ANALYSIS

55(281), May 1, 2019

ISSN 2278–5469 EISSN 2278–5450

DISCOVERY

Production of cement using a blend of palm kernel shell ash, palm fiber ash, chipping dusts and clay soil ash

Ukpaka CP✉, Amadi SA, Idubamo RC

This research study was primarily conducted to investigate the possibility of using a blend of Palm Kernel Shell Ash (PKSA), Palm Kernel Fiber Ash (PKFA), Chipping Dust (CD) and Clay Soil (kaoline) to produce cement that can possibly reduce the rising cost of building material such as cement as well convert waste to wealth in developing economy like Nigeria. The raw materials were sourced locally and unit operation method was used to achieve formulated cement as an end product. ED x 3600B x-ray fluorescence spectrometer and atomic absorption spectrophotometer model S4=71096 were used to analyze the elemental concentration of the raw materials having done the same on Bua cement, Dangote cement and the formulated cement and it was found to meet the standard requirement. Experimental method, modelling approach and comparison of data were carried out to ascertain the possibility of cement production. The concrete made of the formulated cement was subjected to compressive strength test in the ratio of 1:1.5:3 and 1:2:4 for a maximum curing age period of twenty-eight (28) days. The crushing results are 2.8N/mm^2, 3.5N/mm^2, 4.44N/mm^2, 5.33N/mm^2 and 2.0N/mm^2, 2.20N/mm^2, 2.5N/mm^2 and 2.7N/mm^2 respectively. The results show that, strength gained as curing age progresses. However, the result is less when compared to the minimum value of British Standard (BS12) of 16N/mm^2, 19N/mm^2, 21N/mm^2 and 24N/mm^2 but upon improvement and technological advancement, it can favourably compete with any brand of cement.

INTRODUCTION

Cement a common denominator amongst raw materials used in construction sites particularly in the construction and building of roads, bridges and other civil engineering works such as the construction of all sizes of office blocks, ware houses, living quarters and by extension the construction of other social amenities in our cities, communities and towns etc.

Interestingly, the Nigeria Government have recently sought means on how possible vision 2020 housing for all national policy can be achieved, particularly at this point in time as her entire population keeps growing [1-2]. Of course, low cost housing estates alone cannot solve this laudable objectives of the federal Government except the cost of building materials can as well become relatively cheaper, things like cement., hence the need to use palm kernel shell (PKS) and palm kernel fiber (PKF) for the production of cement as an attractive building material because it is rather inexpensive, it can be source locally here virtually in every part of the South-South, South- East and South- West regions of the country [3].

Research is currently being developed in the several other agricultural produce in this area. One of such studies that came close was carried out, where they studied the "Development and Properties of Coconut fiber reinforced composite cement with the addition of fly Ash" [4]. In their research study, they emphatically made it clear that "vast researches have been conducted on application of natural fibers or fly Ash in development of construction materials but limited studies have been made in combining them" [4-6]. Researcher conducted sought to determine the suitability of palm kernel shell as coarse Aggregate in light weight concrete production [7]. This research was conducted both from the Department of Building, Federal university of technology Mina, Niger state and Modibbo Adama university of Technology, Yola, Adamawa state of Nigeria [8]. Also reports on the potential of using palm kernel (PK) ash and shell as a partial substitute for Portland cement (PC) and coarse aggregate in the development of mortar and concrete [9]. Another of such use of agro-waste material from palm oil mills is a research conducted on properties of laterite brick reinforced with oil palm empty fruit bunch fibers; a research carried out in faculty of Architecture, planning and surveying of Teknologi, MARA, Malaysia [10].

Research has revealed the expansive amounts of Agro-waste could progressively be utilized in the production of building materials, by improving their properties and toughness [11]. Federal University of Parana, Department of Mechanical Engineering, University of the State Santa Catarina Brazil, have led an explorative research on a portrayal of soil-cement bricks with the fuse of utilized foundry sand [12]. The concept of using natural fibers such as the palm kernel shell and fiber predates the twenty first century era. Natural fibers such as palm kernel

Department of Chemical/Petrochemical Engineering, Rivers State University Port Harcourt, Nigeria;
✉*Corresponding author:* Department of Chemical/Petrochemical Engineering, Rivers State University Port Harcourt, Nigeria. E-mail: chukwuemeka24@yahoo.com

shell and palm kernel fiber for the formulation of cement [13,14], should be deemed important as the Scientist and Engineers have sought to put waste by-products to good use and also solving the problem of waste disposal, hence converting waste to wealth. The aim of this research is to produce cement with the used of local materials such as mixture of palm kernel shell ash and palm pressed fiber, clay and chipping dust.

MATERIALS AND METHODS

Materials

The materials utilized for this research includes palm kernel shell, agricultural fiber, chipping dust, rotary kiln, clay, furnace, grinder, crusher, ball mill, sealed containers, sieve, batch reactor, concrete compressing machine, cube crushing machine, water, mold, weigh balance, sharp sand, additives such as gypsum and energy disperse x-ray fluorescence spectrometer. Beakers and flasks, Solar thermo elemental Atomic Absorption Spectrophotometer (Flame AAS) mode: S4=71096, burner, hollow cathode lamps, graphical display and recorder, pipets (microliter with disposable tips), pressure-reducing valves, glassware, volumetric flask of suitable precision and accuracy.

Reagents

Air, acetylene, nitrogen dioxide gas, metal free water, stock metal solution,, potassium chloride solution, aluminum nitrate solution, hydrogen tetraoxosulphate (vi) acid (H_2SO_4), trioxonitrate (v) acid (HNO_3) and perchloric acid ($HClO_4$).

Sample preparation

The chipping dust and that of the formulated cement were analyzed using the following systematic method to ascertain the elemental or chemical composition.

Wet Digestion Method

A total volume OF 100ml of H_2SO_4, HNO_3, and HClO in the ratio of 40%:40%:20% was mixed together. The procedure involves:

a) 1g of the sample was weighed into a conical flask
b) 2ml of the mixed acid was added to each of the sample into the conical flask
c) The mixture was digested into a fume cupboard with hot plate until white fumes appear
d) Further cool and filter into a 100ml volumetric flask was carried out and make up to mark with distilled water.

Operation of Atomic Absorptive Spectrophotometer

The difference among manufacturers and models of AASs, makes it was not possible to formulate guidelines appropriate to every instrument. The manufacturer's guidelines should be adhered to, however, as a general guide, proceed as follows:

a) Hollow cathode lamp was installed for the preferred metal.
b) Wavelength dial was established as indicated by the analytical methodology.
c) Slit width was established in agreement with the manufacturer's suggested setting.
d) At this point, the instrument was turned on and an application of the hollow cathode lamp as suggested by the manufacturer was followed suit, and the instrument was kept heated up, until an energy source stabilizes. This takes about 10 to 20 minutes.
e) Realign the current if necessary after the warm-up. The wavelength dail was regulated until maximum energy gain is achieved.
f) The lamp was aligned according to manufacturer's instructions.
g) Suitable burner head was set up and its position amended. A 10cm, single-slot burner head was suggested for air-acetylene flames.
h) Air was turned on and the flow rate was adjusted with respect to manufacturer's instructions so as to give maximum sensitivity for the measurement of the metal.
i) Acetylene was turned on and flow rate adjustment was effected to the specified value.
j) Flame ignition should take effect and allowed to stabilize for few minutes.
k) Aspirate blank and zero instrument.
l) Aspirate a standard solution and adjust aspiration rate of nebulizer to obtain maximum sensitivity.
m) Adjust burner both vertically and horizontally to obtain maximum response.
n) Aspirate blank again and re-zero instrument.
o) Standard was aspirated with a concentration near the middle of the linear range and record absorbance.
p) The instrument was now set to be operated.
q) At the expiration of the analysis, the flame was put out by turning off acetylene first followed by air.

Calculations of the elemental concentration

a) The calibration curve was Estimated and reading was taken in a straight line from the instrument, the concentration in micrograms or milligrams per liter according to calibration
b) The mixture was diluted and concentration readout was multiplied by the suitable dilution factor.
c) The solution mixture was diluted and concentrated sample was used, the concentration readout was divided by suitable concentration factor

Methods

Sourcing for Materials and its Preparation

Palm Kernel Shell/Palm Press Fiber

The palm press fiber is a by- product of agricultural palm produce. Its extraction process is possible either by industrial method or can be obtained within our locality from our local processors. After the harvest of tons of palm produce, for easy extraction of palm pressed fiber, the palm fruits was cooked endothermically to a high degree of temperature in a boiler after which it was mashed to make possible the separation of the different components such as the palm oil, the palm kernel shell as well as the palm fiber.

At this point, the palm fiber was pressed to remove or extract thoroughly the remnants of the red palm oil content which is then allowed to dry. Furthermore, the palm press fiber was allowed to shed off all its water content to make it suitable for our primary purpose while the palm kernel shell was achieved by separation method after braking of the palm nut.

Chipping Dust

For the purpose of this research, some quantity of chippings was collected from dumped site of Julius Berger Company at Azikoro village, Bayelsa state, which then underwent the process of reducing the particle size by sieving and as well crushing.

Clay Soil

Kaolin which is the clay used in this research was collected from a fresh water swamp in Yeghe community of Gokana Local Government Area of Rivers State.

Heating

In order to reduce the moisture content present in the clay and as well the strength of kernel shell, furnace was used to heat the materials at a required temperature.

Crushing

Palm Kernel Shell/Palm Kernel Fiber

Crushing of palm fiber and palm kernel shell was done by subjecting the materials into a crusher differently. The crusher was used to crush the materials into a finely powdered particle.

Clay Soil

Crushing of clay soil was easily achieved by first reducing the size of the clay before subjecting it to a crusher who also crushed to a finely powdered particle.

Chipping Dust

The fineness of particles plays a key role in the quality of cement. Therefore, the particles of the chipping dust was equally subjected to thorough crushing in order to achieve its fineness form.

Sieving

Sieving of the finely crushed powdered particles of palm kernel shell ash, palm fiber ash, and chipping dust, clay soil ash was done using a 150 micro meter sieved because it retained in the standard required 7.5 micro meter sieved.

Raw Mix Preparation

A rationing proportion of fifty is to fifty (50%: 50%) of palm kernel shell ash/palm kernel fiber ash and chipping dust is used since they both contain good quantity of the major constituents to form an heterogeneous mixture known as raw material.

A required proportioned of this raw material and clay soil ash was weighed and measured in the percentage ratio of sixty is to forty (60%:40%), seventy is to thirty (70%:30%), eighty is to twenty (80%:20%), ninety is to ten (90%:10%). The rationing was done, to find out the best ratio to use. The best proportion of raw mixed was determined at eighty percent of kernel shell ash and twenty percent of fiber ash (i.e. 80%:20%). At every eighty is to twenty percent (80%: 20%) of the mixture of kernel shell ash and fiber ash, eighty percent of the mixture was added to twenty percent of clay soil ash to achieved the proportion raw mix. For homogeneous mixture, ball mill machine was used.

Heating of the Raw Mix/Kilning

A specific volume of raw mix was measured, poured into a crucible and placed in a furnace for heating. The mixed in the furnace was heated to varying temperature at several time interims. Heating the crude (raw) mix does not generate clinker rather it stays in its powdered form. This process was carried out in the five varying ratios considered in the raw mix preparation in order to ascertain the best ratio at which the raw mix can be kiln to achieve a better result of producing local formulated cement.

Addition of Additives

Silicate: Silicate is an element which increases the strength of cement. The reaction of silicate with calcium in cement forms hard silicate. For the purpose of this research, requite proportion of silicate at different ratios of ten percent (10%) and twenty percent (20%) was added to the raw mix after kilning. This was done to ascertain the best ratio for the production.

Gypsum: This is a white substance in powdery form which contains minerals made up of calcium sulphate and water ($CaSO_4.2H_2O$). The presence of gypsum in cement controls the quick setting reaction which takes place when the cement is exposed to water. Gypsum is of importance in cement production because it has the characteristics to resist fire. In order to ascertain the right proportion of gypsum to give the desired product, different ratios of gypsum were being added to the ratios of raw mix.

Energy Disperse X-ray Fluorescence (AAS)

EDX3600B X-ray Fluorescence Spectrometer was utilized to regulate quick and precise examination of high resolution and complex composition on agricultural fiber ash, mixture of palm kernel and agricultural fiber ash, clay soil ash, Dangote cement and Bua cement. The materials utilized were fine powdered sample, water, and Energy Disperse X-ray Fluorescence Spectrometer. The non-homogeneous sample which was adequately prepared was well pulverized to fine homogeneous size and then pelletized. The program started with standardization using pure silver standard and a selection was made in respect to the working curve for the sample. An export of the tested sample into excel was done and the program halted. Solar thermo elemental Atomic Absorption Spectrophotometer (Flame AAS,mode: S4=71096) was also used to conduct quick and precise analysis on chipping dust cum formulated cement.

Oxide Composition of the Formulated Cement

The oxide composition of the formulated cement, was analyzed using solar thermo elemental atomic absorption spectrophotometer (flame AAS) model S4 = 71096 and the result shows that it perfectly suits the required standard range. The elements detected are: Magnesium Oxide (MgO), Silicon Oxide (SiO_2), Aluminum Oxide (AL_2O_3), Lime (CaO), Phosphorous Oxide (P_2O_5), Iron Oxide (Fe_2O_3), Manganate (Mn_2O_3), Sulphate (SO_3), Potassium Oxide (K_2O), etc.

Mathematical Model

For this research work, a furnace was used for the kilning process which is taken as a batch reactor at a given temperature. Therefore;

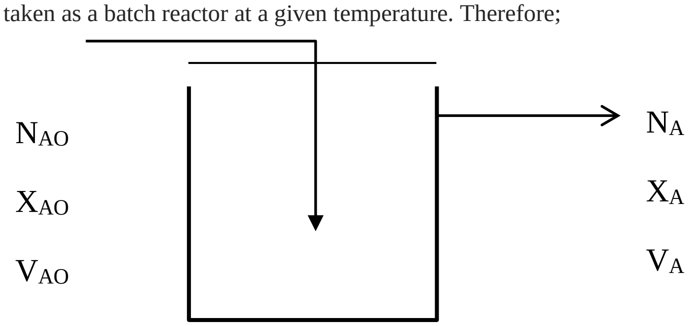

Figure 1 Batch Reactor for the Heating/Kilning Process

Where, N_{AO} = Initial mole of reactants, X_{AO} = Initial molar fraction of the reactants, V_{AO} = Initial Volume of reactants, N_A = Final mole of reactants, X_A = Final molar fraction of the reactants

V_A = Final Volume of reactants

Recall that:

Input = Output + Rate of disappearance + Accumulation (1)

Input = Output
Accumulation = Rate of disappearance
Accumulation = $\frac{d_N}{d_t}$
Rate of disappearance = $(-r_i)V_R$
Substituting the parameters into equation (1), we have

$$\frac{d_N}{d_t} = (-r_i)V_R$$

but,

$$dN_A = V_R dC_A$$

$$\therefore V_R \frac{dC_A}{d_t} = (-r_i)V_R$$

$$\frac{dC_A}{d_t} = -r_i$$

Since A - > B; $r_i = V_A = -K_{(T)}C_A$

$$\frac{dC_A}{d_t} = -K_{(T)}C_A \quad (2)$$

$$\frac{dC_A}{d_t} = -K_{(T)}d \quad (3)$$

But Arrhenius equation = $K_{(T)} = K_o e^{-E/RT}$

$$\frac{dC_A}{d_t} = \left[K_o e^{-E/RT}\right]_{dt} \quad (4)$$

Integrating both sides

$$\int_{C_{AO}}^{C_A} \frac{dC_A}{d_t} = \left[-K_o e^{-E/RT}\right] \int_{t_o}^{t_t} dt$$

$$\text{In} \frac{C_A}{C_{AO}} = \left[-K_o e^{-E/RT}\right] t \quad (5)$$

Flow Chart for Formulated Cement Production (Figure 2)

Production of Cubes (Mix Proportion of Concrete Specimens)

Standard mixing ratio of 1:1.5:3 and 1:2:4 in the weight of 6.1:9.2:18.4 and 1.4:2.9:5.8 with a cube size of 150mm*150mm*150mm* and 100mm*100mm*100mm* respectively in producing the required size of cube. The cube mold was placed on a vibrator in order to ensure that the cube is properly filled up.

Cube Testing

For the purpose of this research, testing of cubes were considered based on the period of curing. The cubes where placed in water for seven, fourteen, twenty-one and twenty-eight days as their curing age. The cubes were weighed before placing it on a cube crushing machine in an angle of forty-five degrees. The concrete compression machine is connected to the cube crushing machine in which the reading for the load (force) of the cube is recorded when there is a failure in the concrete compression machine. (See Appendix E for the crushing of the mould to determine the strength).

Fineness Test

Fineness test was done on the formulated cement and it was observed to retained in 7.5um sieve gauge.

RESULTS AND DISCUSSION

Setting and Hardening Time

Generally, the setting and hardening time of Ordinary Portland Cement (OPC), Dangote cement, Bua cement and that of the formulated cements (PSA), formulated cement (PKSA/PSA) and formulated cement (PKSA/PKFA and CD) are determined by the particle size of the cement distribution. The standard particle size of OPC is 75um. However, 150um was used due to its particles retention in the 75um measurement sieving gauge.

Characterization of Palm Kernel Shell and Palm Kernel Fiber

The table 1 shows the elemental composition of the mixture of Palm Kernel Shell and Palm Kernel Fiber and the percentage. Table 1 show that the palm kernel shell Ash (PKSA) and Palm Kernel fiber contains the major constituents needed for cement production and are within the range of cementious properties. That is, elements present are Calcium Ca, Silicon Si, Aluminum Al and Iron Fe and each element percentages are within the proportion of the standard range when compared to table 3 of the oxide composition of ordinary Portland cement as presented above.

Chemical Analysis of the Chipping Dust

The chipping dust was subjected to AAS analysis as to certain the elemental composition it contains. Table 2 shows the elemental analysis of the chipping dust, and from the result we can see that calcium has 62% which perfectly match for cement production.

Chemical Analysis of Clay Soil

The analysis was carried out to ascertain the elemental composition in the clay soil. From table 3, the functional constituents such as Aluminum, silicon and Iron which makes the clay soil to have weather resistance, adhesion and plasticity nature are illustrated.

Chemical Analysis of the Formulated Cement

The elemental analysis in the table shows that the formulated cement has the major elements and the percentage proportion is right for cement production. Table 4 shows the elemental analysis of the key elements in the formulated cement. This shows that the elements percentage proportions are within the ranges of elements when compared to the existing cement found within Nigeria such as Dangote cement and Bua cement that are predominantly used in our everyday construction work.

Energy Disperse X-ray Fluorescence

Mixture of Palm Kernel Shell and Palm Fiber

From Figure 3 the graph of the atomic adsorptive spectrometer analysis that was conducted using energy disperse x-ray fluorescence spectrometer shows that the mixture of palm kernel ash and palm fruit fiber has some requisite amount of calcium present in it. The high content of calcium in it shows the workability of this mixture in the production of cement. Figure 3 showcase the possible element identified in palm kernel ash and palm fiber mixture as stated.

Bua Cement

The graphical illustration in Figure 4 captures the wavelength at which Aluminum, silicon, calcium, Iron and other minor elements occurs.

Dangote Cement

Figure 5 shows the elemental composition of the chemical properties of Dangote cement at every degree due to its intensity and it is observed that the elemental composition is same with that of Bua cement except variation in percentage.

Clay Soil Ash

Figure 6 shows the behavioural pattern of each element in the clay soil and it is shown that the aluminum, silicon and iron contents in it, is

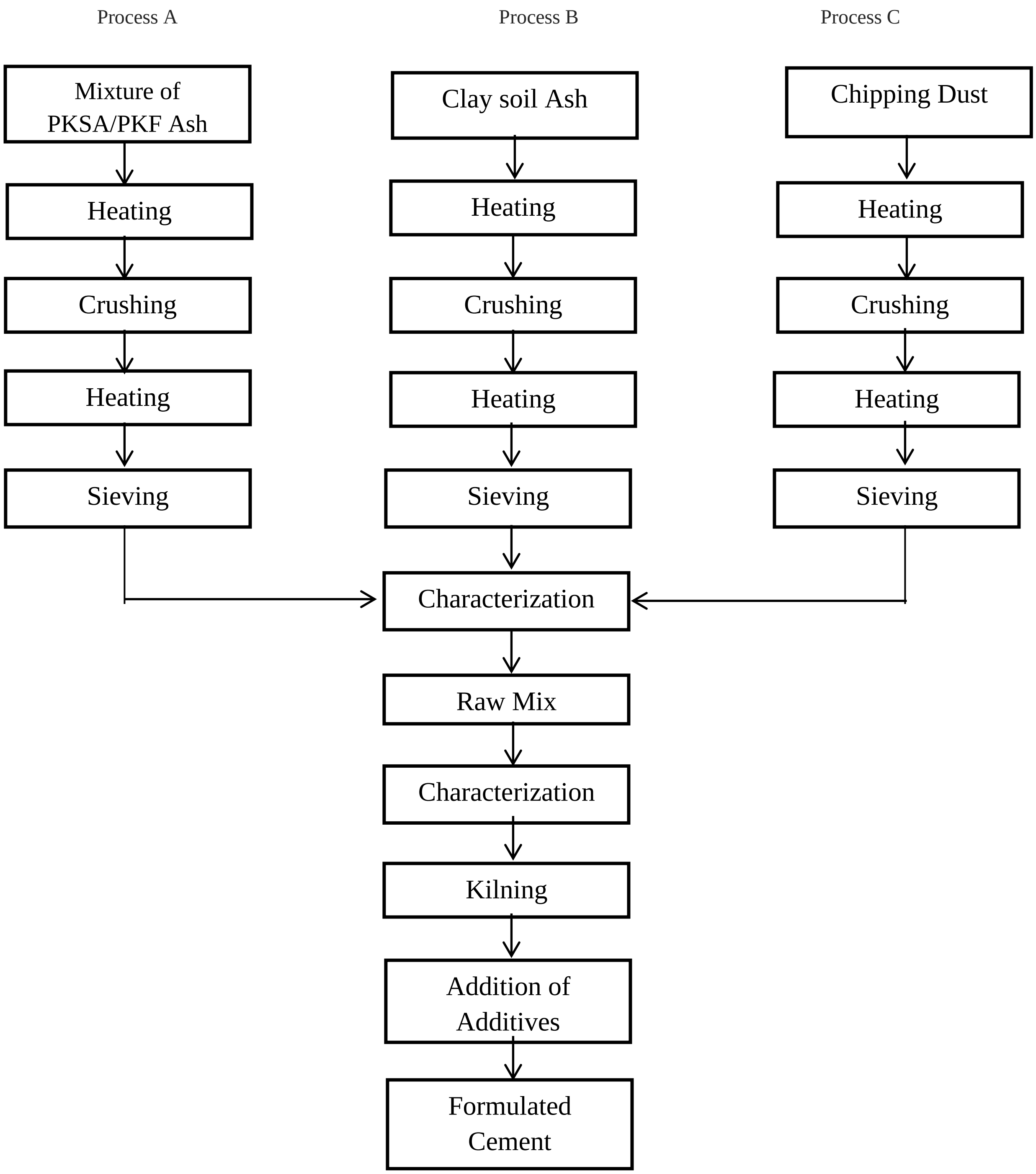

Figure 2 Systematic Manner of Illustrating the Flow Diagram for Formulated Cement Production

Table 1 Chemical Composition of Palm Kernel Shell and Palm Kernel Fiber

Element	Intensity	Content (%)
Al	0.0012	0.2685
Si	0.0040	0.3003
Ca	0.6177	62.5899
Fe	0.0008	0.1604

Table 2 Chemical Composition of Chipping Dust

Element	Ca(%)	Al(%)	Fe(%)
Concentration	62.18	4.05	1.83

Table 3 Chemical Composition of Clay Soil

Elements	Content (%)
Aluminum (Al)	15.5524
Silicon (Si)	17.9840
Iron (Fe)	4.3074
Calcium (Ca)	0.3564

Table 4 Characterization of the Formulated Cement

Sample	Formulated Cement
Ca(%)	61.7
Fe(%)	4.89
Al(%)	2.10
Si(%)	19.21

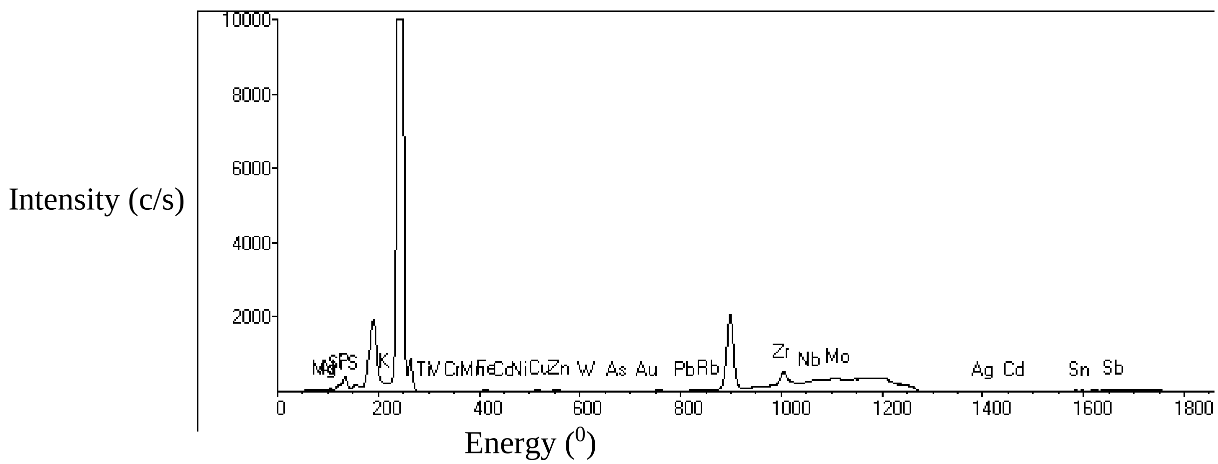

Figure 3 Graph of Analysis on the Characteristics of Palm Kernel Ash and Palm Fiber (Intensity against Energy)

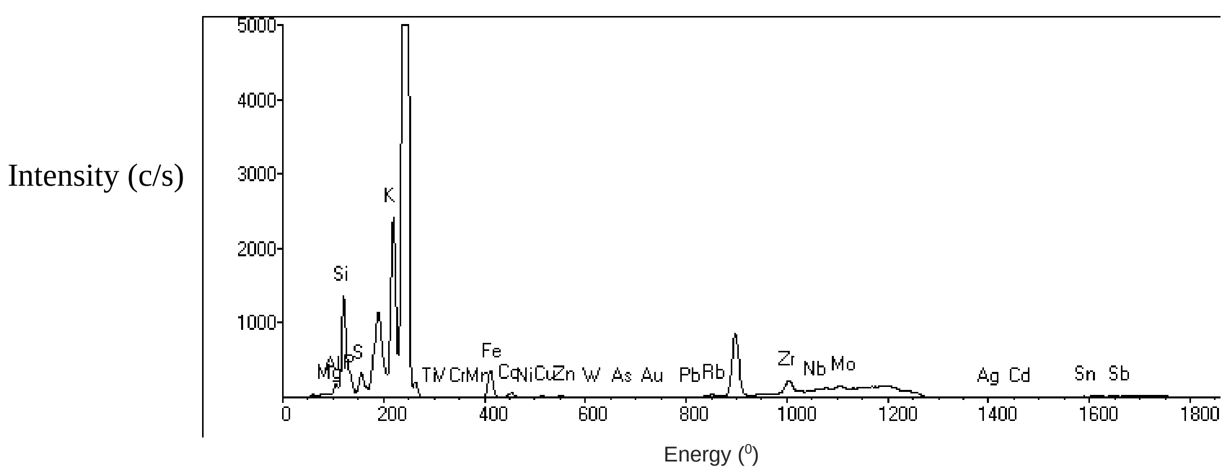

Figure 4 Graph of Analysis on the Characteristics of Bua Cement (Intensity against Energy)

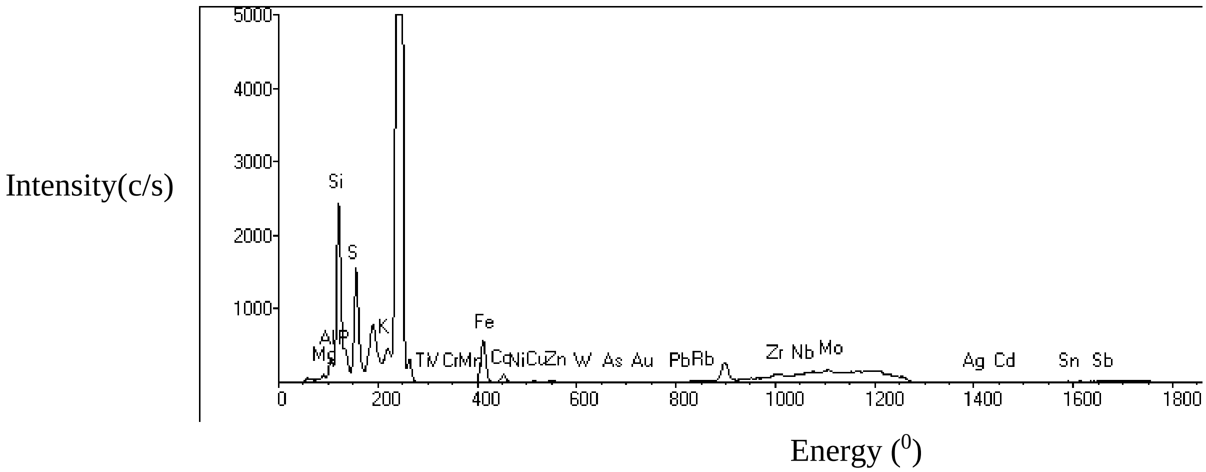

Figure 5 Graph of Analysis on the Characteristics of Dangote Cement (Intensity against Energy)

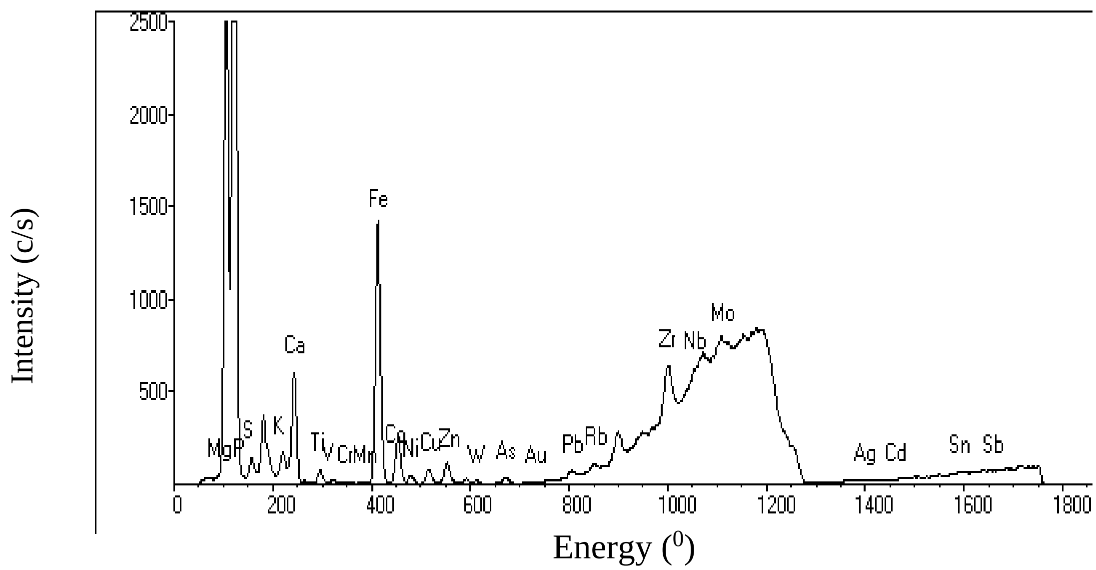

Figure 6 Graph of Analysis on the Characteristics of Clay shell Ash (Intensity against Energy)

necessary for cement production and it also gives the unique characteristics of smoothing of surfaces.

Test of Compressive Strength of the Concrete for Ratio 1:2:4

Table 5 shows the compressive strength of the Concrete with increase in curing age. From the result obtained in the determination of the compressive strength of the concrete using the formulated cement. For the curing ages of 7, 14, 21 and 28 days as presented in the table above, clearly shows the compressive strength increases but with a lower compressive strength when compared to the other ratio 1:1.5:3. The reason being that the proportion of binder used is some worth higher as compared to that used in ratio 1:2:4

Test of compressive strength of the concrete for Ratio 1:1.5:3

Table 6 shows the gauge reading with respect to the curing age of the concrete in ratio 1:1.5:3. From the result obtained in the determination of the compressive strength of the concrete using the formulated cement for the curing ages of 7,14,21 and 28days as presented in the Table 4.6 above also clearly shows the compressive strength increases with an increasing proportion of the binder being used. It further, indicates that the compressive strength increased as curing age for each cube tends to increase. Therefore, it surfaces to say that the concrete gets stronger with time.

Graphical representation of compressive strength development of the 100mm *100mm*100mm concrete cubes up to 28 days

Figure 7 demonstrates the relationship between the concrete strength for maximum period of 28 days and the curing age. Increase in strength of the concrete was observed with increase in curing age. The variation in the concrete strength can be attributed to the variation in the curing age as well as the composition and characterization of the mixture and formulated cement based on the locally source material. The mould formation of 100mm*100mm*100mm* was used to perform the investigation in ratio 1:2:4.

Table 5 Compressive Strength of the Concrete for Ratio 1:2:4

Curing age(days)	Gauge Reading	Stress (N/mm^2)	Minimum values for British Standard (N/mm^2)
7	20	2.00	16
14	22	2.20	19
21	25	2.50	21
28	28	2.80	-

Table 6 Compressive Strength for Concrete with Ratio 1:1.5:3

Curing age(days)	Gauge Reading	Stress (N/mm^2)	Minimum values for British Standard (N/mm^2)
7	60	2.7	16
14	80	3.5	19
21	100	4.44	21
28	120	5.33	-

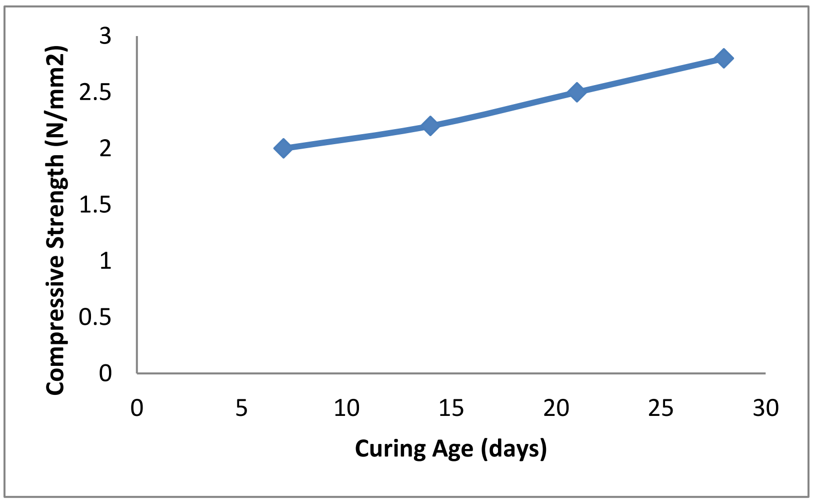

Figure 7 Graphical Analysis of the Concrete Strength against maximum curing age of 28 days

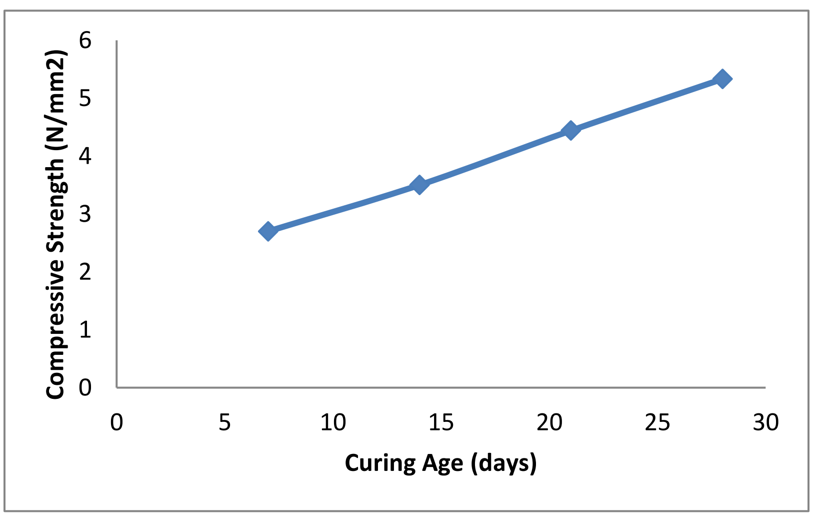

Figure 8 Graphical analysis of compressive strength development against maximum curing age of 28 days

Table 7 Strength of Bua cement, Dangote cement, formulated cement (PSA), formulated cement (PKSA/PSA) and formulated cement (PKSA/PKF) and that of British standard for ratio 1:2:4.

Period (Days)	Bua Cement (N/mm^2)	Dangote Cement (N/mm^2)	Formulated Cement (PSA) (N/mm^2)	Formulated Cement (PKSA/PSA) (N/mm^2)	Formulated Cement (PKSA/PKF) (N/mm^2)	Minimum values for British Standard (BS 12) (N/mm^2)
7	24.0	18.67	16.87	4.512	2.00	16
14	25.78	24.89	18.58	4.821	2.20	19
21	26.67	28.44	23.64	5.213	2.50	21
28	-	-	-	-	2.8	-

Table 8 Range of Elemental Oxide Composition

Oxide	Range (wt %)	Formulated Cement (PKSA/PKF)
CaO	60.2 - 66.3	61.7
SiO	18.6 – 23.4	19.21
Al_2O_3	2.4 – 6.3	2.10
Fe_2	1.3 – 6.1	4.89

Table 9 Percentage Composition of Elements

Elements	Dangote Cement Content (%)	Bua Cement Content (%)	Formulated Cement Content, PSA (%)	Formulated Cement Content, PKSA/PSA (%)	Formulated Cement Content, PKSA/PKF (%)
Al	2.03	1.33	1.78	0.51	2.1
Si	5.44	3.37	3.05	0.78	19.21
Ca	66.72	62.55	62.91	65.66	61.7
Fe	1.49	1.05	0.72	0.28	4.89

Graphical representation of compressive strength development of the 150mm*150mm*150mm concrete cubes up to 28 days

Figure 8 shows similar characteristics with Figure 7 but the strength gain is higher due to the presence of more binder resulting to higher compressive strength with increase in curing age.

Comparison of Concrete for Ratio 1:1.5:3 and 1:2:4

Figure 4.6 illustrates higher compressive strength than Figure 4.5 which means that the more the binder, the more the compressive strength with respect to increasing curing age.

Water Absorption and Setting time of the formulated cement (PKSA and CD)

From the observation, it was noted that concrete made of the formulated cement requires more water due to its high water absorption capacity because of the presence of PKSA. This connote that the setting time as well as the hardening time takes longer. For this study, only fresh water was used all through the experiment.

Strength Comparison

For strength comparison, the details for Bua, Dangote, formulated cement (PSA), formulated cement (PKSA/PSA) and formulated cement (PKSA/PKF) are summarized in Table 7.

Comparison of Oxide Composition of Portland cement with Formulated Cement (PKSA/PKF)

Table 8 shows that the oxide composition of raw materials (PKSA/PKF) and CD used as raw material for this research work is suitable for the cement production because it falls within the standard required range.

Comparison of Elemental Composition of the Bua cement, Dangote cement, formulated cement, (PSA), formulated cement, (PKSA/PSA), and formulated cement, (PKSA/PKF)

Table 9 shows the percentage composition of the major elements such as Aluminum, Silicon, Calcium and Iron present in each of the cements.

Chemical Composition of Mixture of Palm Kernel Shell Ash and Palm Pressed Fiber Ash, Chipping Dust and Clay Soil Ash

The experimental result of the mixture of palm kernel shell ash and palm fruit fiber ash, chipping dust and clay soil ash that was done using atomic adsorptive spectrometer shows below the chemical composition of each element:

Mixture of Palm Kernel Shell Ash and Palm Pressed Fiber Ash

The analysis of the sample shows the percentage composition of major constituent as; Lime (CaO) is 62.6%, Iron Oxide (Fe_2O_3) is 0.2%, Aluminum Oxide (AL_2O_3) is 0.3%, Phosphorous Oxide (P_2O_5) is 0.27%, Silicon Oxide (SiO_2) is 0.30% and Sulphur Oxide (SO_2) is 0.42%

Percentage Composition versus Chemical Elements Found in Clay Soil Ash

Figure 9 illustrates the percentage composition of major element such as Aluminum, Iron, and Silicon available in the clay soil therefore it can be used as a raw material for cement production.

Percentage Composition of Bua Cement

Figure 10 graphically shows that Calcium is a major constituent in cement production. The chemical composition of each element in Bua cement was X-rayed using Energy Disperse X-ray Fluorescence

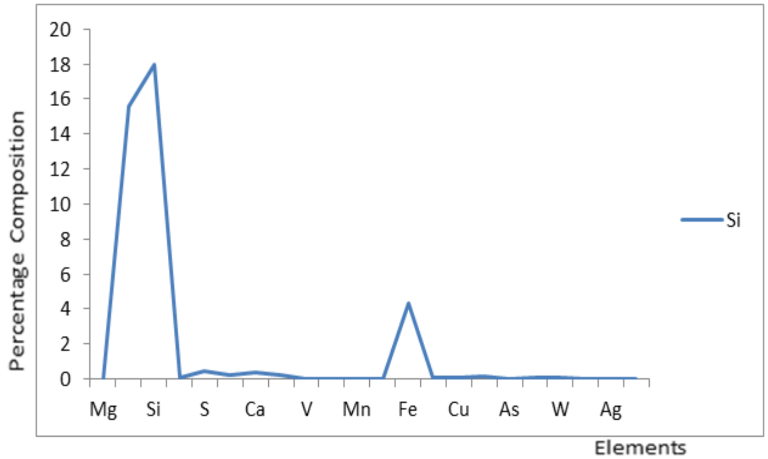

Figure 9 Plot of Composition versus Element

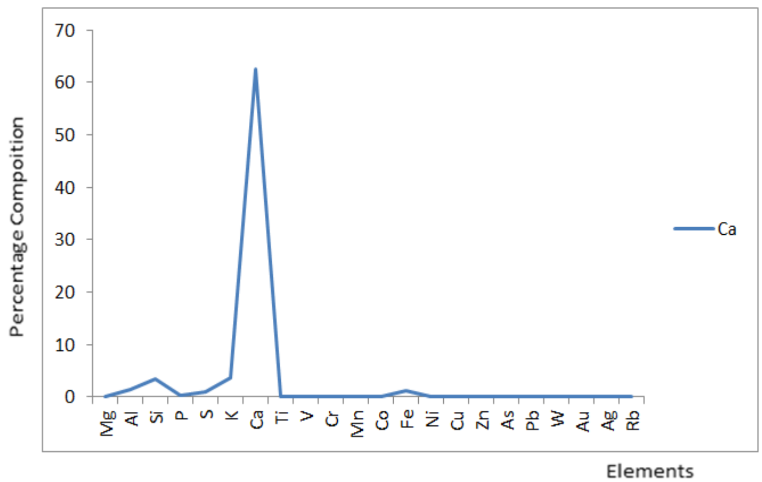

Figure 10 Plot of Composition versus Element

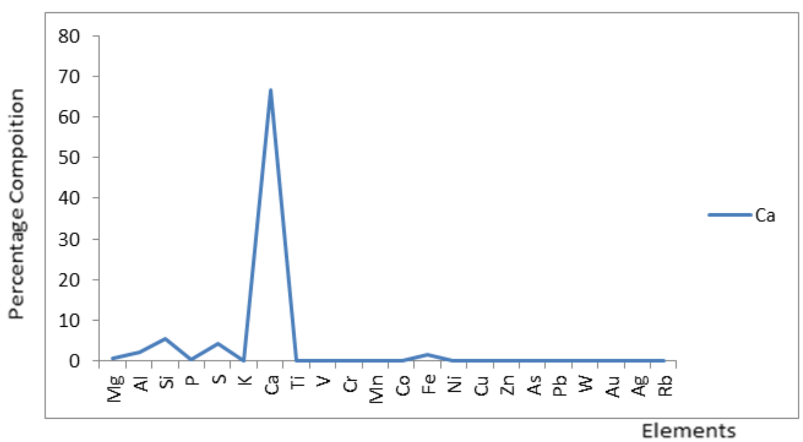

Figure 11 Plot of Composition versus Element

Spectrometer shows Magnesium Oxide (MgO) is 0.0000%, Aluminum Oxide (AL_2O_3) is 1.3338%, Silicon Oxide (SiO_2) is 3.3732%, Phosphorous Oxide (P_2O_5) is 0.2996%, Iron Oxide (Fe2O_3) is 1.0592%, Lime (CaO) is 62.5518%, Sulphate (SO_3) is 0.9295%, Potassium Oxide (K_2O) is 3.5816%, Manganate (Mn_2O_3) is 0.0019%, Titanum Oxide (TiO_2) is 0.0000%, Cromate (Cr2O_3) is 0.0000%, etc.

Percentage Composition versus Chemical Elements Found in Dangote Cement

Figure 11 shows that Calcium is a major constituent in cement production. Figure 11 illustrates the chemical composition of each element in Bua cement was X-rayed using Energy Disperse X-ray Fluorescence Spectrometer shows Magnesium Oxide (MgO) is 0.6721%, Aluminium Oxide (AL_2O_3) is 2.0343%, Silicon Oxide (SiO_2) is 5.4426%, Phosphorous Oxide (P_2O_5) is 0.4459%, Iron Oxide (Fe_2O_3)

is 1.4887%, Lime (CaO) is 66.7244%, Sulphate (SO_3) is 4.3281%, Potassium Oxide (K_2O) is 0.0000%, Manganate (Mn_2O_3) is 0.0069%, Titanium Oxide (TiO_2) is 0.0000% Cromate (Cr_2O_3) is 0.0000%, etc. effect of temperature on the Raw Mix during Kilning. The temperature effect on the raw mix during kilning was not considered in this research work, because the kilning process was done using an oven that heats the raw mix for a steady temperature of 150^0C for 24 hours.

CONCLUSION

Based on the findings from the study, the following conclusion can be drawn:

1. The formulated cement using (PKSA/F and CD) contains all the chemical constituents of cementious properties in the right varying proportion as contained in ordinary Portland cement and that of the existing ones commonly used in Nigeria such as Dangote cement and Bua cement.
2. It was found that, these agricultural by–products have pozzolanic characteristics that, when in use with proper additives will form a basic material for cement production.
3. It was found that, the compatibility that is the binding force depends primarily on the fineness of the particle size materials of the formulated cement.
4. It was also noted that the use of the formulated cement (PKSA/CD) takes longer time to absorbed water hence it also takes longer time to set.
5. An increase in the concrete strength gave a corresponding increase in the curing age
6. It was further investigated that the particle size of cement has a vital impact on the rate of hydration when exposed to water. This shows that, the size of particle distribution is significant in regulating the strength gained by cement at a set time.
7. Finally, the water to binder ratio also plays an essential role in the concrete formation.

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Article Key words

Production, cement, blend, palm kernel shell Ash, palm fiber Ash, chipping dusts, clay soil ash

Article History

Received: 17 February 2019
Accepted: 30 March 2019
Published: 1 May 2019

Citation

Ukpaka CP, Amadi SA, Idubamo RC. Production of cement using a blend of palm kernel shell ash, palm fiber ash, chipping dusts and clay soil ash. *Discovery*, 2019, 55(281), 187-197