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# THE USE OF COCONUT SHELL AS REINFORCEMENT IN CONCRETE

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## ABSTRACT

This research presents the results of an investigation carried out on the compressive strength characteristics of concrete produced with the mix ratio (1:2:4) and a total of 24cubes of sizes 100mm x 100mm were cast and their physical properties determined. Result of the test show that the compressive strength of the concrete decreased as the percentage of the shells increased in the mix ratio given. However, concrete obtained from coconut shells exhibited a higher compressive strength than that without coconut shells. 11.3N/mm$^2$ to 10.7N/mm$^2$ was obtained for 7days curing of coconut shell in mix concrete of 10% to20% respectively as compared to 10.16N/mm$^2$ of 7days curing control test concrete. For 28days curing, 24.4N/mm$^2$ to 20.6N/mm$^2$ was obtained on coconut shells concrete mix of 10% to20% as compared to 21.5N/mm$^2$ of control test of concrete grade 20N/mm$^2$ with Dangote cement. For concrete density both control test and coconut shell mixed concrete were adequately the same in the range of 2400kg/m$^3$ to 2500kg/m$^3$.

**Keywords:** Concrete Production; Coconut Shell; Compressive Strength; Concrete Density; Dangote Cement;

## INTRODUCTION

Infrastructure development across the world created demand for construction materials. Concrete is the premier civil engineering construction materials. Concrete manufacturing involve consumption of ingredients, aggregate, water and admixtures. In addition, operations associated with aggregate extraction and processing are the principal causes of environmental concerns. In light of this, in the contemporary civil engineering construction, using alternative material in place of natural aggregate in concrete production makes concrete a sustainable and environmental construction material. Different alternative waste materials and industrial byproduct such as fly ash, bottom ash, recycled aggregate, crumb rubber, glass were replaced with natural aggregate and investigated properties of the concretes.

Apart from above mentioned waste material and industrial byproducts, few studies identified that coconut shells, as an agricultural by product can also be used as aggregate in concrete. Limited research has been conducted on mechanical properties of concrete with coconut shells as aggregates. However, further research is needed for better understanding of the behavior of coconut shells as aggregate in concrete. There is no study available in the literature on the transport properties which determine durability of the concrete. Thus, the aim of this work is to provide more data in the strengths of coconut shell in concretes at different ratios.

The high demand for concrete in the construction using normal weight aggregate such as gravel and granite drastically reduces the natural stone deposits and this has damaged the environment thereby causing ecological imbalance, there is a need to explore and to find out suitable material to substitute the natural stone. In developed countries, many natural materials like pumice scoria and volcanic debris and manmade materials like expanded blast-furnace

slag, vermiculite and clinker are used in construction works as substitutes for natural stone aggregates. In Nigeria, commercial use of non-conventional aggregate in concrete construction has not yet started.

## STATEMENT OF PROBLEM

The high demand for concrete in the construction using normal weight aggregates such as gravel and granite drastically reduces the natural stone deposits and this has damaged the environment thereby causing ecological imbalance, there is a need to explore and to find out suitable replacement materials to substitute the natural stone in terms of quantity and cost. Few studies identified that coconut shells, as an agricultural by product can also be used as aggregate in concrete. Limited research has been conducted on mechanical properties of concrete with coconut shells as aggregate replacement. However, further research is needed for better understanding of the effective behavior of coconut shells as aggregate in concrete (Dewanshu Ahlawat and L. G. Kalurkar, 2002).

## AIM OF STUDY

The main aim of this research is to determine the strength and durability of coconut shell in the concrete.

## OBJECTIVES

These research objectives are briefly summarized below.

- To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate in concrete with 7 day and 28 day compressive strength.
- To study the behavior of compressive strength and density of the cubes.
- To determine the physical properties of the coconut shell at a specific percentage on the concrete and cement test carried out as follows:

1. Standard consistency test
2. Setting time of cement (Initial and final setting time)
3. Soundness test
4. Specific gravity
5. Control test
6. Compressive strength test

## SCOPE OF THE PROJECT

This project is strictly restricted to the strength and durability of a coconut shell percentage in concrete. The strength properties of coconut shell concrete depend on the aggregate properties of coconut shells and its individual strength characteristics. Experiments on crushing values, impact value, however the project is restricted to the following test.

1. Setting time of cement (initial and final setting time)
2. Standard consistency test
3. Soundness test
4. Specific gravity
5. Control test
6. Compressive strength test

In order to present and provide a sound proper theoretical background to the project earlier stated, the review of literature for this study is done under the following sub-headings.

i. History of coconut
ii. Definition of coconut shell
iii. Properties of coconut shell
iv. Present use of coconut shell
v. Use of concrete in civil engineering

## HISTORY OF COCONUT

The origin of the plant (coconut) is the subject of the earliest modern researchers to draw conclusions about the location of debate. O. F. Cook was one of origin of Cocosnucifera based on its

current-day worldwide distribution Wikipedia (2009). He hypothesized that the coconut originated in the Americas, based on his belief that American coconut populations predated European contact and because he considered pan-tropical distribution by ocean currents improbable. Thor Heyerdahl later used this hypothesis of the American origin of the coconut to support his theory that the Pacific Islanders originated in South America. However, more evidence exists for an Indo-Pacific origin either around Melanesia and Malesia or the Indian Ocean. The oldest fossils known of the modern coconut dating from the Eocene period from around 37 to 55 million years ago were found in Australia and India, but older palm fossils such as some of nipa fruit have been found in the Americas. A species with strawberry-sized nuts (Cocoszeylanica) lived in New Zealand in the Miocene. Since 1978, the work on tracing the probable origin and dispersal of Cocosnucifera has only recently been augmented by a publication on the germination rate of the coconut seed nut and another on the importance of the coral atoll ecosystem. Briefly, the coconut originated in the coral atoll ecosystem without human intervention and required a thick husk and slow germination to survive and disperse.

The coconut tree (Cocosnucifera) is a member of the family Arecaceae (palm family). It is the only accepted species in the genus Cocos. The term coconut can refer to the entire coconut palm, the seed, or the fruit, which, botanically, is a drupe, not a nut. The spelling cocoanut is an archaic form of the word. The term is derived from the 16th-century Portuguese and Spanish word coco meaning "head" or "skull", from the three indentations on the coconut shell that resemble facial features. The coconut is known for its great versatility as seen in the many uses of its different parts and found throughout the tropics and subtropics.

Coconuts are part of the daily diets of many people. Coconuts are different from any other fruits because they contain a large quantity of "water" and when immature they are known as tender-nuts or jelly-nuts and may be harvested for drinking. When mature, they still contain some water and can be used as seed nuts or processed to give oil from the kernel, charcoal from the hard shell (Sapuan S. M., Harimi M. and Maleque M. A., 2005).

## DEFINITION OF COCONUT

Coconut is a large fruit that has a thick shell with white flesh and liquid inside it and that grows in a palm tree. Coconuts are known for their great versatility, as evidenced by many traditional uses, ranging from food to cosmetics. They form a regular part of the diets of many people in the tropics and sub-tropics. Coconuts are distinct from other fruit for their large quantity of water, and when immature they are known as tender-nuts or jelly nut and may be harvested for their potable coconut water Wikipedia (2010). When mature, they still contain some water and can be used as seed-nuts processed to give oil from the kernel, charcoal from the hard shell, and coir from the fibrous husk. The endosperm is initially in its nuclear phase suspended within the coconut water. As development countries, cellular layers of endosperm deposit along the walls of the coconut, becoming the edible coconut flesh.

## PHYSICAL PROPERTIES

The physical properties of aggregates are those that refer to the physical structures of the particles that make up the coconut shell aggregate, which mostly brownish in color and exclusively fibrous.

## SURFACE TEXTURE

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing

material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or Portland cement concrete.

Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of Portland cement concrete.

Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category. Dolomite does not, in general, when the magnesium content exceeds a minimum quantity of the material.

## STRENGTH AND ELASTICITY

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle. High strength and elasticity are desirable in aggregate base and surface courses.

These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for Portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

## DENSITY AND SPECIFIC GRAVITY

Density is the weight per unit of volume of a substance. Specific gravity is the ratio of the density of the substance to the density of water.

## PRESENT STATUS OF COCONUT SHELL

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares. South

East Asia is regarded as the origin of coconut. The four major players India, Indonesia, Philippines and Sri Lanka contribute 78% of the world production. According to FAO statistics (Food and Agriculture Organization) 2007, global production of coconuts was 61.5 MT with Indonesia, Philippines, India, Brazil and Sri Lanka as the major contributors to coconut production. The total world coconut area was estimated approximately as 12 million hectares and around 93 percent is found in the Asian and Pacific region. The average annual production of coconut was estimated to be 10 million metric tons of copra equivalents. Of the world production of coconut, more than 50 percent is processed into copra. While a small portion is converted into desiccated coconut 5 and other edible kernel products, the rest is consumed as fresh nuts.

## PRESENT USE OF COCONUT SHELL

Coconut shells have good durability characteristics, high toughness and abrasion resistant properties; it is suitable for long standing use. Coconut shells are mostly used as an ornament, making fancy items, house hold utensils, and as a source of activated carbon from its charcoal. The powdered shell is also used in the industries of plastics, glues, and abrasive materials and it is widely used for the manufacture of insect repellent in the form of mosquito coils.

The purpose of this research work is to develop a concrete with coconut shells as coarse aggregate. The whole entity could be called coconut shell aggregate concrete. After the coconut is scraped out, the shell is usually discarded as waste. The vast amount of this discarded coconut shells resource is as yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other lightweight aggregate is an interesting topic for study as reported by (Olanipekun E. A., Olusola K. O. and Ata O., 2006).

The study of coconut shells will not only provide a new material for construction but will also help in the preservation of the

environment in addition to improving the economy by providing new use for the coconut shells. Therefore attempts have been taken to utilize the coconut shells as coarse aggregate and develop the new structural lightweight concrete.

## USES OF CONCRETE IN CIVIL ENGINEERING

According to previous project down in the year (2016) in the department of civil engineering library. Concrete as a construction material is the readily available material whose component can be found almost everywhere in the world. Very few construction materials have such advantage. The abundance supply of component that make the concrete was however not only factor that lead the engineer to the selection of concrete as a construction material, the ability of the engineer to analytically determine the strength of a hardened concrete even before it is cast into structural member is an indisputable fact. Calculated proportion of the amount of the components could be used concrete resists certain chemical attack, all the above qualities combine to make concrete, the most unique and essential material in civil engineering world.

## METHODOLOGY

This project is based on the study on effect of coconut shell as reinforcement in concrete. Experiments will be conduct on coconut shells particles in terms of quality control (aggregate impact value, sieve analysis, aggregate crushing value, etc.), compressive strength, density and workability of coconut shell concrete will be focus. A total number of 24 cubes will be prepared. The cubes will be divided into two. For the first 12 cubes, 1:2:4 batching by volume will be used where; 10% of coconut shell will be added during preparation of concrete in 3 cubes, 20% for next 3 cubes, 30% for the next 3 cubes and 40% for the last 3 cubes. These first 12 cubes will be cured for 7 days, and the other 12 cubes will also be prepared with the same volume and percentage of coconut shell but will be cured

for 28 days. A constant water cement ratio of 0.5 will be used for the whole 24 cubes with.

The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we can define what types of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water (British standard code of practice BS4450 1978).

## EXPERIMENTAL INVESTIGATION

**Materials**: The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

1. **Cement:** Portland cement of C53 grade conforming to both the requirements of IS: 12269 and ASTM C 642-82 type-I was used. We are conducting different types of tests on cement, those are Normal Consistency, Initial and Final setting times, Compressive strength of cement, Specific Gravity and Fineness of cement. From the test results obtained the conventional concrete can be designed according to IS10262-82(MIX DESIGN CODE). Finally M30 Grade concrete is designed. (ECO-CARE 2005).
2. **Coarse Aggregate:** Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.
3. **Fine Aggregate:** Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of fine aggregate.

4. **Standard Consistency and Setting Time (Initial and Final Setting Time):** This test is performed to find out the correct amount of water to be added to a given quality of cement so as to get the paste of normal consistency. This test proceeds t all other test of cement for soundness, setting time, tensile strength or for compressive strength. The standard consistency and setting time is done with the vicat apparatus. This involves the process of trial and error until the paste achieved the point of 5mm to 7mm from the bottom of the vicat mould.

**Initial Setting Time:** Prepare a certain sample of standard consistency and placed in vicat mould as before. Determine the initial set using the filled mould and needle with cross sectional area 1mm.

Lower the needle of vicat apparatus gently onto the surface of the paste and quickly release to sink to the bottom of the mould. Repeat each 10minuts in different position of the mould until the paste has stiffened sufficiently for the needle to penetrate met deeper than 5 to 7 mm from the bottom of the mould (read this on scale of vicat).

The initial setting time is timed elapsed between the time when the water is added to the cement and the time at which the needle ceased to penetrate the block as described above. The initial setting time of Portland cement are prescribed-not less than 45minutes.

**Final Setting Time:** Replace the needle used in the initial setting time test (i.e. 1mm square needle) fitting with annular attachment and allowed this to come gently into contact with annular the surface of the cement pastes each 15minuts. Final set is allow said to have taken place when the needle makes an impression on the surface but annular cutting edge fails to do so. This time is the final setting time, and should not exceed 10hours.

## SOUNDNESS TEST OF CEMENT

Soundness test was performed majority to deter excess of magnesia or sulphates. The cement paste upon hydration, under appreciable change of volume causing disruption of the set and hardened mass. This test was performed by the use of Le Chatelire method of measuring is expansion. A test devised by Le Chatelare was prescribed by BS4550, part 3 section 3.7,1978. It was performed by Le apparatus which consists of a small cylinder split along it generation. Two indicator with pointed ends were placed on a glass plate and filled with cement paste assembled and was submerged in water 24 hrs. The distance between the points of indicator was noted.

Furthermore, the mould was then placed on water and boiled for about an hour. The mould was then removed from water and allowed to cool down under room temperature. The distance between pints of indicators was again measured. The difference between the two readings indicated the expansion of the cement and it should not be more than 10mm.

## COMPRESSIVE STRENGTH OF CONCRETE

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test it will be clear whether the Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommend concrete cylinder or concrete cube as the standard specimen for the test. American Society for Testing Materials provides Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, for cube test two types of specimens either cubes of 150 x 150 x 150 mm or 100 x 100 x 100 mm depending upon the size

of aggregate are used. We used cubical moulds of size 100 x 100 x 100 mm for the work/experiment .This concrete is poured in the moulds and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

**NOTE:**

Minimum three specimens should be tested at each selected age. If strength of any specimen varies by more than 15 per cent of average strength, results of such specimen should be rejected. Average of these specimens gives the crushing strength of concrete.

**CALCULATIONS:**

$$\text{Compressive strength} = \frac{Loadatfailure\ (N)}{AReaofconcretecubes(mm^2)}$$

**DETERMINATION OF SPECIFIC GRAVITY**

The aim of the test was to determine to the specific gravity of coconut shell as reinforcement aggregates. The apparatus used are Pycnometer, weighing balance, and ground glass disc and duster.

Similarly a weight of coconut shell particles were taken to be 500g was used and the same procedure was followed but in this case the gas jar and ground was used in place of the pychnometer. The test was carried out twice average value was taken.

It is calculated using $GS = \frac{B}{(P+B)-Ps}$

## WATER CEMENT RATIO (W/C)

It is difficult to specify the optimal w/c ratio for all kinds of wood cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.38, 0.42, 0.45 and 0.55. Sufficient water amount is the prerequisite for high quality cement based products. However, because water can increase the distance between cement particles before and during hydration, and increase the volume of capillary pores, i.e. the porosity of the hydrated products, excess water may adversely affect the physical-mechanical properties of the hydrated products.

Few studies have been done on the effect of w/c ratio on wood/cement concrete composites. It seems that it is not easy to specify an optimal w/c ratio for all kinds of wood/cement concrete composites, because of the wide varieties of raw materials and the dependence of water requirement on wood/cement ratio all found that with the increase of w/c ratio, the strength of the wood/cement concrete composites was reduced. With an increase of wood/cement ratio, more water was needed to obtain maximum bending strength. Hence, it is very much necessary to optimize the wood/cement ratio and w/c ratio for coconut shell aggregate concrete and therefore trial mixes were made and analyzed.

## CASTING OF SAMPLE

The size from the work adopted for concrete cubes was 100x100x100mm. The concrete was mixed with various constituent in their respective percentage, placed and compacted in four layers after proper mixing by hand shovel. The samples were re-moulded after 24 hours and kept in a curing tank for 7 and 28 days as required.

## CURING

The objective of curing is to keep concrete saturated or as nearly saturated to get the products of hydration of cement in water-filled space. The temperature of curing and the duration of moist curing are the key factors for proper curing. The method of curing is one of the main factors affecting the strength development of concrete. The loss of moisture in the capillary pores due to evaporation or dissipated hydration may cause reduction in hydration resulting lower strength. The moist cured samples give higher compressive strength than dry cured samples of concrete with certain admixtures. In all types of curing the strength of concrete is dependent to some extent upon the strength of aggregate. The increment rate in strength is more in crushed stone concrete than in OPS concrete.

## TECHINIQUE

The technique adopted for this study was batching by volume, using a standard mould of 100x100x100 mm for casting the cubes. The mould was assembled prior to mixing and properly lubricated for easy removal of hardened concrete cubes, which were prepared by volume of 0 or 100 percent for granite and coconut shell of the 1:2:4 mix ratio. The mixture was properly turned with shovel until it reached a plastic state and slump test was carried to find the Water Cement ratio of mix and then it was fed into the lubricated cast iron mould, water curing method was adopted. The casted concrete cubes were given 24hrs to set before stripping of formwork. They were then immerse into a curing tank in order to increase the strength of the concrete, promote hydration, eliminate shrinkage, and absorb heat of hydration until the age of test. The cubes were cured for 7 and 28days.

The cubes were then weighted before testing, while densities of the cubes at different times of testing were measured. Prior to testing, the specimen were brought out of the curing tank, left outside in an

open air for about 3hrs before crushing. The compressive strength of the cubes were tested in accordance with BS 1881, using universal crushing machine Mix Design (IS 10292:1982)

## RESULT PRESENTATION AND ANALYSIS OF RESULT

## PRESENTATION OF RESULT

## STANDARD CONSISTENCY TEST

**CALCULATION:**

BRAND OF CEMENT: DANGOTE Portland Cement

**TABLE 1: STANDARD CONSISTENCY TEST**

| Sample No | Weight of cement (g) | Weight of water (g) | Depth of plunger (mm) |
|---|---|---|---|
| 1 | 400 | 90 | 2.00 |
| 2 | 400 | 100 | 2.20 |
| 3 | 400 | 110 | 2.50 |
| 4 | 400 | 120 | 3.20 |
| 5 | 400 | 130 | 4.80 |
| 6 | 400 | 135 | 5.60 |

Standard consistency = $\frac{Weightofwater}{Weightofcement}$ X 100

## SETTING TIME TEST RESULT

**TABLE 2: SETTING TIME TEST RESULT**

| S/N | Max. time (mins) | Weight of cement (g) | Weight of water (g) | Dept of plunger (mm) | Initial time | Final time |
|---|---|---|---|---|---|---|
| 1 | 4 | 400 | 110 | 2.50 | 9:30am-10:07am | 10:07am-03:07am |
| 2 | 4 | 400 | 132 | 5.60 | 9:40am-10:30pm | 10:25am-6:25pm |

## COMPRESSIVE STRENGHT AND DENSITY OF COCONUT CONCRETE CUBES

## CALCULATIONS:

Compressive strength = $\frac{Loadatfailure\ (N)}{AReaofconcretecubes(mm^2)}$

## CALCULATION FOR DENSITY OF CUBES

Density = $\frac{massofcube\ (Kg)}{volumeofcube\ (m)^3}$

## DETERMINATION OF SPECIFIC GRAVITY (GS) TEST RESULT

$GS = \frac{B}{(P+B)-PS} = \frac{500}{(1622+500)-1747} = 2.67$

## SOUNDNESS TEST OF CEMENT

**TABLE 3: SOUNDNESS TEST RESULT TABLE**

| | Length ($L_1$) before boiling (mm) | Length ($L_2$) after boiling (mm) | Expansion ($L_2$ – $L_1$) (mm) |
|---|---|---|---|
| 1 | 13 | 14 | 1 |
| 2 | 13 | 15 | 2 |
| 3 | 12 | 14 | 2 |
| 4 | 12 | 13 | 1 |
| 5 | 12 | 13 | 1 |
| 6 | 12 | 14 | 2 |

Average sample = $\frac{1+2+2+1+1+2}{6} = \frac{9}{6}$

= 1.5mm

## DISCUSSION OF RESULTS

The results obtained from various laboratory test conducted on the cement sample in the course of this research are as follows:

The standard consistency of sample 1 is 22.5%, sample 2 is 25%, sample 3 is 27.5%, sample 4 is 30%, sample 5 is 32.5%, and sample 6 is 33.75%. Therefore, the average standard consistency of the cement is 20.5%.

The setting time of cement paste (initial and final setting time) for Test 1 is 37minuits and 5hours, and for Test 2, the initial and final setting time 43minuits and 8hours. Therefore, it happened to be within the accepted limit stipulated by B.S 4450 part 3(1978). Which says the initial setting time must not be less than 45 minutes and the final setting time must not be more than 10hrs for normal cement.

The compressive strength of cubes cured for 7 days with 10%, 20%, 30%, and 40% 0f coconut shell was found to be; 11.5N/mm$^2$,10.7N/mm$^2$, 9.6N/mm$^2$, and 9.4N/mm$^2$. And for cubes cured for 28 days with 10%, 20%, 30%, and 40% was found to be; 24.4N/mm$^2$, 20.5N/mm$^2$, 18.8N/mm$^2$, and 18.5N/mm$^2$. Therefore the compressive strength of cubes cured for 7days and 28days is less than that of normal concrete, and can be used as low bearing concrete component of a building structure where necessary.

Finally the calculated density of cubes cured for 7 days with 10%, 20%, 30%, and 40% are; 2490 kg/m$^3$, 2210kg/m$^3$, 2040kg/m$^3$, and 2010kg/m$^3$. And the calculated density of cubes cured for 28 days with 10%, 20%, 30%, and 40% were; 2380kg/m$^3$, 2230kg/m$^3$, 2050kg/m$^3$, and 1890kg/m$^3$. For the density of coconut shells concrete cubes cured for 7days and 28days happened to be less heavy compared to the density of normal concrete cubes.
From the above results, the study on the effects of coconut shell as reinforcements in concrete showed that;

1) The compressive strength of the coconut shell concrete decreases as the percentage of the coconut shell increases.

2) As the number of coconut shell increases the surface area increased, thus requiring more cement for proper bonding.
3) Since cement content was constant, there was no extra bonding and strength reduced in the concrete.
4) Coconut shell aggregates are potential candidates for the development of new composites because of their high strength and modulus properties.

## CONCLUSION

It is clear that the compressive strength of the concrete decreases as the percentage of the coconut shell increases, and coconut shell are more suitable as low strength giving light weight aggregate when used as reinforcements in concrete production.

Basically, 10% to 20% coconut shell yield a better result without the required specification as compared to control concrete.

Any percentage above 20% cannot be recommend because is below the control requirement.

## RECOMMENDATION

1. It is advisable that coconut shells can be used as an aggregate at 10% to 20% respectively in order to attain better strength at control cost.
2. Since coconut shells are known as waste, by using it in concrete it is another source of local reinforcement and aggregate.
3. By using coconut shells in concrete is another ways of pollution control as a medium of waste management.
4. Economically is another source of income, means of trade for the new employees to be fully employed.

However, it is clear that coconut shells is very useful in concrete if more research and quality control measures were clearly down and adhere to in the cost of concrete mix design.

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# APPENDIX

## Table 4: COMPRESSIVE STRENGHT FOR CONTROL TEST

# APPENDIX

| CONTROL | | | | COMPRESSION TEST | | CONCRETE CUBES | Grade = 20N/mm$^2$ | | | DATE 02/08/2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project/location | | | | Slumps[mm] = 35mm | | | Type of slump: True | | | Cement ; Dangote | | | |
| Placing detail | | | | | | | | | | Compaction factor = 75% | | | |
| Cube no & identification Mark S/N | Size of Specimen mm | Date cast | Age of testing [days] | Date tested | Curing condition | Weight of cube Kg | Type of fracture slump | Density of cube Kg/m$^3$ | Mix proportion | Crushing load Mm | Crushing strength N/mm$^2$ | Average N/mm$^2$ | Remarks |
| 0% | 100 x 100 | 26/07/2016 | 7 | 2/08/2016 | Water | 2.42 | True slump | 2420 | 1:2:4 | 100 | 10.0 | | |
| 0% | 100 x 100 | 26/07/2016 | 7 | 2/08/2016 | Water | 2.59 | " | 2590 | " | 105 | 10.5 | 10.16 | |
| 0% | 100 x 100 | 26/07/2016 | 7 | 2/08/2016 | Water | 2.45 | " | 2450 | " | 100 | 10.0 | | |
| | | | | | | | | | | | | | |
| 0% | 100 x 100 | 26/07/2016 | 28 | 23/08/2016 | Water | 2.21 | " | 2210 | " | 200 | 20.0 | | |
| 0% | 100 x 100 | 26/07/2016 | 28 | 23/08/2016 | Water | 2.37 | " | 2370 | " | 220 | 22.0 | 21.5 | |
| 0% | 100 x 100 | 26/07/2016 | 28 | 23/08/2016 | Water | 2.56 | " | 2560 | " | 225 | 22.5 | | |

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