace slag, and silica fume. But perhaps the biggest benefit of using some of these other materials is the reduction in the need to use cement, also commonly referred to as Portland cement. The reduction in the production and use of cement will have many beneficial effects. These benefits will include a reduction in the creation of carbon dioxide emissions and a reduction in energy consumption, both of which will improve the global warming situation. It is estimated that the production of cement worldwide contributes five to eight percent of global carbon dioxide emissions.

In addition, the use of fly ash and furnace slag is usually cheaper than cement and they have properties that improve the quality of the final concrete (Martin Dawson, 2010).

2.2 Concrete

Concrete is an artificial material comparable in appearance and properties to some natural lime stone rock. It is a man-made composite, the major constituent being natural aggregate such as gravel, or crushed rock, sand and fine particles of cement powder all mixed with water. The concrete as time goes on through a process of hydration of the cement paste, producing a required strength to endure the load (Maninder and Manpreet, 2012). Concrete is defined in student Encarta as a mixture of sand, cement, aggregate and water in specific proportions that hardens to a strong stony consistency over varying length of time. The aggregate in this context refers to rock particles of size above $5mm^2$. American concrete institute also sees concrete as an engineering material made from a mixture of Portland cement, water, fine and coarse aggregate and small amount of air. Olanipekun (2006) defines concrete as a composite material consisting of a binding medium within which the particles are embedded. Other scholars also define concrete as a combination of aggregates and a paste composed of a Portland cement and water. The aggregate refer to sand and gravels or crushed stones (Mannan and Ganapathy, 2002). Concrete is a widely used construction material in civil engineering projects throughout the world for the following reasons: It has great resistance to water, structural concrete elements can be formed into a variety of shapes and sizes and it is usually the cheapest and most readily available material for the job (Olanipekun, 2006).

2.3 Lightweight Concrete

2.3.1 Definition

Lightweight concrete is a concrete which has an oven dry weight of not less than 800kg/m^3 and not more than 2000kg/m^3 by replacing dense natural aggregate either wholly or partially with light weight aggregates(BS 206-1). Lightweight concrete is a type of concrete which has weight of 150 pounds per cubic foot.

White sees Lightweight concrete as concrete with weight ranging from about 140 to 160 pounds per cubic foot.

Light weight concrete is a well-known material and has been in use for many years. Both natural and manufactured lightweight aggregates can be used and the concrete is ideal for internal applications where its excellent thermal properties are valued.

Lightweight concrete can be used in factory pre-stressing, The Don Caster Grandstand roof being an excellent example. On the economic front, lightweight aggregate is more expensive than dense aggregate and 20% reduction in weight can result in a similar reduction in potential strength. Lightweight concrete has a lower modulus of elasticity value than dense concrete. This gives a higher pre-stress demand than normal dense concretes which tends to counter the lower weight advantage.

2.3.2 Classification of Lightweight concrete

Lightweight concrete can be classified according to the unit weight per cubic foot such as;

- Insulating Lightweight concrete: is a type of lightweight concrete which weighs about 20 to 70 pounds per cubic foot
- Structural Lightweight concrete: This is a type of concrete which weighs up to 115pounds. It had 28-day compressive strength in excess of 2000psi.
- Semi Lightweight concrete: This is a concrete which has a unit weight of 115 to 130 pounds per cubic foot ,White(2001)

2.3.3 Uses of Lightweight concrete

Lightweight concretes are used for variety of works in construction industry. The first extensive use of lightweight concrete is making blocks,

Presently, Lightweight concretes are used for in-situ and pre-cast walls, floors, and roof sections as well as fire proofing, White (2001)

Lightweight concretes are used for making pre-cast structural units, wall lining and partitions. Handoo,(2000)

Lightweight concrete is required for non-load bearing walls, non-structural floors, strip footings and other non-load bearing structural elements. It is worth stressing that coarse aggregate usually takes about 60% of the overall self-weight of normal weight concrete, thereby determining the quantity of reinforcement required to resist forces acting on the structural member.

2.4 Components of Concrete

2.4.1 Cement

The most generally used cement is ordinary Portland cement (OPC), but other additional materials such as pozzolana, silica fume and fly ash can also be included as long as their acceptance has been proven. The manufacture of Portland cement consists of ingredients mainly lime, silica, alumina and iron oxide from limestone and clay/shale which react together on firing to form a series of more complex products. The relative proportions of these oxide compositions are responsible for influencing the various properties of particular cements; in addition to the rate of cooling and fineness of grading which affects the strength of the cement. In many structural applications, the choice of cement has a lesser influence on the long-term performance of concrete than the practical aspects of mix control, cement content, water content, aggregate quality, and compaction, finishing and curing (Newman and Choo, 2003). (BS EN 197-1, 2000) classifies cements into five main types depending on its constituents. Which are?

- Portland cement.
- Portland composite cement.
- Blast furnace cement.
- Pozzolanic cement.
- Composite cement.

2.4.2 Chemical Components of Cement

Four main compounds are considered as the major constituents of cement and these compounds are presented in Table 2.1. The composition of Portland cement is based on the 'Bogue composition' which are given in the equations below.

$C_3S = 4.07 (CaO) - 7.60 (SiO_2) - 6.72 (Al_2O_3) - 1.43 (Fe_2O_3) - 2.85 (SO_3)$

$C_2S = 2.87 (SiO_2) - 0.754 (3CaO.SiO_2)$

$C3A = 2.65 (Al_2O3) - 1.69 (Fe_2O_3)$

$C_4AF = 3.04 (Fe_2O_3)$

Table 2.1 .Compound composition and its contribution to hydration of Portland cement

Chemical formula	**Shorthand notation**	**Weight percent**	**Reaction Rate**	**Contribution to strength**
$3CaO.SiO_2$	C_3S	50	Moderate	High
$2CaO.SiO_2$	C_2S	25	Slow	Low initially and high later
$3CaO. Al_2O_3$	C_3A	12	Fast	Low
$4CaO.Al_2O_3.Fe_2O_3$	C_4AF	08	Moderate	Low

Source:(Nawy, 2008)

It is seen that the major products of the hydration reactions, which primarily account for the strength of concrete, are the calcium silicate hydrates (C_3S and C_2S) that make up most of the hydrated cement (Nawy, 2008). These silicates are the most vital compounds responsible for the strength of hydrated cement paste and are formed from the reactions between the two calcium silicates and water.

2.4.3 Water

In general, portable water is safe for use in concrete. Water containing harmful substances such as salts, silts, suspended particles, organic matter, oil, or sugar can unfavorably affect the strength and setting properties of cement and disturb the affinity between aggregate and cement paste (Nawy, 2008). Therefore, the suitability of water should be examined before use. As a rule, any water with silt content below 2000 mg/L is suitable for use in concrete (Shetty, 2005).

2.4.4 Coarse Aggregates

Aggregates were originally viewed by Troxellet al. (1968) as being inert and dispersed all through the cement paste in concrete, largely due to economic reasons, that is, as a fill material. Studies have shown that fine and coarse aggregates are very important in concrete because aggregates occupy 60% to 75% of the concrete volume and strongly influence the concrete's freshly mixed and hardened properties, mix proportions, and economy (Quiroga and Fowler, 2004). The vital requirement of an aggregate for concrete is that it remains constant within the concrete (both in the fresh and hardened states) and in any given environment, throughout the design life span of the concrete (Smith and Collis, 2001). Coarse aggregates are materials retained on 5mm (3/16 inches) test sieve and containing only so much finer material as allowed from the various sizes.

Table 2.2: Type of Coarse Aggregate and Source

TYPES	SOURCE
Uncrushed gravel	From natural disintegration of rock
Crushed stone	From crushing of gravel or hard stone
Partially crushed gravel	Product of the blending uncrushed and crushed gravel

According to Suryakanta, (2014), commonly, fine aggregate passed 12 4.75mm sieve and contains only so much coarser as is permitted by specification. Normally, river sand and crushed and stone with fineness modulus of 1.78 were passed through a 2.36 mm sieve analysis. Commonly, materials used are having maximum particle size with 2.36 mm diameter.

2.4.5 Fine Aggregates

Sand may be described into three major parts, which are natural sand, crushed stone and crushing gravel sand.

Table 2.3 shows the different type of coarse aggregate and their source which all of the fine aggregate are from rock. According to Suryakanta, (2014), commonly, fine aggregate passed 4.75mm sieve and contains only so much coarser as is permitted by specification. Normally, river sand and crushed sandstone with fineness modulus of 1.78 were passed through a 2.36 mm sieve analysis. Commonly, material used are having maximum particle size with 2.36 mm diameter.

Table 2.3: **Type of Fine Aggregate and Source**

Types	**Source**
Natural sand	From natural disintegration of rock
Crushed stone sand	From crushing of hard stone
Crushed gravel sand	From crushing of natural gravel

2.4.6 Water-Cement Ratio

The water–cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix and has an important influence on the quality of concrete produced.

A lower water-cement ratio leads to higher strength and durability, but may make the mix more difficult to place. According to Rakennustekniikan, koulutusohjelma (2010), water-cement ratio is a very important factor in concrete production, and it has crucial effects to both, fresh and hardened concrete properties. A difference in water amount as small as 5 kg/m^3 can cause tremendous effects to workability of fresh concrete. The main variation in water amount comes from the aggregates, and aggregate moisture contents may vary due to the fact that aggregates from a new delivery with different moisture content are used. Also during wintertime when the aggregates are heated in order to get warm concrete, the aggregate mass can locally differ in temperature and moisture content affecting the workability of the concrete.

2.4.7 Properties of Aggregates

Aggregate possess certain properties, which directly influences the strength of concrete. Some of these properties cannot be measured qualitatively and some indirect measures are taken sometimes. The main properties of aggregates, which may influence the concrete properties, are:

- Shape
- Texture
- Size gradation
- Moisture content
- Specific gravity
- Bulk unit weight
- Strength of aggregate
- Soundness
- Wear resistance
- Alkali-aggregate reaction
- Impurities
- Unsound particles

2.4.8 Curing Process

Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and subsequently continuous increase in the strength, once curing stops strength increase of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually stops when the relative humidity within the capillaries drops below 80%. With insufficient water, the hydration will not continue and the resulting concrete may not possess the necessary strength and impermeability. The continuous pore structure formed on the near surface may allow the entrance of harmful agents and would cause various durability problems. Moreover due to early drying of the concrete micro-cracks or shrinkage cracks would develop on surface of the concrete. When concrete is exposed to the environment, evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the partial hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix will affect the curing of concrete.

Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking (YashNahata et al., 2013). Curing of the concrete is also governed by the moist-curing period, longer the moist-curing period, higher the strength of the concrete assuming that the hydration of the cement particles will go on. Curing has a strong effect on the properties of hardened concrete; appropriate curing will increase the durability, strength, volume stability, abrasion, resistance, impermeability and resistance to freezing and thawing (YashNahataet al. 2013).According to YashNahata et al. (2013), there are three method of curing which includes; air curing, water curing and saturated wet covering. Air curing is a curing method where the concrete cubes are left in open air to be cured at room temperature. Water curing is a curing method where the concrete cubes were cured in water tank at room temperature. Saturated wet covering is a curing method where moisture retaining fabrics such as burlap cotton mats, gunny bag and rugs are used as wet covering to keep the concrete in a wet condition during the curing period.

2.5 Properties of fresh concrete using kernel shells

As the result of crushing during extracting the oil from the palm nut, the hard palm oil shells are received as crushed pieces. A lot of fine particles were produced; therefore, the sieving process will be needed to remove the large amount of fine particles. After the sieving process, the shells are then air-dried before use in concrete mixing. (A.A.A., A. 1997). Since the palm oil shells are lighter than the cement matrix, it tends to segregate in the wet concrete mixes.

Trial mixes are normally necessary to achieve a good mix design. The workability of freshly mixed concrete depends on the mix proportions, the materials and environmental conditions. The aggregate normally occupy about 70% of the total volume of the concrete. The total specific areas of the aggregate are minimized by proper selection of the size, proportion of the fine and coarse aggregate, and the shape of aggregates. The surface texture and the shape of aggregates affect the void content and the water requirement of the concrete mixing. The fineness modulus of aggregate is a numerical index of the fineness which indicates the mean size of that aggregate. The fineness modulus of aggregate is a prime indication in obtaining the required strength and workability which can give the most economic mix design. (Mannan, M.A., G.C., 2004). 15 The workability of fresh concrete and bonds between the mortar phase and the aggregate are influenced by the physical characteristic of the aggregate such as the roughness, texture and shapes. The surface texture of the aggregate can be smooth or rough; whereas the surface can be glassy, smooth, granular, rough, crystalline, and porous. (M.L., G., 2000). The roughness and the porosity of the surface of the aggregate affect the development of the bond. The porous surface of the aggregate can improve the development of bond by the suction of the paste into its pores. (Mannan, M.A., G.C., 2004). A study was done by a group of researchers on the workability of fresh concrete with palm oil shells as aggregates. The results showed that the PKS concrete has better workability than that of the normal concrete. In the same water cement ratio, the smooth surface of the palm oil shells may has led to a better workability, slump and compaction factor when compared with the normal concrete. (Mannan, M.A., G.C., 2004).

This similar trends also being reported that the presence of palm kernel shell as aggregate can lead to better workability for a same water-cement ratio.(FO., O., 1988).However as the percentage of the PKS replacement increase, the slump of the concrete will decrease. This may due to the higher shells content combined with the irregular and angular shapes of the shells lead to poor workability. Lower workability might also due to the friction of the angular shapes between the shells and lower fines content. (Alengaram, U.J., J.M.Z., Mahmud H.). Besides, the porosity of the shells can influence the workability. The higher the porosity of the shells, the absorption capacity will be higher, which consequently reduces the workability. The lower compacting values of the shells indicate that less work is done on the shell concrete by gravity. This may due to the lower density of the shell aggregate when compared with granite aggregate. (D.C., O., 1990).

2.5.1 Compressive Strength

The proportion of the palm oil shells and the water cement ratio normally affect the workability and the compressive strength of the concrete with palm oil shells as aggregate. The 28 day cube compressive strength of the concrete are found to be vary in the range of 5.0 to 19.5 N/mm2. (A.A.A., A., 1997). The compressive strength of concrete with kernel shells was found continue to increase with age. This shows that the kernel shells do not undergo any degradation after mixed with the concrete matrix. Besides, study was done by other researchers that the compressive strength of the kernel shells concrete at 28 day was higher than the minimum required strength of 17 MPa as required by ACI 318 (1995) for structural purposes. (Teo, D. C. L., L.Y.F.). Even though the compressive strength of the kernel shells concrete continues to develop with age, but still remained below that of the normal concrete. The development of the compressive strength of Crushed PKS concrete was about 49-55% lower compared with the normal concrete. (Mannan, M.A., G.C., 2004). Although the kernel shell aggregate is a type of organic material, but study was done by other researchers showing that the biological decay was not evident as the concrete cubes gained strength even after 6 months. (Teo, D.C.L., M.M.A., Kurian V.J., 2006).

2.5.2 Flexural Strength

Reinforced concrete beam made from palm oil shells are found to be exhibited satisfactory in structural behavior. With a lightweight concrete mix of 1:1.5:0.5/0.5 cement, sand, palm kernel shells and water-to-cement ratio, a 28 day cube compressive strength are found about 17.5 N/mm^2. (A.A.A., A., 1997).Study done by other researchers has shown that the 28 day flexural strength of kernel shell concrete was about 14% to 17% of the compressive strength whereas for normal concrete, the flexural strength is about 13% to 15%. This shows that the behavior of the kernel shell concrete is similar with the normal concrete. (Mannan, M.A., G.C., 2002). However, the flexural strength of concrete with kernel shell is weak in resisting bending stress compared with the normal concrete. (Teo, D. C. L., L.Y.F.). These flexural strength values obtained still fall within the normal range of the conventional concretes, in which the flexural strength is about 10 to 23% of its compressive strength. (S.,S.1995).The flexural strength of concrete depends on physical strength of coarse aggregate to some extent, just like compressive strength. (Mannan, M.A., G.C., 2002). Besides, the flexural strength is influenced by the diffused moisture distribution in the test samples significantly. (Short A., K.W., 1978). As the density decrease, the flexural strength also decrease. (D.C., O., 1990).

2.6 Palm kernel shell

Palm kernel shells are derived from the oil palm tree (elaeisguineensis), an economically valuable tree, and native to western Africa and are common throughout the tropics (Omange, 2001). They are used in commercial agriculture in the production of palm oil. The African oil palm (elaeisguineensisis) native to West Africa, occurring between Angola and Gambia. The generic name is derived from the Greek word for oil, (elaion) while the species name has referred to its country of origin (Sulyman and Junaid, 1990). In Nigeria, about 1.5 million tons of Palm Kernel Shells (PKS) are produced annually; most of which are often dumped as waste products (Nuhu-Koko, 1990). The waste could be converted to wealth by using it in the production of asphaltic concrete. Some years ago, the use of local materials in the construction industry has been campaigned by the Nigerian government to limit costs of construction (Mohammed, 2014). There has been a greater call for the findings and development of alternative, agro-based and, non-conventional local construction materials in view to connect the maximum potential of agricultural waste in agricultural sector. Palm oil shells are one of the naturally occurring raw materials and obtained as a byproduct when palm oil is extracted from the palm nuts. The palm oil tree, which the palm oil shell is extracted from,is a type of wet tropical tree, which found mostly around the equatorial zone. (D.C.O.1990).The agricultural waste as aggregates can be used as an alternative to conventional construction material in producing the aggregate concrete. These agricultural wastes are produced in a large quantity from the palm oil mills and can be used as aggregates in producing lightweight concrete.

These agricultural wastes also can be used in production of cementitious materials, its fibers can be used in particle boards or sheets and its shell can be used as aggregates. (A.A.A.1997).The material properties and structural performance of lightweight concrete made from palm oil shell are found to be similar with the lightweight concrete made from common aggregates such as clinker, foamed slag, and expanded clay. The palm oil shells are hard and crushed as a result of the process of extracting the oil. Sieving is needed in order to remove the fine particles. After sieving, the shells are air-dried before used in concrete mixing. (Satish Chandra, L.B.)

2.7 Types of the palm oil fruits

The palm oil produces two types of oils. The fibrous mesocarp produces the palm oil whereas the palm kernel produces the lauric oil. In the conventional milling process, the fresh fruit bunches are sterilized, then the fruitlets are stripped off, then digested and pressed to extract the crude palm oil. The nuts separated from the fiber in the press cake and cracked to obtain the palm kernels. The palm kernel then crushed in another plant to obtain the crude palm kernel oil and a byproduct, palm kernel cake which is used as animal feed. Palm oil has a balanced ratio of saturated and unsaturated fatty acids whereas the palm kernel oil has saturated fatty acids almost the same with the composition of coconut oil. (Teoh, C.H. 2002). Palm kernel shells is a type of agricultural solid wastes and as being an organic material, it can be biodegradable and decay over a long period of time if the environment is full with moisture and sufficient air are present. (Mannan, M.A., A.J., Ganapathy C., Teo D.C.L. 2006). Presently, the uses of palm oil shell are limited to the fuel for burning and as finishes in mud houses. The shells can provide several advantages if it was found to be structurally adequate. Such depend on the species and the time of year. (D.C., O. 1990)Sometimes, advantages include the low density of the shells which can reduce the self-weight of the material, good thermal insulation and good sound absorption. (D.C., O. 1990). Palm oil shells are dark grey to black in color. The shell has two faces that are outer face and inner face. The outer face are from which the fibers and palm oil has been extracted, and this face can be smooth or rough depend on the extraction process. The inner faces are from which the kernel are extracted, and this face is relatively smooth. (D.C., O. 1990). The shells also have irregular shapes such as angular or polygonal, depending on the extraction process. Besides, the thickness of the shells is variable and can range from 0.15 to about 3mmthe oil coating can present on the surface of fresh palm oil shells, therefore, pretreatment to remove this oil coating are necessary. The pretreatment can be done via various ways, including natural weathering, boiling in water, and washing with detergent. (Teo D.C.L. M.M.A., Kurian V.J.2006). The mechanical properties of palm oil shell, crushed granite and sand are shown in Table 2.2. From the Table 2.2, it shows that the shell has higher water absorption with a capacity of 23.3%. This high water absorption may due to the high porosity in the shell. This shows that the shell need more water compared to the conventional aggregate to attain the same consistency. (D.C.O. 1990). Since the shell has higher water absorption, the shells need to be pre-soaked in portable water for 24 hour to achieve saturated surface dry (SSD) condition before mixing. This is to prevent the absorption from occurring during the mixing. (Teo, D.C.L, M.M.A., Kurian V.J, Ganapathy C 2007). The mechanical properties of palm oil shell, crushed granite and sand are shown in Table 2.2. From the Table 2.2, it shows that the shell has higher water absorption with a capacity of 23.3%. This high water absorption may due to the high porosity in the shell. This shows that the shell need more water compared to the conventional aggregate to attain the same consistency. (D.C., O. 1990) Since the shell has higher water absorption, the shells need to be pre-soaked in potable water for 24 hour to achieve saturated surface dry (SSD) condition before mixing. This is to prevent the absorption from occurring during the mixing. (Teo, D.C.L, M.M.A., Kurian V.J, Ganapathy C 2007).

Table 2.5: Chemical Composition of PKS (Palm Kernel Shell) Aggregate

Elements	Results (%)
Ash	1.53
Nitrogen (N)	0.41
Sulphur(S)	0.000783
Calcium (C)	0.0765
Magnesium (MgO)	0.0352
Sodium (Na_2O)	0.00156
Potassium (K_2O)	0.00042
Aluminium (Al_2O_3)	0.130
Iron (Fe_2O_3)	0.0333
Silica (SiO_2)	0.0146
Chloride (Cl)	0.00072
Loss on ignition	98.5

Source:(Teo, D.C.L, M.M.A., Kurian V.J, Ganapathy C 2007).

2.8 Waste material with partial replacement

Attempts have been made by various researchers to reduce the cost of concrete constituents and hence total construction cost by investigating and ascertaining the usefulness of materials which could be classified as agricultural or industrial waste. Some of these wastes include sawdust, pulverized fuel ash, palm kernel shells, rice husk and ash, slag, fly ash which is produced from milling stations, thermal power station and waste treatment plants (Usman et al., 2012, Kumar et al., 2012). The market inflationary trend and the constituent materials used for concrete have led to high cost of construction (Ndoke, 2006). In the same write up, an assessment was carried out on the performance of palm kernel shells as a partial replacement for coarse aggregate in asphalt concrete. It was concluded that palm kernel shells could be used up to 30% in asphalt concrete production. Nowadays, there are some waste material which are being identified to be replace of fine aggregate in concrete production. As an example, according to D. Dahiru and J. Usman (2012), polymer waste material were identified to be partial replacement of fine aggregate in concrete production. Polymer waste material which are include polyethylene packing bags and pure water bags were collected from dump and processed to be fine aggregate with size 4.75mm. The result showed increase of 30% of polymer waste material leads to decrease of 53% compressive strength and decrease of 73.3% in tensile strength (D. Dahiru and J. Usman, 2012). According to SadoonAbdallah and Mizi Fan (2014), waste glasses were studied to be replaced of fine aggregate in concrete production. Waste glass which from used windows were used as a material of the study. The result showed the increase of percentage of replacement of waste glass would increase the compressive strength of concrete. According to Sreekrishnaperumal, Thanga,Ramesh, et al. (2013), furnace slag and welding slag were studied to be replace of fine aggregate in concrete production. Furnace slag and welding slag were collected from local fabrication industries were used as a material. Normal concrete with zero replacement were used as a reference materials. The result showed the better performance of the concrete as a partial replacement of concrete. The compressive strength on seventh day of concrete cubes increases from 10% to 15% replacement of sand by welding slag than the reference materials. Similarly 10% of furnace slag showed an optimum strength of 21.1 N/mm^2. The compressive strength on 28th day of concrete cubes increases from 5% to 15% of replacement of sand by welding slag than the reference materials. The optimum compressive strength of slag concretes has been found to be 41 N/mm^2 for 5% welding slag and 39.7 N/mm^2 for 10% furnace slag. The results show that 5% of welding slag and 10% furnace slag replacement with sand is very effective for practical purpose. Then, according to Dr. Festus A. Olutoge, et al. (2012), palm kernel shell ash can be used as a replacement of cement.

Palm kernel shells which were collected from palm oil mill were burnt and grinded into fine ash particles. Palm kernel shell ash was sieved through 45um sieve in order to remove any foreign material and bigger size ash particles. The result showed the concrete strengths were increased with the increase of curing age but were decrease with increasing percentage of palm kernel shell ash in concrete

2.8.1 Comparisons of palm kernel shells with other agricultural wastes

The strength properties of concrete with palm oil shells as aggregate were compared with other lightweight concrete with other agricultural wastes as aggregates. Four types of agricultural wastes were studied including palm oil shells, palm oil clinkers, rice husks and coconut shells. The palm oil clinkers are the byproducts of the palm oil mills energy generating burners. Both the palm oil clinkers and the coconut shells needed to be crushed and broken into size not larger than 20 mm before use in concrete mixing. Before using these agricultural wastes, these aggregates wastes need to be air-dried. The concrete mixed with a ratio of 1:1:2 of cement, sand and agricultural wastes with water-cement-ratio of 0.55.

CHAPTER THREE
MATERIALS AND METHODS

3.1 Introduction

The demand for concrete continues to be on the increase due to myriads of construction activities that are not only essential to sustain the present civilization, but also aimed at providing housing needs for the low income earners, which constitute the largest group of the populace. Although concrete consists of cement, sand, gravel, and water, the most expensive of these is cement. In Nigeria, for example, with an estimated deficit of 16 to 18 million housing unit, about 112 million tonnes of cement is required (Oluwakiyesi, 2001).

Subsequently, research efforts have been directed at finding alternative and suitable materials as partial replacement for cement, especially from both industrial and agricultural wastes. Some of the industrial wastes that have been found suitable include: fly ash Wilson and Ding (2007), Silica fume Yilmak, (2010) and blast furnace slag Fernandez,(2007). The agricultural wastes found suitable are: saw dust ash, rice husk ash, Givi.et.al,(2010), periwinkle shell ash , sugar cane straw ash, bamboo leaf ash, Bambara groundnut shell ash, groundnut ash, pitchstone fines, cassava peel ash Salau and Olonade, (2011),pulverized bone Falade et al,2013, palm kernel ash

3.2 Selection of materials

3.2.1 Sources of Materials

The experimental studies were carried out on materials which were sourced within Awka. The sharp river sands used was obtained from a building construction site. The PKS (Palm kernel shell) used were bought in Awka at where they were stockpiled as wastes. After sourcing these PKS (Palm kernel Shell), they were washed thoroughly to remove impurities that could affect the properties of the concrete and later spread in an open space to dry up. The Dangote Portland Cement used was bought in Awka.

3.3 Test Apparatus

The following apparatus were used in the course of this study for the experiments include:

i. Weighing Balance

ii. B.S Sieves

iii. Moulds

iv. Rammer/Tamping Rod

v. Slump Cone

vi. Universal Testing Machine

3.3.1Moulds

An open cast-iron or steel square comprising four sides and a base plate to which the mould is clamped. They are of size 150mm by 150mm by 150mm. They were
properly oiled and tightened before usage.

Plate 3.1: Steel Mould

3.3.2 Weighing Balance

It is also used for weighing the cubes after curing. This has a range of 0.00-50.00 kg and it is used in weighing the required proportion of constituent materials for the concrete, as batching is by weight.

Plate 3.2: Weighing Balance

3.3.3 B.S Sieves

These are to be used in the sieve analysis of fine aggregates, coarse aggregate and quarry dust and are also used in getting the required sizes of granite for the purpose of the experiment. They are circular vessels with a bottom of woven wire to separate different sizes of aggregate.

Plate 3.3: Set of B.S sieves.

3.3.4 Rammer/ Tamping Rod

It shoud have a length of 400mm long. 1.8kg mass and a bottom ramming face 25 mm, which is used to tap the concrete during casting to achieve good compaction.

3.3.5 Other Instruments

This includes the trowel, shovels, scrappers, head pans, wheelbarrow, measuring tape etc.

3.4Raw Materials

3.4.1 Sand (fine aggregate)

The river sand used was clean, and free from clay, dirt and any organic or chemical matter of any kind. The sand was sieved by mechanical sieve shaker to pass through 4.75mm and 0.075mm sieve in order to fulfill the requirement.

3.4.2 Grained Palm Kernel as fine aggregate

Palm kernel shells were obtained was obtained in the already cracked and oil-extracted form, the fibrous outer parts of the nut already removed. It was kept indoors in sacks for 2 months. It was washed and graded in accordance with the British Standard methods of sampling, testing and sieve test of light weight aggregates for concrete. Other alternative, the shells were will obtained directly from any factory as palm kernel shell supplier. The quantity required for the experiment were crushed manually for 1week with the help of a hammer (Monday hammer). The particle diameter is 2.36 mm.

3.4.3 Cement

The cement used was Dangote Portland Cement .The cement is commonly used for the construction in the country, and is available in almost all part of Nigeria. For this reason, I limited myself to using Dangote Portland Cement; usage of other brands might affect the results of the tests obtained.

3.4.4 Water

In the moulding of the concrete cubes and partially replaced with crushed PKS(Palm Kernel Shell), water free from impurities and noted to be clean, portable, fresh and odorless was used throughout the experiment.

Grading of aggregates (particle size distribution)

Grading of aggregate is done by means of sieve analysis. Grading of aggregates defines the properties of different sizes in the aggregates. Sieve analysis is the test carried out on soil sample to determine the particle size distribution in soil material to ascertain the behavior pattern of the soil material. In this experiment, dry sieve analysis was adopted. This was done by shaking the sample through successive standard sieves of different aperture stacked together and noting the percentage of the aggregate retained by sieve.

A plot of the percentage passing each sieve against the sieve size (mesh) gives the grading of the aggregate sample. The grading is noted to have considerable effect and economy in the use of cement (Okpala 1990). According to (Handoo,et al, 1997),it is important to note that of a given consistency and cement content, a well graded aggregate produces a stronger mix than a poorly graded one. Aggregate grading is a major factor in assessing the workablitity of concrete mix which further affects the important characteristics of fresh concrete mix, Note the presence of finer particles in aggregates gives cohesion to the mix while excess of large particles results in harsh mix.

3.4.5 Grading of Fine aggregates (Sand)

Aim: To determine the particle size Distribution of the Fine Aggregates

Apparatus used:

i. Mechanical Sieve Shaker

ii. Set of Standard sieves

iii. Weighing Balance (maximum readable to 1000gram)

iv. Sample of the aggregate (sand 500gram)

v. Trowel

vi. Receivers sieve brush

3.4.6 Summary of test procedure

i. About 500grammes of the sample was weighed and soaked into waterfor 12hours.After 12 hours, the sand was washed through 0.075mm sieve and I ensured no particle was lost in the process.

ii. The sample was transferred into a pan and place into the oven in the lab to dry for about 18 hours
iii. The stacks of sieves with the largest opening were places above the smaller ones
iv. I poured the sand into the sets of sieves from the top and placed the cover along the stack of sieves.
v. I switched on the mechanical sieve shaker for about 15 minutes. After 15 minutes has elapsed, I turned it off and remove the stack of sieves
vi. I weighed the amount of soil retained on each of the sieve and recorded the values.
vii. I then calculated the mass retained on each sieve, percent mass retained, cumulative percent mass retained and cumulative percent passing.

3.4.7 Grading of the Crushed PKS Aggregates

Aim: To determine the Particle Size Distribution of the Crushed PKS (Palm Kernel Shell) Aggregates

Apparatus Used

i. Mechanical Sieve Shaker
ii. Set of standard Sieves
iii. Weighing Balance (maximum readable to 1000gram)
iv. Sample of the aggregate (PKS 300 gram)
v. Trowel
vi. Receivers Sieve brush

3.4.8 Water/Cement Ratio Determination

The water/cement used for the experimental study is generally 0.6.This was made so because I want to achieve a specific strength for a specific water/cement ratio. The use of different w/c ratio affects the strength of the concrete. This now makes it fit in the use of a particular ratio in carrying out the work.

3.4.9 Material Mixing

The aggregates (sand and crushed PKS) were spread in a uniform layer on a had clean and impermeable floor and the Dangote Portland Cement was spread over the aggregate and the dry materials were mixed thoroughly by turning from one end of the floor to the other until the mix appears uniform. Water was then added gradually so that neither water nor cement could escape in which a chemical reaction called hydration took place. The mix was turned over again until it appears uniform and homogeneous.

3.5 Moulding

Block manual moulds of 150 x 150 x 150mm were used for this experiment. The interior of the mould was first lubricated with mould oil to prevent the blocks from sticking to the sides so as to give the block a surface and enable easy removal of the mould from the block after casting. The mould materials were then poured into the mould to the required level and compacted 35times. Before filling the mould with the mixed materials, each layer of the mix is compacted 35times.

Demoulding of the blocks was done after 12hours.The freshly made blocks were not over handled to avoid distortion.

3.6 Slump Test

Firstly, the internal surface of the cone mould was cleaned carefully and then oiled. The cone mold was placed on a clean, smooth, horizontal and non-porous base plate. The quantities of the materials used were batched by volume. The concrete materials were mixed at 0.6 water/cement ratio. After the mixing, the mould was filled with fresh concrete in three layers and each layer was tamped 25times with a steel rod. After filling the mould, excess concrete was removed and the top surface was leveled. The base plate was firmly held as the mould was been lifted gently in the vertical direction. The unsupported concrete slumped and the decrease in height at the center point was measured

3.7 Crushing of concrete cubes

Compressive strength of the casted cubes was tested at 7days, 14 days, 28days age of curing. The cubes to be crushed were aired before being placed on the universal testing machine. Weight of the cubes were tested and noted. The cube to be tested was placed in the space in between bearing surfaces. Care was taken to prevent existence of any loose material or grit on the metal plates of the machine. The cube placed on the bearing plate was aligned properly with the center of the thrust in the testing machine plates. The loading was applied axially on the specimen without any shock and was increased at the rate of 120KN/min till the specimen collapses. Due to constant application of Load, the specimen cracked at a point and the breakdown of the specimen was noted.

3.8 Formula used for Computation

3.8.1 Compressive Strength

The Compressive strength of concrete cube is computed as follows:

$$\text{Compressive Strength } (N/mm^2) = \frac{\text{Applied Load (N)}}{\text{Area of the Cube (mm x mm)}}$$

Applied Load=Force (N)

Now conversion of applied load from Ton Force to KN to N

Area of the Cube =150mm x 150mm =22500mm^2

3.8.2 Sieve Analysis

Coefficient of Uniformity, Cu $=\frac{D60}{D10}$

Coefficient of Curvature, Cc = $\frac{\mathrm{D30}^2}{\mathrm{D60} \times \mathrm{D10}}$

For a Sand to be well graded

The Coefficient of Uniformity Cu should be greater than 6 (Cu >6)

The Coefficient of Curvature Cc should be less than or equal to 1 and greater than or equal to 3(1≤Cc≤ 3)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

This comprises of the results and analysis of tests done in the process of this project. This includes Particle size distribution, workability test (Slump Test) and Compressive Strength Test.

4.2 Results and Discussion

4.2.1 Sieve Analysis Results

Table A. Grain Analysis of Fine Aggregate (Sand)

Sieves sizes (mm)	**Weight Retained (g)**	**%Weight retained**	**% Cumm Weight retained**	**% Cumm Weight passing**
4.75	1.05	0.21	0.21	99.79
2.36	23.82	4.76	4.97	95.03
1.18	71.68	14.34	19.31	80.69
0.600	93.82	18.76	38.07	61.93
0.300	175.44	35.09	73.16	26.84
0.150	121.04	24.20	97.36	2.64
0.075	8.24	1.65	99.01	0.99
Tray	0.24	0.05	99.06	0
Total	**500**	**99.06**		

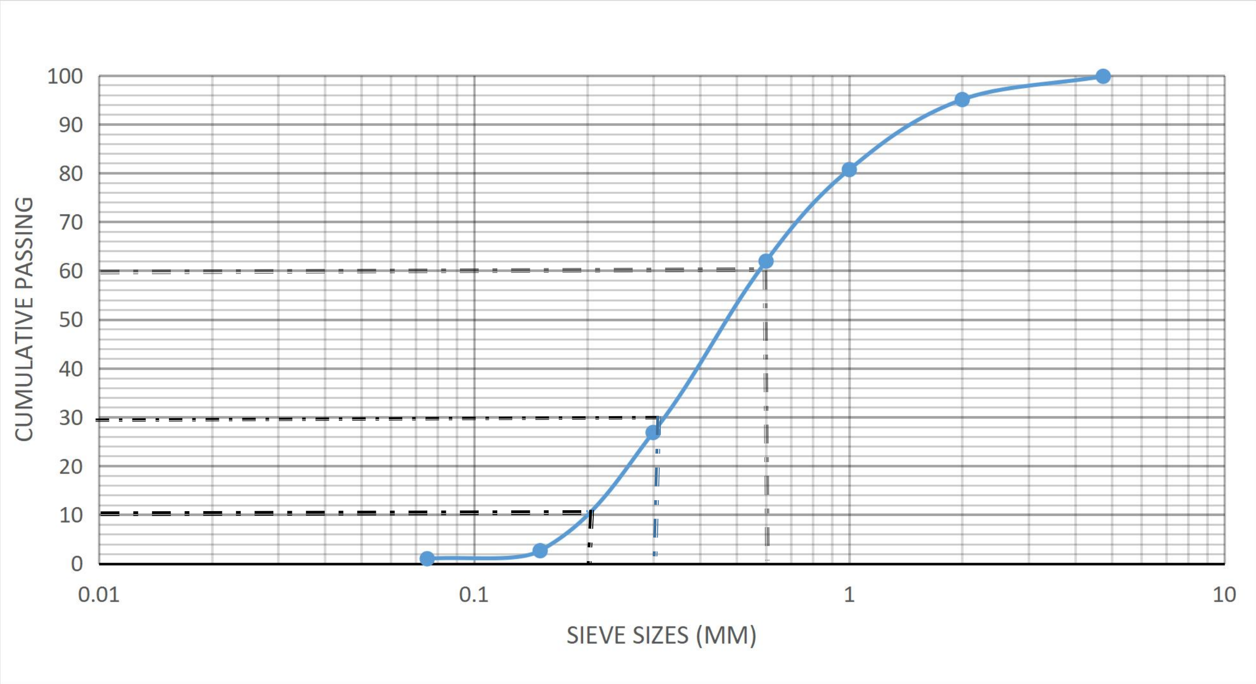

Figure 4.1: Particle Size Distribution for Sharp Sand

From the graph;

D60	0.45
D30	0.33
D10	0.21

Uniformity Coefficient Cu	2.14
Coefficient Curvature Cc	1.15

Coefficient of Uniformity, Cu $= \frac{D60}{D10} = \frac{0.45}{0.21} = 2.14$

Coefficient of curvature, Cc $= \frac{D30^2}{D60 \times D10} = \frac{0.33^2}{0.45 \times 0.21} = 1.15$

The Coefficient of Uniformity, Cu is 2.14 which is less than the minimum required value which is the value of sand and the Coefficient of curvature equals 1.15 and which is neither greater than or equal to 1 nor is it less than or equal to 3.Therefore ,The Cu Standard was not met therefore the sand was poorly graded.

Table B. Grain Analysis of Crushed PKS (Palm kernel shell) Aggregate

Sieve sizes (mm)	Weight Retained (g)	%Weight retained	% Cumm Weight Retained	% Cumm Weight Passing
4.75	5.74	1.91	1.91	98.09
2.36	165.79	55.26	57.17	42.83
1.18	66.13	22.04	79.21	20.79
0.600	32.58	10.86	90.07	9.93
0.300	15.25	5.08	95.15	4.85
0.150	8.18	2.72	97.87	2.13
0.075	3.22	1.07	98.94	1.06
Tray	3.11	1.04	100.00	0
Total	**300**	**100.0**		

Visual examination of crushed palm kernel shell shows it to be as fine as the conventional sharp sand. It is, however lighter in weight when compared with normal sharp sand, indicating the density of concrete made with palm kernel shell will be less compared with the density of sand concrete with the volume. It is also gritty when rubbed between fingers.

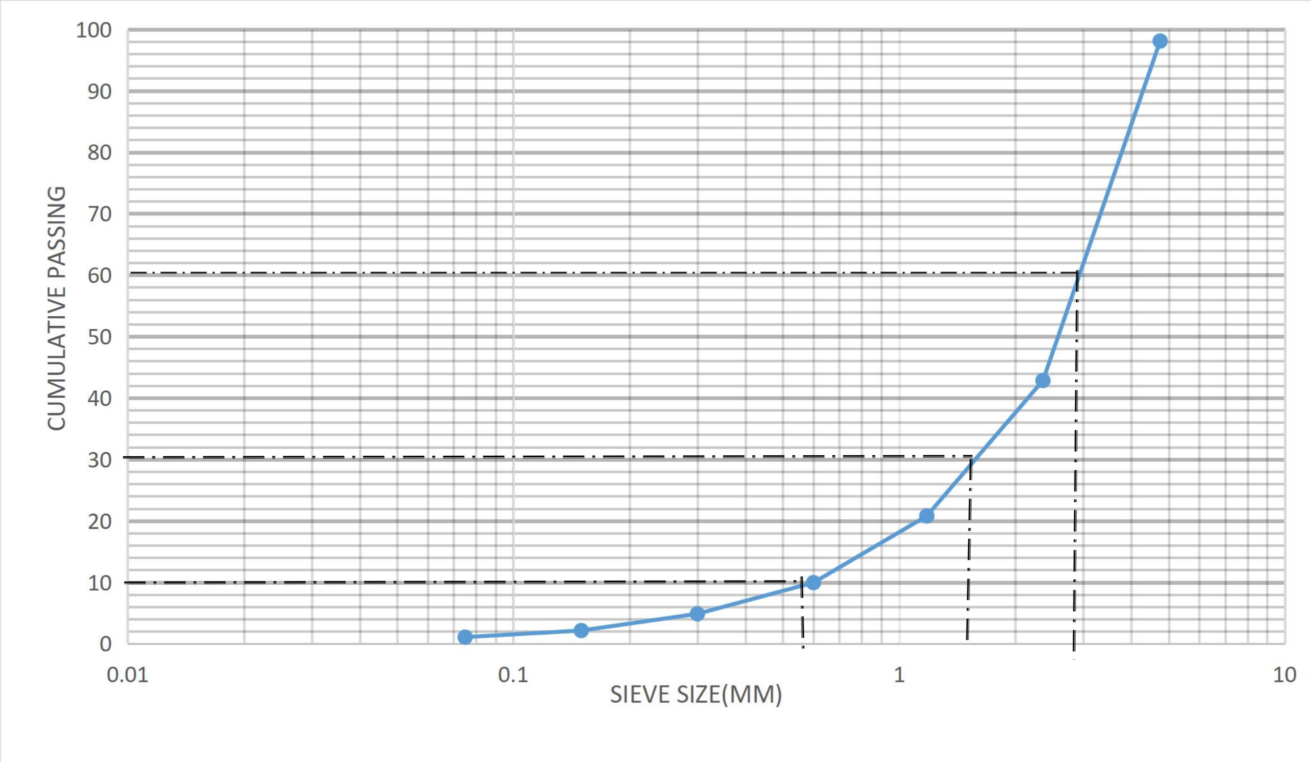

Figure 4.2: Particle Size Distribution for Crushed PKS (Palm Kernel Shell) Aggregate

From the graph:

D60	3.0
D30	1.5
D10	0.3

Uniformity Coefficient Cu	10.0
Coefficient Curvature Cc	2.5

Coefficient of Uniformity, Cu = $\frac{D60}{D10} = \frac{3.00}{0.3} = 10.0$

Coefficient of curvature, Cc = $\frac{D30^2}{D60 \times D10}$ $=\frac{1.5^2}{3.0\,X 0.3}$ = 2.5

The Coefficient of Uniformity, Cu is 10 which is greater than the minimum required value which is the value of sand and the Coefficient of curvature equals 2.5 and which is greater than or equal to 1but less than or equal to 3.Therefore ,The Cu Standard was not met therefore the crushed PKS (Palm kernel shell)was well graded.

4.3 Workability Test

The workability test was conducted with a water-cement ratio of 0.6 for the various tests immediately after mixing. The height of the slump after removing the mould was measured using the standard tamping rod and measuring rule. The slump values was shown in the table below;

Table C; Workability Test Values (Slump values)

Percentage of Crushed PKS (Palm Kernel Shell) added	Height of Slump cone (mm)	Height of Mix (mm)	Slump Value (mm)
0%	300	258	42
10%	300	275	25
20%	300	281	19
30%	300	282	18

Based on the workability, it shows that the slump value reduces with the addition of crushed Palm kernel shell in the mix at different percentages.With the information above ,it can be noticed that the addition of Crushed palm kernel shell reduces the workability of concrete at various percentages used(10%, 20%, 30%) during the experiment.

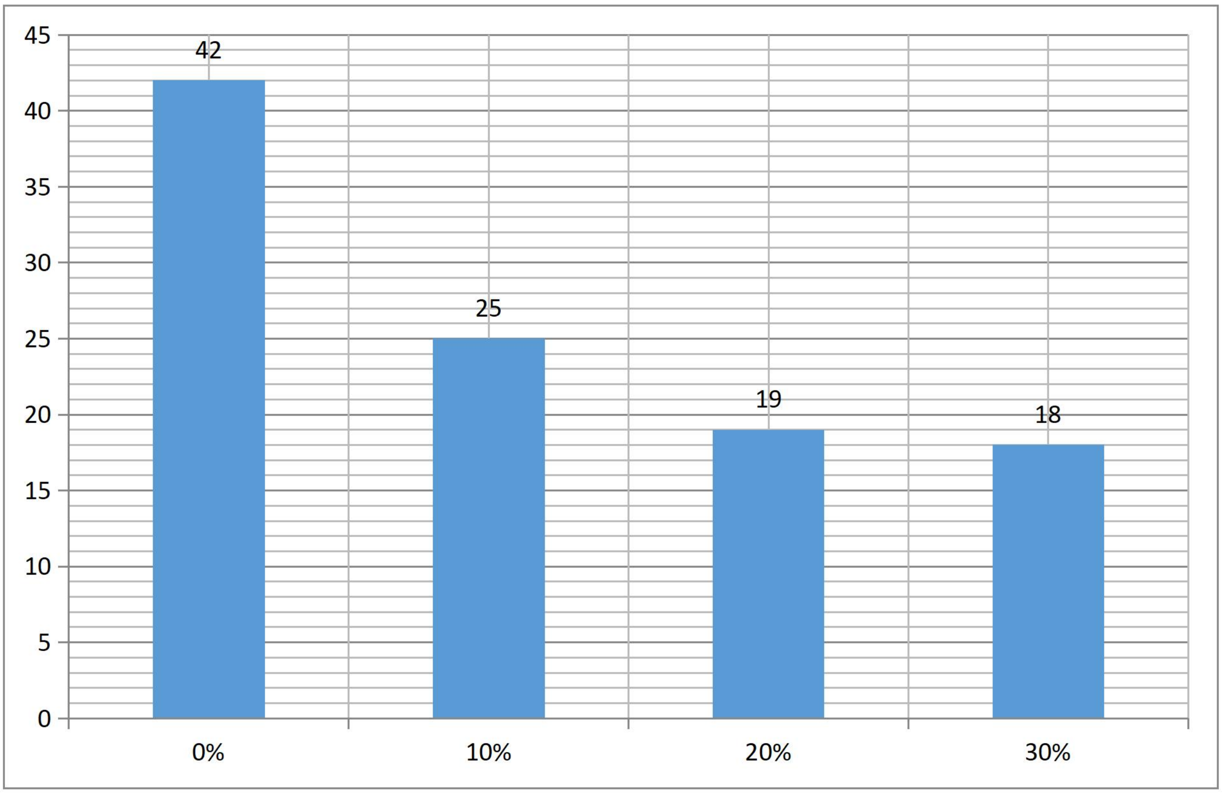

Figure 4.4: Slump Values of different percentages of Crushed Palm kernel Shell (PKS) added

Ranges of Workability of Concrete

Very low workability : Slump value :0-25mm

Low workability : Slump Value :25 -50mm

Medium workabilty: Slump value : 50-100mm

High workability : Slump value: 100-175mm

With the information above ,it can be noticed that the addition of Crushed palm kernel shell reduces the workability of concrete at various percentages used(10%, 20%, 30%) during the experiment.

4.4 Density & compressive Strength test Result for 0% Crushed palm kernel shell in 7, 14, 28 days

Table 4.1: The Result of compressive Strength for 0% Crushed Palm Kernel shell in 7, 14. 28 days

LAB NO	Parameters	7 Days	14 Days	28 Days
1	**Content of Crushed PKS added**	0%	0%	0%
2	**Size of Cube (mm)**	150 x 150x 150	150 x 150 x 150	150 x 150 x 150
3	**Mix ratio**	1:2:4	1:2:4	1:2:4
4	**Weight of the Cube(kg)**	8.00 7.66	8.10 7.89	8.20 8.18
5	**Concrete Density(kg/m$^{3)}$**	2.304	2.340	2.426
6	**Applied Load for Cube 1 & Cube 2**	303.75 290.25	456.75 407.25	495.00 528.00
7	**Compressive strength of Cube 1 & Cube 2**	13.5 12.9	20.3 18.1	22.0 22.5
8	**Average Compressive Strength(N/mm^2)**	13.20	19.2	22.75

4.5 Density & compressive Strength test Result for 10% Crushed palm kernel shell in 7, 14, 28 days

Table 4.2: The Result of compressive Strength for 10% Crushed Palm Kernel shell in 7, 14. 28 days

LAB NO	Parameters	7 Days	14 Days	28 Days
1	**Content of Crushed PKS added**	10%	10%	10%
2	**Size of Cube (mm)**	150 x 150 x 150	150 x 150 x 150	150 x 150 x 150
3	**Mix ratio**	1:2:4	1:2:4	1:2:4
4	**Weight of the Cube(g)**	7.50 7.41	7.60 7.82	7.92 8.10
5	**Concrete Density(kg/m$^{3)}$**	2.19	2.34	2.37
6	**Applied Load for Cube 1 & Cube 2**	288.00 267.75	384.75 371.25	410.25 438.75
7	**Compressive strength of Cube1 & Cube 2**	12.8 11.9	17.1 16.5	20.9 19.5
8	**Average Compressive Strength(N/mm^2)**	12.35	16.8	20.2

4.6 Density & Compressive Strength test Result for 20% Crushed palm kernel shell in 7, 14, 28 days

Table 4.3: The Result of Compressive Strength for 20% Crushed Palm Kernel shell in 7, 14. 28 days

LAB NO	Parameters	7 Days	14 Days	28 Days
1	**Content of Crushed PKS added**	20%	20%	20%
2	**Size of Cube (mm)**	150 x 150 x 150	150 x 150 x 150	150 x 150 x 150
3	**Mix ratio**	1:2:4	1:2:4	1:2:4
4	**Weight of the Cube(kg)**	6.70 6.40	6.90 6.50	7.00 6.60
5	**Concrete Density(kg/m^3)**	1.94	1.98	2.01
6	**Applied Load for Cube 1 & Cube 2**	258.75 229.5	351.00 364.50	405.00 400.50
7	**Compressive strength of Cube1 & Cube 2**	11.5 10.2	15.6 16.2	18.0 17.8
8	**Average Compressive Strength(N/mm^2)**	10.85	15.9	17.9

4.7 Density & compressive Strength test Result for 30% Crushed palm kernel shell in 7, 14, 28 days

Table 4.4: The Result of compressive Strength for 30% Crushed Palm Kernel shell in 7, 14. 28 days

LAB NO	Parameters	7 Days	14 Days	28 Days
1	**Content of Crushed PKS added**	30%	30%	30%
2	**Size of Cube (mm)**	150 x 150 x 150	150 x 150 x 150	150 x 150 x 150
3	**Mix ratio**	1:2:4	1:2:4	1:2:4
4	**Weight of the Cube(g)**	6.60 6.20	6.60 6.30	7.00 6.60
5	**Concrete Density(kg/m^3)**	1.891	1.91	1.97
6	**Applied Load for Cube 1 & Cube 2**	202.50 226.95	303.75 351.00	344.25 400.50
7	**Compressive strength of Cube1 & Cube 2**	9.00 10.2	13.5 15.6	15.3 17.8
8	**Average Compressive Strength(N/mm^2)**	9.6	14.55	16.55

Table 4.5: Table showing the various compressive strengths with their various curing ages

	0%(N/mm^2)	10%(N/mm^2)	20%(N/mm^2)	30%(N/mm$^{2)}$
7 DAYS	13.20	12.35	10.85	9.60
14 DAYS	19.20	16.80	15.90	14.55
28 DAYS	22.75	20.20	17.90	16.55

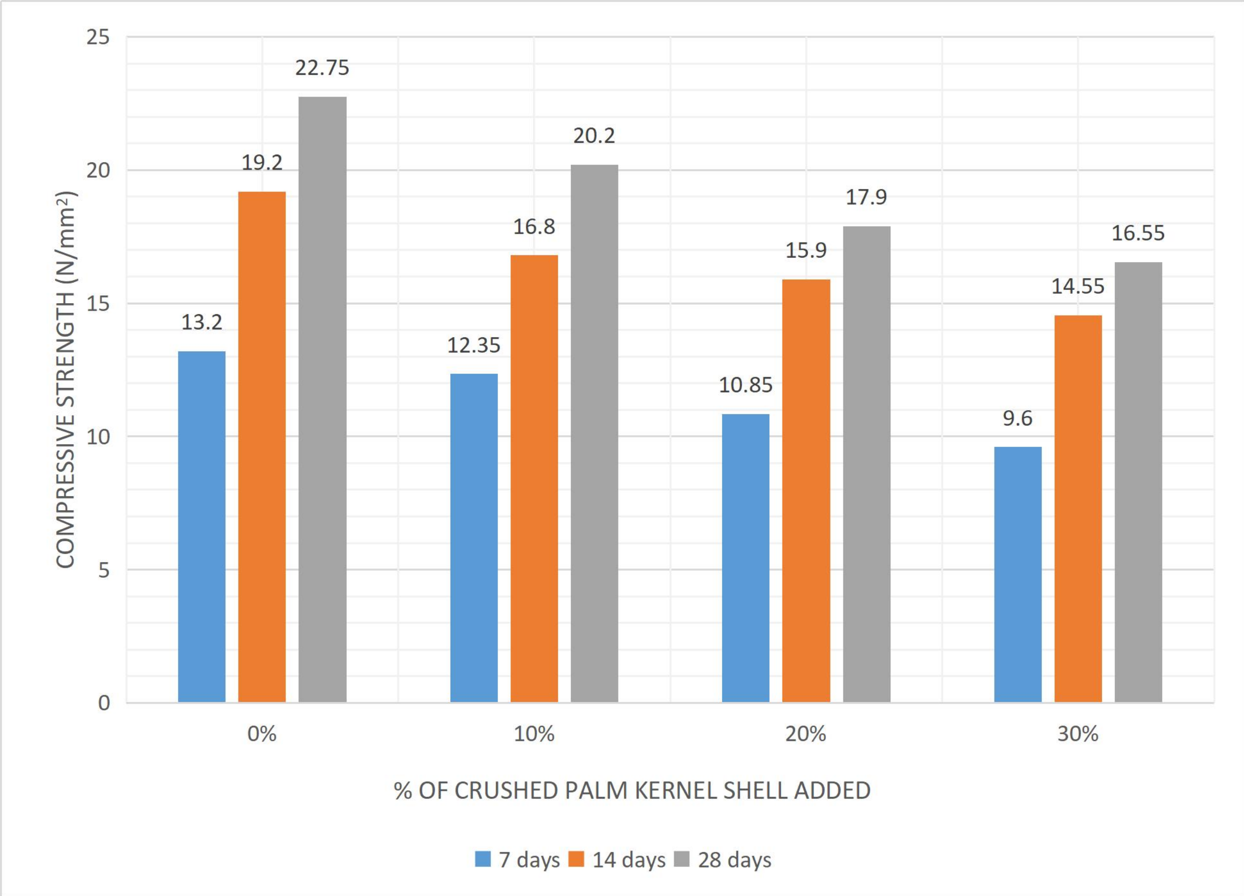

Figure 4.4: Various Compressive strengths with the (%) percentage of crushed palm kernel shell added

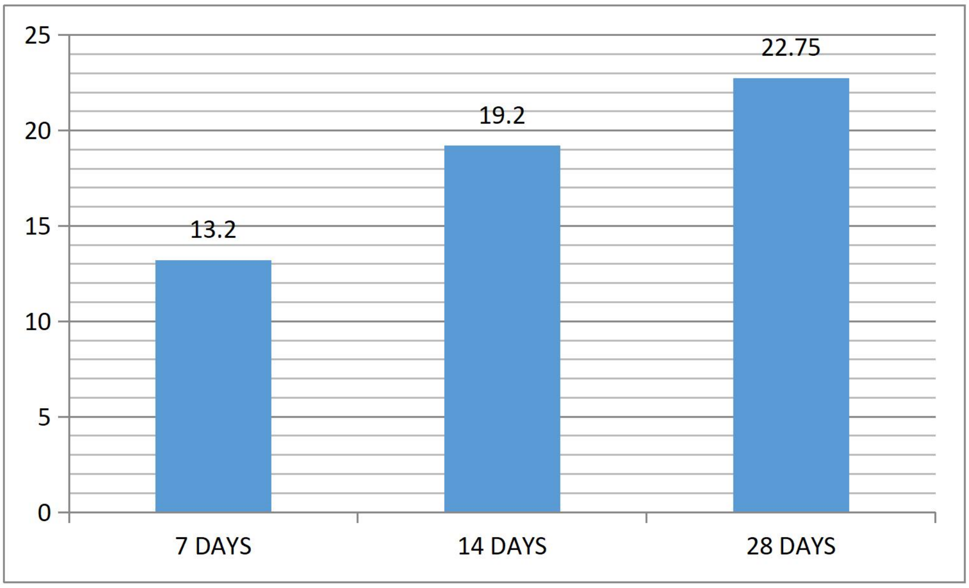

Figure 4.5: Compressive strength for 0% crushed palm kernel shell with curing ages

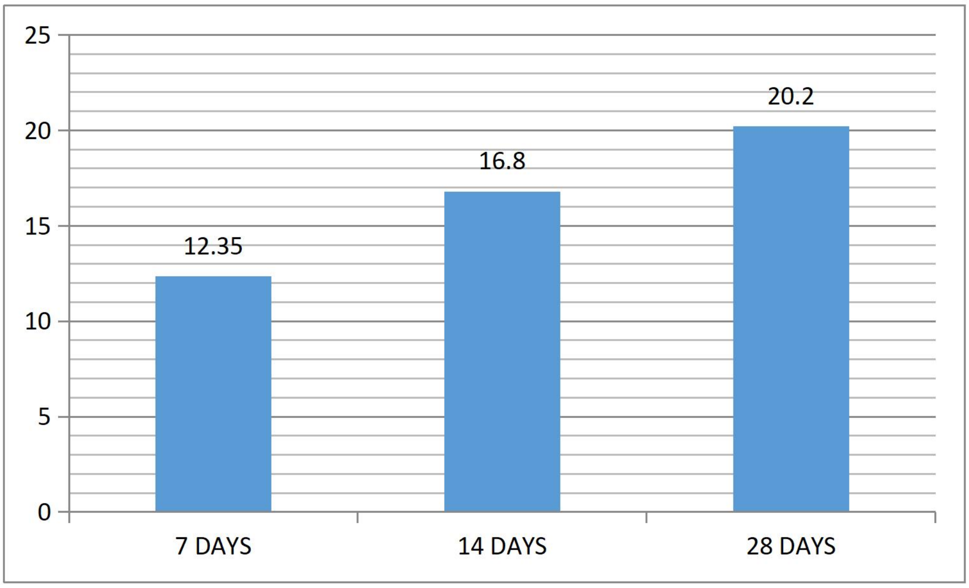

Figure 4.6: Compressive strength for 10% crushed palm kernel shell with curing ages

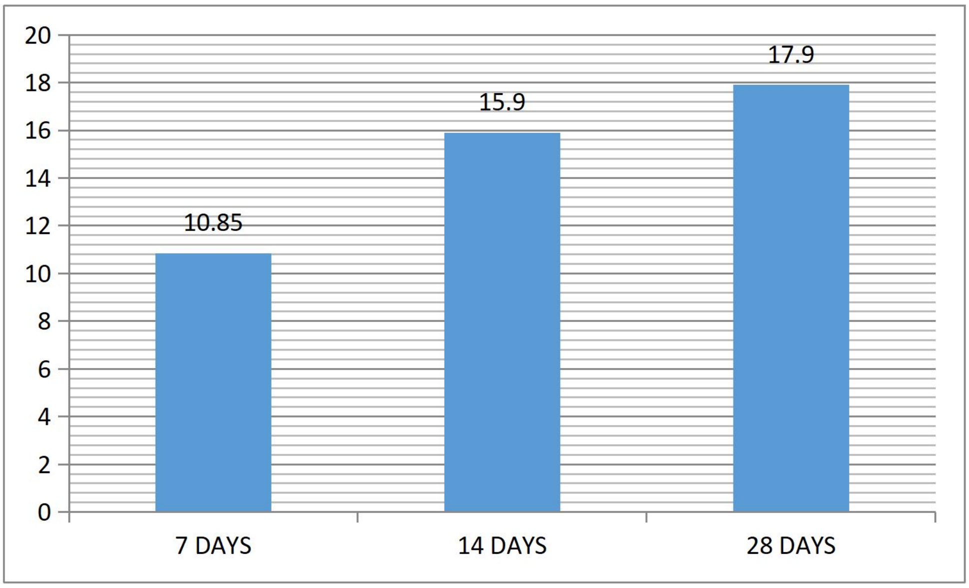

Figure 4.7: Compressive strength for 20% crushed palm kernel shell with curing ages

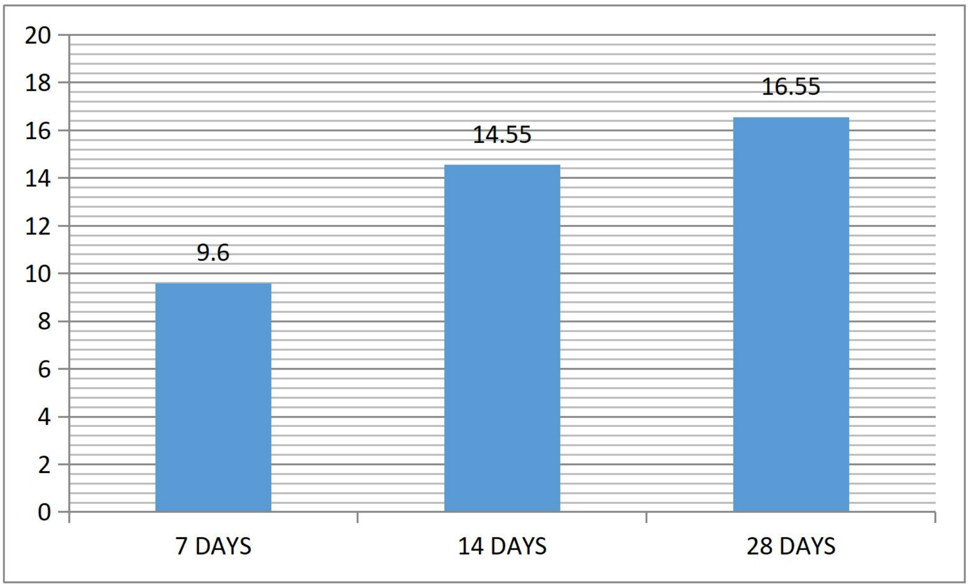

Figure 4.8: Compressive strength for 30% crushed palm kernel shell with curing ages

From the various graphs and figure above , it can be observed that the compressive strength of each percentage replacement(0%,10% 20%,30%)used increases with the curing ages(7 days, 14days, 28days) making 28 curing days the highest compressive strength for each percentage of Crushed palm kernel shell used in the experiment.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1Conclusion

From the Results for this investigation, the following conclusions were made;

1. From the Investigation above ,With average concrete density of about 2000kg/m^3, Percentage of Crushed Palm kernel shell(PKS) from 10%, 20%, 30% can be comparable with lightweight aggregate for the production of lightweight concrete
2. There exists a consistent pattern of strength-age curves for concrete with normal sand and crushed palm kernel shell content, though crushed palm kernel shell concrete exhibited lower strength at 28 days compared to the corresponding to normal sand concrete.
3. For the given mix proportion which is (1:2:4) mix, the compressive strength decreases gradually with increase in crushed palm kernel shell.

With the above information, it can be concluded that the presence of palm-kernel shell in concrete reduces the strength characteristics of concrete compared to normal sand. Crushed Palm kernel shell (PKS) can be a partial substitute for normal sand in concrete for non-load bearing structural elements.

5.2 Recommendations

From the results obtained

1. Crushed palm kernel shell is recommended to be used as a partial replacement of fine aggregate(substitute material) in making light weight concrete
2. Further studies should be done on introduction of additives and to determine the effect it will have on the concrete workability.
3. Subsequent studies on palm kernel shell concrete should allow a curing age of up to 90 days and above. More research is needed to reduce water absorptive nature of palm kernel shell of concrete.
4. The use of fly ash and admixtures like super plasticizers with crushed palm kernel shell in concrete production should also be looked into to determine if significant properties can be attained most especially the increase in its workability.

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APPENDIX

MIX PROPORTIONS

Calculations

Volume of mould =Volume of Cube

Volume of Cube =0.15 x 0.15 x 0.15 = $3.375 \times 10^{-3} m^3$

Using the mix proportion of 1:2:4 and water/cement ratio of 0.6

1 part of cement

2 parts of sand or Crushed palm kernel shell (CKPS)

4 parts of granite

1+2+4+0.6 =7.6

(0.15 x 0.15 x 0.15) x 2400kg/m^3 = 8.1kg

Wastage

10% of 8.1kg = 0.81 kg

Total mass = 8.1 + 0.81 = 8.91 kg

For 0%(Control Mix)

For the total mass of constituent of one cube:

$\frac{1}{7.6}$x 8.91kg =1.17kg (CEMENT)

$\frac{2}{7.6}$x 8.91kg = 2.34kg (SAND)

$\frac{4}{7.6}$x 8.91 kg = 4.69kg (GRANITE)

$\frac{0.6}{7.6}$x 8.91kg = 0.70 kg (WATER)

For 10% replacement with crushed palm kernel shell

10% of mass of sand

Mass of sand = 2.34kg

10% of 2.34 kg = 0.234kg

Mass of sand =2.34 kg – 0.234kg = 2.106kg

$\frac{1}{7.6}$x 8.91kg =1.17kg (CEMENT)

$\frac{4}{7.6}$x 8.91 kg = 4.69kg (GRANITE)

$\frac{0.6}{7.6}$x 8.91kg = 0.70 kg (WATER)

For 20% replacement with crushed Palm kernel shell

20% of mass of sand

Mass of Sand = 2.34kg

20% of 2.34kg = 0.468kg

Mass of sand to be used = 2.34 – 0.468 kg = 1.872kg

$\frac{1}{7.6}$x 8.91kg =1.17kg (CEMENT)

$\frac{4}{7.6}$x 8.91 kg = 4.69kg (GRANITE)

$\frac{0.6}{7.6}$x 8.91kg = 0.70 kg (WATER)

For 30% replacement with crushed palm kernel shell

30% of mass of sand

Mass of sand = 2.34kg

30% of 2.34 kg = 0.702kg

Mass of sand = 2.34kg – 0.702kg = 1.638kg

$\frac{1}{7.6}$x 8.91kg =1.17kg (CEMENT)

$\frac{4}{7.6}$x 8.91 kg = 4.69kg (GRANITE)

$\frac{0.6}{7.6}$x 8.91kg = 0.70 kg (WATER)

APPENDIX A:Slump Values of different percentages of Crushed Palm kernel Shell (PKS) added

Percentage of Crushed PKS (Palm Kernel Shell) added	Height of Slump cone (mm)	Height of Mix (mm)	Slump Value (mm)
0%	**300**	**258**	**42**
10%	**300**	**275**	**25**
20%	**300**	**281**	**19**
30%	**300**	**282**	**18**

APPENDIX B: Table showing the various Compressive strengths with their various curing ages

	0%(N/mm²)	**10%(N/mm²)**	**20%(N/mm²)**	**30%(N/mm²)**
7 DAYS	13.20	12.35	10.85	9.60
14 DAYS	19.20	16.80	15.90	14.55
28 DAYS	22.75	20.20	17.90	16.55