EFFECT OF PALM KERNEL SHELL ON THE COMPRESSIVE STRENGTH OF CONCRETE

BY

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CERTIFICATION

This is to certify that this project was undertaken by Faruku Abubakar Bagudu and meets the requirement for the award of the Post Graduate Diploma in Agric Engineering (Soil and Water Option), Federal University of Technology Minna, Niger State Nigeria

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DEDICATION

This work is dedicated to my mother Hajiya Fadima Mohammad Anaruwa (Late) and all members of Galadima Sayyadi Family.

ACKNOWLEDGEMENT

Generally, academic research of this nature is not an undertaken that can start and finish single handedly by the candidate. External aids either morally or Financially are required so as to achieve completion and good results.

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ABSTRACT

Hitherto, palm kernel shells are being used as fuels or for soil conservation in filling trenches, but with the advent of technology and the need to source local building materials palm kernel shells are now mixed with concrete in different proportions so as to increase the compressive strength. In this study, palm kernel shells were mixed in different proportion with concrete and the compressive strength was obtained by inserting the concrete mix in a cube box of about 150mm x 150mm in size. The tests were carried out after the cube has gained a considerable strength for a period of 7, 14, 21 and 28 days. The results of the tests showed that the strength of the concrete mixed with palm kernel shells increased with increase in curing period. The highest strength of 8.03 N/mm^2 was obtained after a period of 28 days. The result also showed that the product has less weight compared to the normal concrete and absorbed more water. Thus it is recommended that such products be used at lintels levels of construction.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 GENERAL

Concrete is a structural material widely used in construction Industry. It consists essentially of cement, fine aggregate (sand) and coarse aggregate (natural gravels or chippings). These constituent materials are mixed together with water to form the concrete. The cement serves as binder to the aggregates while the aggregates serve as the filler materials (Fine and coarse). Concrete has the unique distinction of being the only construction material manufactured on the site; where-as other materials are merely shaped to be at the work site. The aggregates occupy the larger proportion in the volume of concrete.

Of importance in concrete mix are the aggregate grading, aggregate/cement ratio as well as the water/cement ratio because the strength of concrete depends on them. The fresh concrete should be workable in order to be properly placed and the hardened concrete need to be durable and attain a specific compressive strength. A mean strength greater than the specified strength must be the aim of mix design. The most important variables affecting the strength of concrete at a given age are the water/cement ratio and the degree of compaction. When concrete is fully compacted its compressive strength is inversely proportional to the water/cement ration (from Abrams 1919 by Aguwa 1998).

The oil palm is one of the sources of vegetable oil. The palm tree is found in the warm, high rainfall, tropical forest areas. It grows best

(Taylor 1975) recommended that the ratio of cylinder to cube strength approached almost unity for very high strength concrete having a 20 days strength of 700kg/cm.

The flexural strength of concrete is determined by subjecting a plain concrete beam to flexural test under transverse loads. The theoretical maximum tensile stress reached in the bottom fibre of a standard test beam is referred to as the modulus of rupture. The magnitude of modulus of rupture depends on the dimensions of the beam and the type of loading.

(Neville 1981) stated that during curing of concrete, temperature also controlled the rate of progress of the reactions of hydration and consequently affects the development of strength of concrete.

The studies above showed that the strength of concrete depends on both age and temperature of whether. It was discovered that the strength maturity relation depends on the properties of the cement and on the general quality of the concrete and it is valid only within a range of temperatures.

2.1 <u>DEFINITION OF CONCRETE AND ITS PROPERTIES</u>

Concrete is made by mixing together stone chips (coarse aggregate), sand (fine aggregate), cement (the binder) and water (the medium of mixing the above ingredients into a unifies plastic mass) (Aguwa 1998). It is the water that sets off the chemical process of hydration of cement. Unlike steel, concrete can be made locally almost anywhere as long as cement is available. It is the best construction material used in most of the poorer countries.

Some important properties of concrete include, workability, durability, resistance to compressive stress and ability to protect steel. The inert aggregate occupies large proportion in volume of concrete.

2.2 MATERIAL OF CONCRETE

The materials that are mainly used for the formation of concrete include:

(i) Cement
(ii) Water
(iii) Fine aggregate
(iv) Coarse aggregate
(v) Admixture (necessary in special cases)

2.2:1 CEMENT

Cement is the binder in the concrete structure (Aguwa 1998). The ability of certain limes to harden under water it is stated dependent on their clay contents. The first artificial cement was produced by the English mason and building contractor Joseph Arpdim. (Shirley 1975) He patented the process of production of the materials in December 15, 1824.

Modern Portland cement are made from one raw material rich in calcium and another rich in silicon. These materials are, respective chalk or limestone and clay or shale. Clay and shale usually contain significant quantities of compound of aluminium and iron. It is the iron that imparts the characteristics gray colour to ordinary Portland cement.

2.2:2 **WATER**

Water is the medium of mixing the whole constituent materials of concrete into unified plastic mass. The material used for making concrete is mixed with water for two reasons (Aguwa 1998). First to cause the reaction between cement and water which results in cement activity as binding agent and secondly to make the materials of concrete sufficiently plastic to be placed in position. The water used for mixing concrete must be drinkable. It should not contain sugar or salt in significant quantities.

2.2:3 **AGGREGATES**

Aggregates form more than three quarters of the volume of concrete and the selection and proportioning of coarse and fine aggregates greatly influence the properties of both fresh and hardened concrete (Jackson 1991). The choice of grading maximum aggregates size and aggregate cement ratio are subjected to concrete mix design. Broadly, aggregates can be classified according to density as normal, light weight and heavy aggregates. (Jackson 1991).

2.2:3:1 **NORMAL AGGREGATES**

These usually consist of natural materials, hard crushed rock or natural gravel and sands, but artificial materials like crushed bricks and blast furnace slag can also be used. The specific gravity of these materials, usually lies between 2.6 – 2.7 (ACl manual of concrete part 1 1981). Because satisfactory concrete for most of purposes can made with a very wide range of aggregates, local sources of supply usually determine which aggregate will be used. Where very high strength,

- One part of cement to nine part of all in aggregates for mass Concrete foundation 1:9
- One part of cement to two parts of sand and four parts of coarse aggregate, for lintel and concrete floor – 1:2:4
- One part of cement to one and a half part of sand and three parts of coarse aggregate for narrow reinforced concrete beams and columns – 1.15:3.

2.5:1 **COMPRESSIVE STRNGTH**

The compressive strength of high weight aggregates is usually related to cement content at a given slump rather than water-cement ratio. Water reducing or plastisizing admixture are frequently used with high weight concrete mixtures to increased workability and facilitate placing and finishing. (Shirley 1975).

Some cases compressive strength can be increased with the partial replacement of high weight fine aggregate with a good quality of natural sand. (Shirley 1975).

2.5:2 **MODULUS OF ELASTICITY**

The short-term stress-strain curve for concrete in compression is as shown in Fig. 1 below. The slope of the initial tangent modulus at any point P. The slope of the curve is the tangent modulus and the slope of line joining P to the origin is the secant modulus. The values of the secant modules depend on the rate of application of the load.

The dynamic modulus is determined by subjecting a beam specimen to longitudinal vibration (Macginley and Choo 1990). The values obtained is unaffected by tangent modulus in the Fig. 1 below the secant modulus can be calculated from the dynamic modulus.

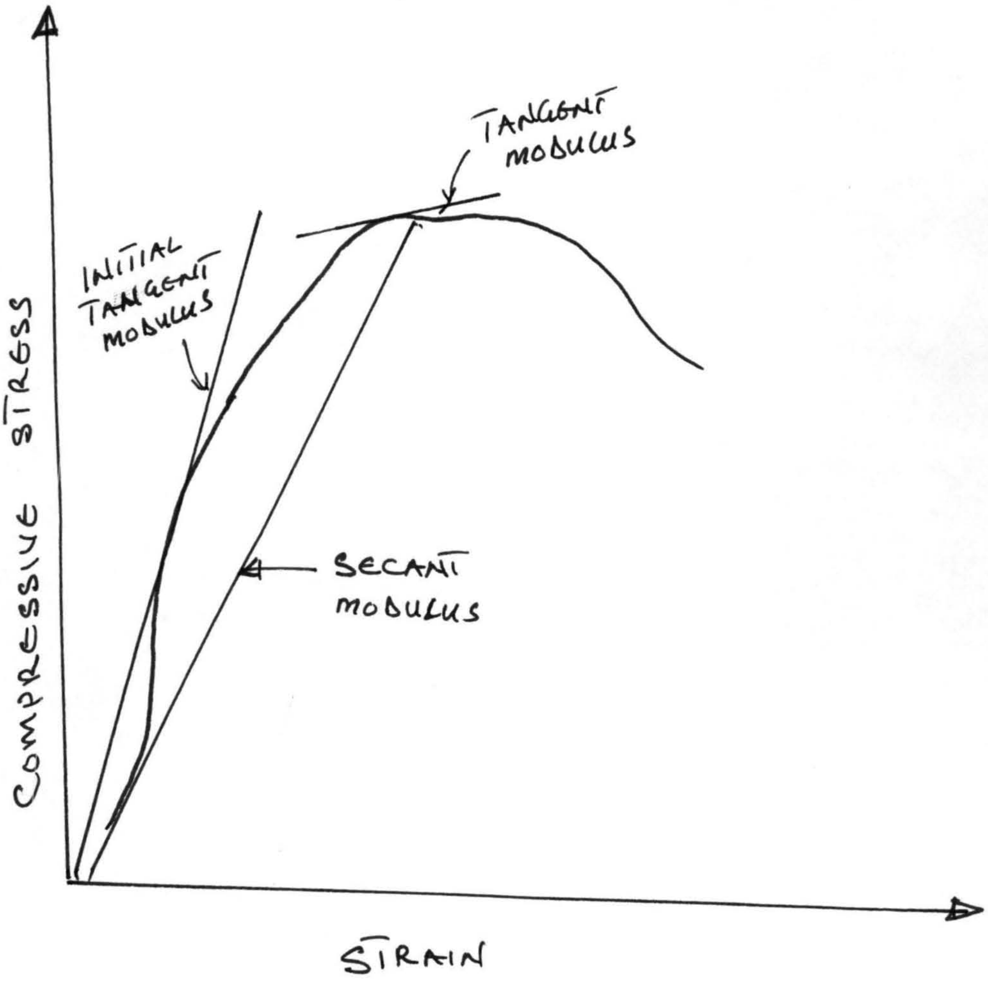

FIG. 1.0 STRESS - STRAIN CURVE.

2.5:3 **CREEP**

Creep in concrete is the gradual increase in strain with time. In a member subjected to prolonged stress the creep is much longer than the elasticity strain on loading. If the specimen is unloaded there is an immediate elastic recovery and a slower recovery in strain due to creep. (Neville 1981).

The main factor affecting creep strain are the concrete mix and strength, the type of aggregate, curving, ambient relative humidity and the magnitude and duration of sustained loading.

(Macginley and Choo 1990) specified that the creep strain Ecc is calculated form the creep co-efficient by the equation.

$$ECC = \frac{\text{Stress}}{E} xQ \qquad (1)$$

Where E is the modulus of elasticity of the concrete at the age of loading. The creep co-efficient Q depends on the effective section thickness. The age of loading and the relative ambient humidity values of Q can be taken from BS 8100 part 2 (Macginley and Choo 1990)

2.5:4 **SHIRINKAGE**

Shirinkage or drying shirinkage is the contraction that occurs in concrete when it dries and hardens. Drying shrinkage is irreversible but alternate wetting and drying cause expansion and contraction of concrete (Neville 1981).

The aggregate type and content are the most important factors influencing shrinkage. The larger the size of the aggregate the lower the workability of concrete with a large shrinkage strain. On the other hand, non-shrinkage aggregates such as granite or gravel give lower shrinkage. (Aguwa 1998). A decreased in the ambient relative humidity also increases shrinkage. (Aguwa 1998).

2.6 MEASUREMENT OF WORKABILITY

a. Slump Test

The fresh concrete is tamped into a standard cone which is lifted off after filling and the slump is measured. The slump is 25-50mm for low workability and 100 –175mm for high workability (Machinglry and Choo 1990).

b. Compacting Factor Test

The degree of compaction achieved by a standard amount of work can be measured. The apparatus consist of two conical hoppers placed over one another and over a cylinder. The upper hopper is filled with fresh concrete, which is then dropped into the second hopper and into the cylinder. (Shirley 1975). The compacting factor is the ratio of the weight concrete in the cylinder to the weight of an equal volume of fully compacted concrete. The compacting factor for concrete of medium workabilility is about 0.9. (Shirley 1975).

2.7 TEST ON HARDENED CONCRETE

2.7:1 *Compression Test*

There are three types of specimen used for compression test. They include:

i. Cubes

ii. Cylinder

iii. Square Prism (Jackson 1991).

Each shape gives different strength results and furthermore for a given shape the strength also varied with size.

(Jackson 1991) BS 1881: part 116 specified the used of concrete cubes for determining compressive strength; 150mm cube are widely used for quality control proposes.

However, cored cylindrical specimens are used for measuring the compressive strength of concrete in *In situ* and precast members (BS 1881: part 120) (Jackson 1991). For the purpose of this work the cube is considered.

2.7:2 *Cube Test*

It is preferred that the mould and the base be clamped together during casting as this reduce leakages of water. Studies were shown that before assembling the mould, its making surface should be covered with mineral oil and thin layer or similar oil must be applied to the inside surface of the mould in order to prevent the development of bond between the mould and the concrete. (Naville 1981).

BS 1881: part 3, 1970 prescribed that the mould be filled in three layers. Each layer of concrete is compacted by not less than 25 strokes of 22mm square rammer. Ramming if is noted should continue until sufficient compaction has been achieved. For it is essential that the concrete in the cube be fully compacted if the compressive test is to be representative of the properties of fully compacted concrete. The mould is filled to over flowing and after compaction excess concrete is removed by dawning motion of a steel wire.

After the top of the cube has been furnished by means of a trowel, the cube is stored undisturbed for twenty-four (24) hours at a temperature of 18°C to 22°C and a relative humidity of not less than 90 percent. At the end of this period, the mould is stripped and the cube is further cured in water at 19°C to 21°C (Naville 1981).

Standard cubes are tested at prescribed ages, generally 28 days with additional test often made at 3 to 7 days. In this compression test, the cubes is normally placed with the cast faces in contact with the palatrans of testing machine i.e. the position of the cube when tested is at right angle to that as cast.

According to BS 1881, part 4, 1970. the load on the cube should be applied at a constant rate of stress equal to 15Mpa/min (Naville 1981). As a result of the non linearity of the stress-strain relation of concrete at high stress, it is noted that the rate of increase in strain must be increased progressively as failure is approached and speed of the movement of the head of the testing machine be increased only with a hydraulically operated machine.

CHAPTER THREE

3.1 MATERIALS AND METHODS

Throughout the world the principal civil engineering construction material is concrete. The control and quality of concrete in all its various forms i.e quick setting, high strength, reinforced etc is of paramount importance to the design and material engineer. In this thesis work, the preparation and testing of palm kernel shells mixed with cement, water, sand and granite in different proportion to form concrete cubes in the mix ratio 1:2:4 to determine the suitability or otherwise from palm kernel shell in concrete mix.

In order to make effective concrete cube test the following equipment are used:-

a. 150 –150mm mould

b. 2 Spanner

c. Mould oil

d. 1 Tapping bar

e. Wire brush

f. Curing Tank

g. Steel tank

h. Set of upper racks

i. Set of lower racks

j. Vibrating table

k. Multiflow mixer.

l. Tipper stand.

3.2. **METHOD**

The palm kernel nut was obtained in the market and a hard stone used to break the shells to separate the shells and the meat. After that the shells were washed with detergent to remove the impurities. After washy the actual volume of the total shells was taken which was $0.0278m^3$. The other materials were obtained form the workshop and their quantities are as stated below:-

1 Total volume of granite - $0.015m^3$

2. Total volume of cement - $0.0085m^3$

3. Total volume of sand - $0.0015m^3$

4. Total volume of palm kernel shells - $0.278m^3$

The materials are mixed and cast in steel or cast iron moulds generally 150mm2 cubes which conformed to the cubical shape recommended. (Source) (Jackson 1991). The mould and the base were clamped together during casting.

In the clamping of the mould and the base, the mating surfaces were covered with mineral oil and the base too. Each layer of concrete was compacted by not less than 25strokes of a steel bar which is 380mm long with weight of 1.8kg and cross section of 25mm square. Ramming continued until sufficient compaction was achieved. This is essential because the concrete in the cube should be fully compacted if the compressive test is to be representative of fully compacted concrete. The mould was filled to over flowing and after the compaction, excess concrete was removed by downing motion of a steel rule. After the cube had been furnished, they were undisturbed for period of 24 hours at a temperature of 18°C to 22°C and not less than 90 percent relative humidity. At the end of the period the cubes were stopped off and marked for later identification. The identification of the concrete cubes were as follows:-

1. 4 cubes of one part of cement to two part of sand, three parts of granite and one part of palm kernel shells – pk1.
2. 4 cubes of one part of cement to two parts of sand to two parts of granite to two parts of palm kernel shells – pk2.
3. 4 cubes of one part of cement to two parts of sand, to one part of granite to three parts of palm kernel shells – pk3.
4. 4 cubes of one part of cement to two part of sand and four part of palm kernel shells – pk4

After the identification mark the cubes were immediately submerged in a curing tank until it was time for testing. They were tested at 7, 14, 21 and 28 days.

In the compression test cubes were placed with the cast faces in contact with the platens of testing machine i.e. the position of each cube when tested was at a right angle to the cast. The load on the cube was applied at a constant rate of stress equals to 15mpa/min due to the non-linearity of the stress-strain relation of concrete at high stress. The increase in the strain was increased progressively when approaching the failure. Four concrete cubes when crushed each day i.e. 7, 14, 21 and 28 days.

Also it can be observed that the difference in strength between pk1, and pk4 was greater at the 21st day of curing. It can this be inferred that the palm kernel and aggregate mix has the greatest compressive strength after 21 days of curing.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The result obtained form the tests were recorded in the typical cube test sheet, which is shown in Table 1. From Table 1 it can be observed that the weight of cube is increasing with increase in age due to the absorption of water by the palm kernel shells.

It can be noticed that the concrete produced with higher ratio of aggregates developed higher strength than that produced with higher percentage of palm kernel shell.

It is also observed from the results obtained that at crushing the failure of all cubes produced from palm kernel mixed normal aggregates are normal which showed that the cubes are well casted and cured.

Summary of the compressive strength from Table 2 showed that the maximum strength obtained from the test at the end of 28 days for pk1, pk2, pk3, pk4 are $8.03N/mm^2$, $7.75N/mm^2$, $6.64N/mm^2$, $5.44N/mm^2$ respectively.

From Table 2, it can be seen that the different concrete mixed obtained using the kernel shell increase in strength with increase in age. The results showed that the greatest compressive strength was obtained at the end of the 28^{th} days with pk1.

From Table2, it can be seen that the different in strength between pk1, and pk2 is not much compared to that between pk1, and pk4. this is because there is no percentage of normal aggregate in the pk4 mix which was purely palm kernel shell.

TABLE 1.0 TYPICAL CUBE TEST RECORD SHEET

REF. MARK ON CUBE	DATE OF CASTING	DATE OF TEST	AGE AT TEST DAYS	NORMAL SIZE mm or in.	AVERAGE WEIGHT IN AIR kg (A)	AVERAGE MAXIMUM LOAD kN	AVERAGE COMPRES-SIVE STRENGTH (N/mm^2)	TYPES OF FAILURE AND REMARKS
PK1	20/03/01	27/03/01	7 Days	150mm	6.75kg	126	5.63	Normal Failure
PK2	21/03/01	28/03/01	7 Days	150mm	6.36kg	119	5.27	Normal Failure
PK3	22/03/01	29/03/01	7 Days	150mm	6.39kg	108	4.81	Normal Failure
PK4	21/03/01	28/03/01	7 Days	150mm	6.00kg	77	3.44	Normal Failure
PK1	20/03/01	03/03/01	14 Days	150mm	6.70kg	140	6.23	Normal Failure
PK2	21/03/01	04/04/01	14 Days	150mm	6.52kg	130	5.79	Normal Failure
PK3	22/03/01	05/04/01	14 Days	150mm	6.61kg	124	5.51	Normal Failure
PK4	21/03/01	04/04/01	14 Days	150mm	6.09kg	96	4.28	Normal Failure
PK1	20/03/01	01/04/01	21 Days	150mm	6.75kg	169	7.54	Normal Failure
PK2	21/03/01	11/04/01	21 Days	150mm	6.67kg	154	6.71	Normal Failure
PK3	22/03/01	12/04/01	21 Days	150mm	6.64kg	132	5.97	Normal Failure
PK4	21/03/01	11/04/01	21 Days	150mm	6.52kg	110	4.89	Normal Failure
PK1	20/03/01	17/04/01	28 Days	150mm	6.84kg	180	8.03	Normal Failure
PK2	21/03/01	18/04/01	28 Days	150mm	7.00kg	174	7.75	Normal Failure
PK3	22/03/01	19/04/01	28 Days	150mm	6.28kg	149	6.64	Normal Failure
[illegible]	21/03/01	18/04/01	28 Days	150mm	5.75kg	122	5.44	Normal Failure

Table 2, Summary of the Result obtained from Table 1 shows the compressive strength of concrete with palm kernel shells in different proportion.

Ratio of Palm Kernel Shell	Compressive Strength in Ages			
	7 Days	14 Days	21 Days	28 Days
Pk 1	5.63N/mm^2	6.23N/mm^2	7.54N/mm^2	8.03N/mm^2
Pk 2	5.27N/mm^2	6.79N/mm^2	6.71N/mm^2	7.75N/mm^2
Pk3	4.81N/mm^2	5.51N/mm^2	5.97N/mm^2	6.64N/mm^2
Pk4	3.44N/mm^2	4.28N/mm^2	4.89N/mm^2	5.44N/mm^2

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

An investigation into the possibility of utilizing palm kernel shell in concrete mix has been conducted. It can be concluded from the studies that there is generally a reduction in the weight of the concrete obtained from the palm kernel mixed when compared to the normal concrete. The concrete obtained from the palm kernel mix increase in compressive strength with increase in curing days. The greatest strength was obtained after 28 days of curing.

5.2 **RECOMMEDATION**

Based on the results of this work it can be recommended that:-

(i). When using palm kernel shells in concrete mix, such concrete obtained should be used where insulating application is required so as to prevent it from coming in contact with too much water.

(ii). It also recommended that further work should be carried out in the area of tensile strength as to ascertain the suitability or otherwise of such material.

(iii). Also Some other mixing ratio such as 1:3:6 or 2:3:6 can be used.

(iv). Cement and sand must be mix first before putting aggregate then water.

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