EFFECT OF RIPE AND UNRIPE PLANTAIN PEEL ASH ON STRENGTH PROPERTIES OF CONCRETE.

BY

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CVE/12/0830

A project report submitted to the Department of Civil Engineering, Federal University Oye Ekiti in partial fulfillment of the requirements for the award of B.Eng in Civil Engineering.

2017

ABSTRACT

There has been a growing concern in the development of alternative building materials to ensure housing for low-income earners who cannot afford owning houses due to high cost of modern materials. Plantain (Musa paradisiaca) peels are the major by-product of plantain fruits, constituting about 40% of the fruits but are presently underutilized. This work covers the investigation into the effect of Ripe Plantain peel ash (RPPA) and Unripe Plantain peel ash (UPPA) as admixtures to concrete. RPPA & UPPA were sun-dried and burnt to Ash in a furnace. Both RPPA & UPPA were added to the concrete as admixture in the proportion of 1.5% and 2.5% each for a specific water/cement ratio. The mix design used was 1:2:4 and the water-cement ratio used was 0.7. Ripe Plantain Peel Ash (RPPA) contained lesser percentage of Silica (SiO_2) & Alumina (Al_2O_3) compared to Unripe Plantain Peel Ash (UPPA) using Spectrometry method of analysis. The Silica (SiO_2) content for RPPA was 46.367% & 54.000% for UPPA while the Alumina (Al_2O_3) content for RPPA was 2.197% and 3.080% for UPPA. The method of curing used was moist curing. The slump test was carried out to determine the workability of the concrete and compressive strength test was carried out on cube for 7, 14, 21 & 28 days. The result showed that the workability of the concrete increased with the addition of the admixtures. The Slump value obtained from the control mix was 20mm while the addition of RPPA at 1.5% and 2.5% were 24mm and 26mm respectively and the addition of UPPA at 1.5% and 2.5% were 25mm and 26mm respectively. The compressive strength of the concrete was observed to decrease on the addition of both RPPA & UPPA. The control mix at 28 days has a compressive strength of 22.39N/mm^2 while the addition of RPPA at 1.5% & 2.5% were 14.28N/mm^2 & 11.95N/mm^2 respectively and addition of UPPA at 1.5% & 2.5% were 12.43N/mm^2 & 10.23N/mm^2 respectively. The concrete can as well be classified as normal weight concrete based on the density range of 2251kg/m^3 and 2400kg/m^3. Therefore, the finding of this study indicates that Ripe Plantain Peel Ash (RPPA) and Unripe Plantain Peel Ash (UPPA) both decreases the strength of concrete. The addition of RPPA & UPPA as admixture to concrete will not be suitable for structural members.

KEY WORDS: Ripe plantain peel ash, Unripe plantain peel ash, Workability, Compressive strength, Admixture, Concrete.

ACKNOWLEDGEMENT

My profound gratitude goes to Almighty Allah who made it possible for me to carry out this report and study in general. My appreciation goes to my beloved parents, Mr. Olatunji Luqman and Mrs. Olatunji Aminat whom their tireless moral and financial supports made my study possible.

I will like to express my heartfelt gratitude to my supervisor, Dr. O.A. Adetayo, civil engineering department, my lecturers and also to my colleagues. Thank you all for your great contributions. I pray that Allah in His infinite and endless mercy reward you all abundantly. Thank you all, I am highly grateful.

DEDICATION

To Almighty Allah who gave me the strength, power and ability to be able to accomplish this task and also my parents who are always there for me in terms of financial assistance and words of encouragement.

CERTIFICATION

This is to certify that this report was put together and written by **OLATUNJI JUBRIL** with matriculation number **CVE/12/0830** under my supervision, in partial fulfillment of the requirements for the award of Bachelor degree in Civil Engineering (B.Eng), Federal University Oye Ekiti, Ekiti State.

12/12/2017

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing Materials
RPP	Ripe Plantain Peel
UPP	Unripe Plantain Peel
RPPA	Ripe Plantain Peel Ash
UPPA	Unripe Plantain Peel Ash
RHA	Rice Husk Ash
PFA	Pulverized Fuel Ash
POFA	Palm Oil Fuel Ash
OPC	Ordinary Portland Cement
BS	British Standard
RCC	Reinforced Concrete

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CHAPTER ONE

INTRODUCTION

1.1 General Background

Concrete is a composite material composed of gravels or crushed stones (coarse aggregate), sand (fine aggregate) and hydrated cement (binder). The paste is typically made up of portland cement and water and may also contain supplementary cementing materials (SCMs), such as fly ash or slag cement, and chemical admixtures.

It consists of four different type of ingredients; coarse aggregate, fine aggregate, Portland cement, and water. But concrete has its own disadvantages due to considerable brittleness, which results in poor fracture toughness, poor resistance to crack propagation, and low impact strength.

Concrete is a composite material which is made up of a filler and a binder, the binder (cement paste) glues the filler together to form a synthetic conglomerate. Admixture ranging from addition of chemical to the use of waste materials have been advocated for use in concrete almost from the time when cement was first invented. They are used to alter or improve some of the properties of fresh or hardened concrete or both. This is because of the ease with which they can affect the improvement quickly and sometimes more economically.

Concrete is widely used in construction industry such as high rise building, bridge, houses, tunnels, bridges and others due to its durability. The concrete behavior is strong and durable and also produces environmental friendly structure. Concrete is widely used because it has several benefits such as, more durable, energy-efficient, low maintenance, affordability, fire-resistance, excellent thermal mass and also versatility.

Concrete is no doubt an important building material, playing a part in all building structure. It is environmental friendly construction material which offers the stability and flexibility in designing all building structures. Concrete are attractive for use as construction materials. Since, there are many advantages of concrete such as built-in-fire resistance, high compressive strength and low maintenance. However, concrete also have a disadvantage which is that concrete is inherently brittle material.

On the other hand, concrete is also well known of its major problem associated with low tensile strength compared to compressive strength. Because of that, many new technologies of concrete and some modern concrete specifications approach were introduced. There have been many experimental works conducted by introducing a new material or recycled material as a replacement to aggregate or cement in concrete (Ahmad et al., 2008).

Development of high strength concrete is often considered a relatively new material, but its development and usage has been gradual over many years. The growth has been possible as a result of recent developments in material technology and a demand for higher-strength concrete.

The utilization of waste by-products in concrete has garnered positive outcomes over the past few decades in terms of the cost savings and conservation of natural resources. Some of the resources currently being employed for concrete production are prone to having negative effects on the environment besides being non-renewable. This has resulted in an increase in research to develop alternative feed to reduce and maintain a non-excessive usage of natural sources.

Nowadays, the use of recycled materials as concrete ingredients is gaining popularity and development because of increasingly stringent environmental legislation. Furthermore, there is significant research on many different materials for cement usage substitutes and replacement such as Rice Husk Ash (RHA), Grinded rice husk (GRH), palm oil fuel ash (POFA), pulverize fuel ash (PFA) and many others fiber and pozzolanic material (Awal and Hussin, 1996).

1.2 Components of Concrete

1.2.1 Aggregate

Coarse aggregate as shown in Figure 1.1, is a granular material obtained from rocks and crushed stones. It may also be obtained from synthetic material like slag, shale, fly ash and clay for use in light-weight concrete. Sand obtained from river beds or quarries is used as fine aggregate. The fine aggregate along with the hydrated cement paste fill the space between the coarse aggregate.

The important properties of aggregate are as follows.

Shape and texture

Size gradation

Moisture content

Specific gravity

Unit weight

Durability and absence of deleterious materials.

Figure 1.1 Coarse Aggregate

1.2.2 Cement

Cement shown in Figure 1.2, is a binder, a substance used in construction that sets, hardens and can bind other materials together. In present day concrete, cement is a mixture of lime stone and clay heated in a kiln to 1400 - 1600°C.

Basic Chemical Components of Portland cement:

Calcium (Ca)

Silicon (Si)

Aluminum (Al)

Iron (Fe)

Typical Raw Materials:

Limestone ($CaCo_3$)

Sand

Shale, Clay (SiO_2, Al_2O_3, Fe_2O_3)

Iron Ore/Mill Scale (Fe_2O_3)

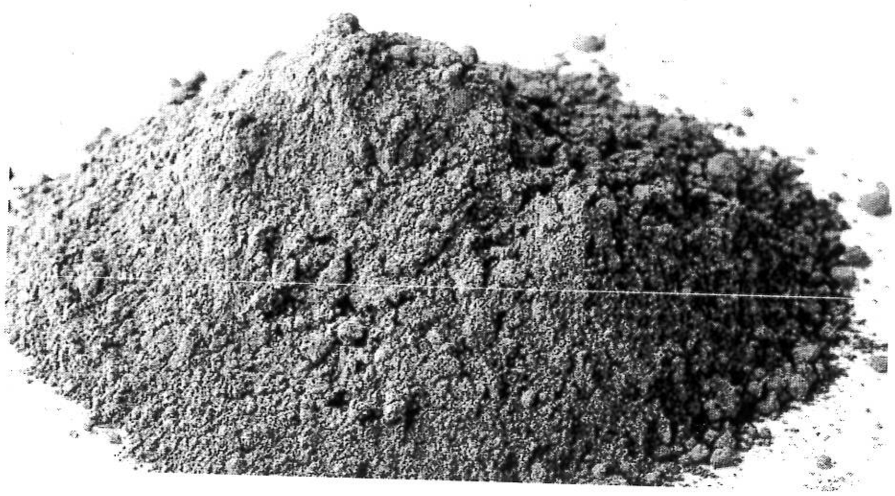

Figure 1.2 Cement

1.2.3 Water

The amount of water in concrete controls many fresh and hardened properties of concrete including workability, compressive strengths, permeability, water tightness, durability, weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life. Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

1.2.4 Admixtures

These are natural or manufactured chemicals which are added to the concrete before or during mixing. The most often used admixtures are air-entraining agents, water reducers, water-reducing retarders and accelerators.

The common mineral admixtures are as follows.

Fly ash

Ground granulated blast-furnace slag

Silica fumes

Rice husk ash

Metakoline

They are cementitious and pozzolanic materials.

Importance of admixtures

1. Admixtures give special properties to fresh or hardened concrete.
2. Admixtures may enhance the durability, workability or strength characteristics of a given concrete mixture.
3. Admixtures are used to overcome difficult construction situations, such as hot or cold weather placements, pumping requirements, very low water-cement ratio specifications.

1.2.5 Pozzolan

A pozzolan is a siliceous and aluminous material which when combined with calcium hydroxide, in the presence of water to form compounds exhibit the cementitious properties at room temperature and has the ability to set under water. The American Society for Testing Materials (ASTM) defines pozzolan as a "siliceous or siliceous aluminous material which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties". Pozzolans are commonly used as an addition (the technical term is "cement extender" or "cement replacement materials") to Portland cement concrete mixtures to increase the long-term strength and other material properties of Portland cement concrete and in some cases reduce the material cost of concrete.

Today, modern pozzolanic cements are a mix of natural or industrial pozzolans and Portland cement. Apparently, the usage of pozzolans can decrease in the use of Portland cement when producing concrete; this is more environmental friendly than limiting cementitious materials to Portland cement. The characteristic of high alkalinity in pozzolana materials makes it especially resistant to common forms of corrosion from sulfates for the underwater usage. The extent of the strength development depends upon the chemical composition of the pozzolan: the greater the composition of alumina and silica along with the vitreous phase in the material, the better the pozzolanic reaction and strength display.

Pozzolanic materials are therefore defined with respect to their use as cementitious material instead of chemical and physical phenomena by the virtue of which it hardens. There are lots of pozzolanic materials which are available in the world today. These materials differ entirely in their composition, mineralogical constitution, origin etc. (Lea, 1988) divided the pozzolan into two main group natural and artificial materials.

Natural materials do not require any treatment for their use as pozzolan other than grinding to increase the surface area. However, the artificial materials are produced by improving the properties of weak pozzolan. Natural pozzolan include the materials of volcanic origin, compact materials (tuffs) and materials of sedimentary origin.Volcanic pozzolan which gets deposited and later on exposed due to weathering action is called compact materials or tuffs. Weathering cause either zeolitisation (conversion into zeolite which is a natural or synthetic hydrated alumino-silicate with an open three-dimensional crystal structure, in which water molecules are held in cavities in the lattice) or argillation (weathering of aluminum silicates) which turns the glass of pozzolan either into zeolitic minerals or clay minerals.

1.3 Concrete curing

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. The need for adequate curing of concrete cannot be overemphasized. Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing. Exposed slab surfaces are especially sensitive to curing as strength development and freeze-thaw resistance of the top surface of a slab can be reduced significantly when curing is defective.

With proper curing, concrete becomes stronger, more impermeable, and more resistant to stress, abrasion, freezing and thawing. The improvement is rapid at early ages but continues more slowly thereafter for an indefinite period as shown in Figure 1.3

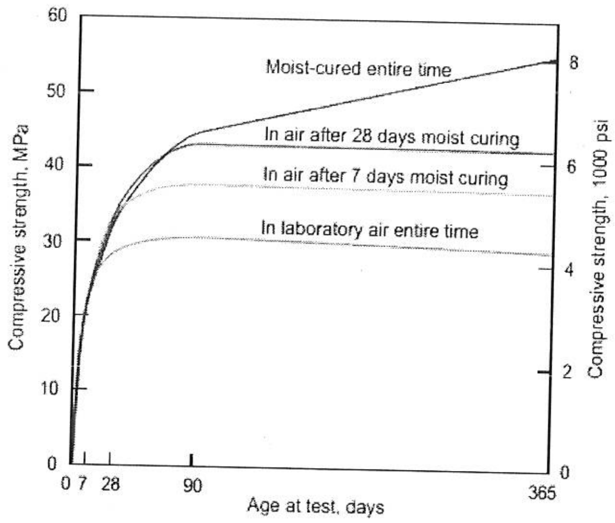

Figure 1.3 Effect of moist curing time on strength gain of concrete

1.4 Aim and Objectives

1.4.1 Aim

The major aim of this work is to determine the effect of ripe plantain peel ash and unripe plantain peel ash on strength properties of concrete.

1.4.2 Objectives

The general objective of this study is to investigate the compressive strength of concrete when ripe & unripe plantain peel ash are used as admixture. The specific objectives of this study are:

1. To determine whether the concrete will decrease or increase the compressive strength of concrete on addition of plantain peel ash (ripe and unripe).
2. To determine the alumina and silica composition of the plantain peel ash (ripe and unripe)
3. To determine the workability of concrete on addition of plantain peel ash.
4. To analyze the results with the aim of making a better recommendation.

1.5 Scope of Project

So many properties of concrete such as creep, strength, durability, modulus of elasticity, shrinkage, water tightness etc., are been investigated by researcher and are hence been improved on, but this research work is on the compressive strength of concrete containing different proportions of RPPA & UPPA. Investigations into other properties are outside the scope of this work.

1.6 Significance of Project

This project will be of great importance. Listed below are part of the project significance;

1. The management of agricultural waste.
2. Natural Resources Management.

1.7 Chemical Composition of Plantain

Plantain (Musa paradisiaca) peels (see Figure 1.5) are the major by-product of plantain fruits (see Figure 1.4), constituting about 40% of the fruits but are presently underutilized. Plantain fruits are similar to potatoes in composition but contain more potassium, protein content is about 1% and starch content of more than 20%. They later decrease during ripening while the sugar content can increase, the starch content at full ripeness is always much higher in plantains than in desert bananas, the opposite is true for their sugar levels, banana fruits have high energy value (435kj or 104cal/100g). They are rich in ascorbic acid or vitamin c and vitamin b. Plantains are rich in vitamin A.

Figure 1.4 Ripe Plantain

Figure 1.5 Plantain Peel

Figure 1.6 Plantain peel ash

1.8 Workability

Workability is the ability of a fresh (plastic) concrete mix to fill the form or mold properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration) and can be modified by adding chemical admixtures, like super plasticizer.

Factors Affecting Workability

- Water Content
- Mix Proportions
- Size of Aggregates
- Surface Texture of Aggregate
- Grading of Aggregate
- Use of Admixtures

CHAPTER TWO

LIERATURE REVIEW

2.1 Overview

This chapter covers the overview of literature on experiments conducted by authors on adding supplementary waste materials to concrete as a pozzolanic material, thereby showing the importance of using supplementary waste pozzolanic material as admixture to concrete.

2.2 Literature Review on Plantain, Admixtures, Concrete and Pozzolan

2.2.1 Plantain

According to (Inusa, 2006), plantain belongs to the family Musa Ceae, genus Musa originated in south East Asia area between Indian, Papua, Musa Alumiminata and musabalbisiana. The plantain is a free-like herb perennial but mono-corpic, from two to six meters high, with milky juice in all part. The following constitutes the major components of the tree (Samson, 1983).

The corm is underground part of the plantain plant, its shape is cultivar dependent but is mostly roundish, at its tip, it bears the apical meristem or growing point from which leaves develop upwards and stem tissue downwards. The corm is as such the true stem of the plants albeit underground. The apical meristem remains below or at soil level during vegetation growth. But rises quickly after flower initiation. New leaves develop centrally from the growing and push aside the older ones, which ultimately die and disintegrate there by exposing nodes and internodes (Muhammad 2005).

The cylindrical pseudosterm is borne by the corm, a leaf of three parts i.e. a sheaths or enlarged peptide, a petiole, and a liming or blade, leaf sheaths of successive leaves closely encircle each other, this is the psedostem or false, stem, the trees, stem (corm) is located under the apical meristem in the soil.

Brunch develop from inflorescence that originates from meristem from the corm after flower initiation, the inflorescence remains in the pseudo stem at soil level for about two months, But as soon as the last two to four leaves unfurl, It quickly rise through the pseudo stem after the last leaf has unfurl, this emergence is called shooting.

Plantain are produced in the backyards and are mixed with other food crop in shifting cultivation systems, they are predominant in the low land humid tropics of Congo Kinshasa, Congo Brazzaville, Gabon, Cameroon, Nigeria, Ghana, Cote d'voire, Guinea and Liberia. More than 90% of all bananas produced in Africa are consumed locally. Nearly 50% of these consist of high land cooking bananas and beer bananas while plantains account 32% and desert bananas 18 % (Inusa, 2006).

Plantain fruits are similar to potatoes in composition but contain more potassium than other plants spices, protein content is about 1% and starch content of more than 20%. They later decrease during ripening while the sugar content can increase. The starch content at full ripeness is always much higher in plantains than in desert bananas, the opposite is true for their sugar levels, banana fruits have high energy value (435kj or 104cal/100g).

They are rich in ascorbic acid or vitamin C and vitamin B. Plantains are rich in vitamin A (Samson, 1983).

(Morton, 1987) reported that over the years, plantain has been more importantly utilized as foods. The fruits are either eaten raw or processed as foods and raw material for industrial purposes. The peels are well known for animal feeds due to their high moisture content, sources of fibres.

In some African countries like Kenya and Uganda, they serve as raw materials and source of binder for briquettes (a fuel resource made from any agro-industrial wastes that can be recycled for cooking or heating) as reported by (Megan, 2007), little is known about the exploitation and application of their natural resins present in peels.

According to (Mantell, 1942) and (Harborne, 1984), resins from plants are known for their binding characteristics

Their ready availability is also a concern and crucial factor, especially in Nigeria where most of these products are imported; hence, the need for cheap and readily available binders that would be of equal or better qualities to these synthetic products has become imperative. Due to the high cost of thermosetting resin in board production in Nigeria, a great deal of interest is being developed on the use of cement as a binding agent, fortified with other mineralizing agents (Ajayi, 2000).

Different mineral binders, including Portland cement, magnesia and gypsum, are used to fabricate boards with different properties (Simatupang and Geimer, 1990).

However, the most expedient binder, concerning strength, durability and acoustic insulation properties is Portland cement (Frybort et al, 2008), but their density has become a major concern as increased strength was always facilitated by more cement. Chemical composition of ripe plantain peel ash; moisture contents 61.3%, protein contents 3.15%, ash contents 6%, fat contents1.2%, crude fibre 1.11%, sugar contents 12.8%, carbohydrate 27.24%, and total solid 38.7g / 100g (Egbebi and Bademosi, 2011).

In the investigation conducted by (Okorie et al, 2015), peels of unripe plantain, ripe plantain, unripe banana and ripe banana were investigated using standard techniques. All the peel samples studied contained considerable amounts of Ca, Mg, K, Na, P, Zn, Cu, and protein while the amount of Pb in all the peel samples were quite low to cause any deleterious effects. The study showed the nutritional relevance of the peels of these plants. Unripe plantain peel contained significantly higher amounts of zinc compared with other peel samples investigated while unripe banana peel had the least although it did not differ significantly from that of ripe plantain peel.

Table 2.1 Mineral Composition of Ripe Plantain and Unripe Plantain Peel

Groups	**Ca**	**Mg**	**K**	**Na**	**P**
RPP	6.81 ± 1.15	0.84 ± 0.23	10.6 ± 0.85	6.09 ± 1.29	0.59 ± 0.01
UPP	7.62 ± 0.17	1.22 ± 0.45	9.32 ± 0.59	6.07 ± 0.10	0.60 ± 0.14
Groups	**Zn**	**Cu**	**Pb**	**Fe**	
RPP	1.49 ± 0.13	0.95 ± 0.35	0.05 ± 0.03	22.48 ± 0.68	
UPP	2.60 ± 0.28	0.86 ± 0.06	0.11 ± 0.01	346.10± 22.77	

Source: Okorie et al., Journal Nutr Food Sci, 2015.

2.2.2 Admixtures

According to (Jackson and Dhir, 1998), admixtures are substances introduced into concrete mixes in order to alter or improve the properties of the fresh or hardened concrete or both.

In general these changes are affected through the influence of the admixtures on hydration liberation of heat, formation of pores and development of gel structure. Concrete admixture should only be considered for use when the required modification cannot be made by varying the composition of the basic constituents materials, or when the admixtures can produce the required effects more economically (Inusa, 2007).

It can be concluded from the findings of (Neville 1981), since admixtures may also have detrimental effects, their suitability for a particular concrete should be carefully evaluated before use, based on a knowledge of their main active ingredients, on trial mixes, cement water ratio, ambient condition and its dosage.

There are types of admixtures available for use depending on the property requirements, they include; accelerators, retarders, air-entraining agents, water reducers or plasticizers, pigments, pozzolanas, pore fillers and super plasticizers (Neville, 1981).

(Vasumathi, 2003), experimentally investigated the properties of concrete when cement is replaced by fly ash and sand by quarry dust separately and simultaneously. Tests were conducted on workability at fresh state and compressive strength at hardened state at the age of 7, 14 and 28 days. The sand was replaced from 0 to 25% at increment of 5%. From the test results it was observed that workability was decreased due to addition of quarry dust. Better result on 28 days compressive strength was obtained on replacement of fly ash, quarry dust, fly ash and quarry dust at 5%, 15% and 10% respectively. It was concluded that replacement of cement with fly ash and sand with quarry dust resulted economical construction and also a solution for reducing the environmental pollution.

Retarders as the name implies, delay the beginning of the setting and hardening of concrete, they are most useful in hot countries where concrete has to be transported for some distances, and for concreting in large quantities in the hot weather, when it is important to avoid the formation of 'cold joints' (Feldman and Dhir, 1998).

According to (Mehta and Monteiro, 1997), the use of supplementary materials has found widespread applications in the construction industry also because of its tendency to act as a pancea for durability related problems. Plain concrete mixes if used in mass concrete construction like dams would result in very high heat of hydration thereby leading to problems like thermal cracking. The use of materials like fly ash or slag offers the possibility of reducing the temperature rise almost in direct proportion to amount of Portland cement replaced.

The work of (Manmohan and Mehta, 1981), durability to chemical attack is improved with the use of most fly ashes and slag's mainly due to the pore refinement of concrete made with such materials. Experiments have shown that cement pastes containing 10-30% low calcium fly ash causes significant pore refinement in the 28 to 90 day curing period.

Also, problems of dispersion of the air-entraining agents due to high carbon contents in the fly ash have been reported. Researchers have argued that as long as sufficient air content and spacing factor is provided, high carbon contents in fly ash do not pose a problem (Sturrup et al. 1983).

(Obilade, 2014) reported the research work on the properties of Rice Husk Ash (RHA) when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with RHA by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served as the control. Compacting factor test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with RHA increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with RHA. It is recommended that further studies be carried out to gather more facts about the suitability of partial replacement of OPC with RHA in concrete.

(Rodway 1998), tested five different fly ashes covering a wide range of lime contents, which were used as 25 % replacement in concrete mixtures. It was found that regardless of the lime content of the fly ash, satisfactory air void size and spacing values could be obtained to produce durable fly ash concrete.

(The Cement and Admixtures Association 1977), reported that two things will happen when a surface active agent is placed into a suspension of cement particles.

1. The surface active agents 'tail' is absorbed on the surface of the cement particle with the negative charge protruding into the water. As a result, the cement particles do not collect together and therefore more surface area is available for reaction with the water. At the same time, water that may be trapped inside a cement particle floc is released. The combined effects improve the workability of the cement mix; this can be seen in Figure 2.1
2. Entrapped air is also more readily removed since orientation of the surface active agents prevents the air bubble from attaching to cement particles, as shown in Figure 2.2

The compressive strength of concrete decreases with the increase in percentage of the ash which implies that plantain peel ash decreases the strength of concrete. (Dahiru and Ma'ruf, 2016)

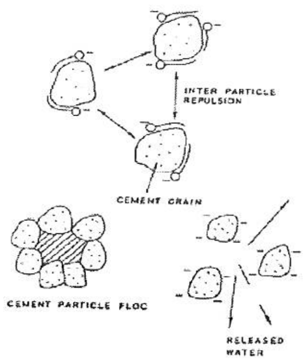

Figure 2.1 Effect of surface active agent on cement particle floc

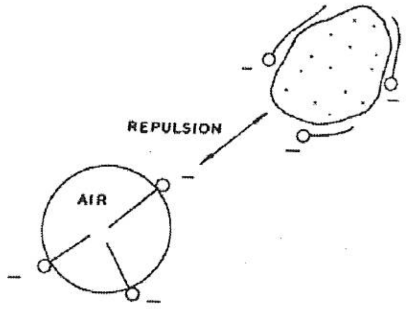

Figure 2.2 Repulsion of air bubble by surface Active Agent

An experiment was conducted to investigate the properties of concrete when cement was partially replaced by fly ash and natural sand by crusher stone powder simultaneously. The compressive strength and flexural strength were studied. The behavior of concrete when subjected to heat cycles was also studied. The replacement of sand was from 0- 40% at increments of 10%. Using OPC the design mix of 1: 1.2: 2.4 was prepared with water cement ratio 0.30. To facilitate the flow of concrete a super plasticizer was used. In temperature resistance test, the concrete cube specimen was subjected to heat cycles say 8 hours of heating at 60°C followed by 16 hours of cooling at 25°C. Two heat cycles say 15-day cycle and 30-day cycle were adopted. From test results it was observed that 28-day compressive strength was maximum at 30% sand replacement and this was due to the fact that crusher powder fills up the maximum voids to get dense concrete and fly ash liberates strength during later periods. Similarly, flexural strength was also maximum at 30% replacement itself. Due to heat cycle there will be some loss in compressive strength as well as flexural strength. The maximum resistance to heat was developed at 30% sand replacement. From the above test results it was concluded that quarry dust and fly ash may be used as replacement materials in concrete (Patagundi and Patil, 2002).

(Amitkumar D. Raval et al., 2013), reported that the ceramic industry inevitably generates wastes, irrespective of the improvements introduced in manufacturing processes and about 15%-30% production goes as waste. They stated that these wastes pose a problem in present-day society, requiring a suitable form of management in order to achieve sustainable development. In their research study, they replaced (OPC) cement by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight for M-25 grade concrete & the wastes employed came from ceramic industry which had been deemed unfit for sale due to a variety of reasons, including dimensional or mechanical defects, or defects in the firing process. They concluded that the use ceramic masonry rubble as active addition endows cement with positive characteristics as major mechanical strength and the economic advantages and reuse of this kind of waste has advantages economic and environmental, reduction in the number of natural spaces employed as refuse dumps.

2.2.3 Concrete

2.2.3.1 Definition

Concrete is a synthetic construction material made by mixing cement, fine aggregate (usually sand), coarse aggregate (usually gravel or crush stone), and water in the proper proportions. The product is not concrete unless all four of these ingredients are present (Zongjin Li 2011).

2.2.3.2 Constituents of Concrete

The fine and coarse aggregates in a concrete mix are the inert, or inactive, ingredients. Cement and water are the active ingredients. The inert ingredients and the cement are first thoroughly mixed together. As soon as the water is added, a chemical reaction begins between the water and the cement. The reaction, called hydration, causes the concrete to harden. This is an important point. The hardening process occurs through hydration of cement by the water, not by drying out of the mix. Instead of being dried out, concrete must be kept as moist as possible during the initial hydration process. Drying out causes a drop in water content below that required for satisfactory hydration of the cement. The fact that the hardening process does not result from drying out is clearly shown by the fact that concrete hardens just as well underwater as it does in air (Peterman et al., 1986).

2.2.3.3 Concrete as a Building Material

Concrete may be cast into bricks, blocks, and other relatively small building units, which are used in concrete construction. Concrete has a great variety of applications because it meets structural demands and lends itself to architectural treatment. All important building elements, foundations, columns, walls, slabs, and roofs are made from concrete. Other concrete applications are in roads, runways, bridges, and dams (Peterman et al., 1986).

2.2.3.4 Properties of Fresh Concrete

Concrete remains in its fresh state from the time it is mixed until it sets. During this time the concrete is handled, transported, placed and compacted. Properties of concrete in its fresh state are very important because the influence of the quality of the hardened concrete. The fresh concrete has the following properties (The History of Concrete).

a. Consistency

Consistency of a concrete mix is a measure of the stiffness or sloppiness or fluidity of the mix. For effective handling, placing and compacting the concrete, consistency must be the same for each batch. It is therefore necessary to measure the consistency of concrete at regular intervals. Slump test is commonly used to measure consistency of concrete (ACI 1999).

b. Workability

The workability of a concrete mix is the relative ease with which concrete can be placed, compacted and finished without separation or segregation of the individual materials.

Workability is not the same thing as consistency. Mixes with the same consistency can have different workabilities, if they are made with different sizes of stone – the smaller the stone the more workable the concrete.

It is not possible to measure workability but the slump test, together with an assessment of properties like stone content, cohesiveness and plasticity, gives a useful indication.

c. Settlement and bleeding

Cement and aggregate particles have densities about three times that of water. In fresh concrete they consequently tend to settle and displace mixing water which migrates upward and may collect on the top surface of the concrete. This upward movement of mixing water is known as bleeding; water that separates from the rest of the concrete is called bleed water.

d. Plastic shrinkage

If water is removed from the compacted concrete before it sets, the volume of the concrete is reduced by the amount of water removed. This volume reduction is called plastic shrinkage. Water may be removed from the plastic concrete by evaporation or by being absorbed by dry surfaces such as soil or old concrete or by the dry wooden form work.

e. Slump loss

From the time of mixing, fresh concrete gradually loses consistency. This gives rise to the problems only if the concrete becomes too stiff to handle, place and compact properly.

Slump loss in concrete is caused due to the following reasons;

i Hydration of cement (generating more heat)

ii Loss of water by evaporation

iii Absorption of water by dry aggregates

iv Absorption of water by surfaces in contact with the concrete.

2.2.3.5 Properties of Hardened Concrete

Fully cured, hardened concrete must be strong enough to withstand the structural and service loads which will be applied to it and must be durable enough to withstand the environmental exposure for which it is designed. If concrete is made with high quality materials and is properly proportioned, mixed, handled, placed and finished, it will be the strongest and durable building material (Naik et al., 1998: Pala et al., 2007). Below are the properties of hardened concrete;

a. Strength

When we refer to concrete strength, we generally talk about compressive strength of concrete. Because, concrete is strong in compression but relatively weak in tension and bending. Concrete compressive strength is measured in pounds per square inch (psi). Compressive strength mostly depends upon amount and type of cement used in concrete mix. It is also affected by the water-cement ratio, mixing method, placing and curing. Concrete tensile strength ranges from 7% to 12% of compressive strength. Both tensile strength and bending strength can be increased by adding reinforcement.

b. Creep

Deformation of concrete structure under sustained load is defined as concrete creep. Long term pressure or stress on concrete can make it change shape. This deformation usually occurs in the direction the force is applied.

c. Durability

Durability might be defined as the ability to maintain satisfactory performance over and extended service life. The design service life of most buildings is often 30 years, although buildings often last 50 to 100 years. Most concrete buildings are demolished due to obsolescence rather than deterioration. Different concretes require different degrees of durability depending on the exposure environment and properties desired. Appropriate concrete ingredients, mix proportions, finishes and curing practices can be adjusted on the basis of required durability of concrete.

d. **Shrinkage**

Shrinkage is the volume decrease of concrete caused by drying and chemical changes. In another word, the reduction of volume for the setting and hardening of concrete is defined as shrinkage.

e. **Modulus of Elasticity**

The modulus of Elasticity of concrete depends on the Modulus of Elasticity 0f the concrete ingredients and their mix proportions. As per ACI code, the modulus of Elasticity to be calculated using following equation:

$E = 33\omega \sqrt{f_c}$ (psi)

Where, ω = unit weight of concrete, Ib/ft^2

f_c = 28 days compressive strength of concrete

For normal weight concrete ($90Ib/ft^3$ to $160Ib/ft^3$), we assume that formula

$E = 57000\sqrt{f_c}$

f. **Water tightness**

Another property of concrete is water tightness. Sometime, it's called impermeability of concrete. Water tightness of concrete is directly related to the durability of concrete. The lesser the permeability, the more the durability of concrete.

2.2.3.6 Chemical properties of Portland cement

Concrete is a mixture of cement (commonly Portland cement), aggregates (gravel and sand), water and admixtures. (Joseph Aspdin, 1824) invented the modern cement which known as Portland cement. It is obtained by mixing together calcareous material, such as limestone or chalk ($CaCO_3$) and argillaceous materials such as clay or shale (SiO_2, AL_2O_3) at clinkering temperature (1500 °C) and girding the resulting clinker. The main compounds which form Portland cement are Tricalcium Silicate (C_3S) which represents 45-55% and it is responsible for early strength, Dicalcium Silicate (C_2S) which represents 20-25% and it is responsible for strength at later ages, Tricalcium Aluminate (C_3A) which represents 10-12% and it facilitates the combination of lime and silica, and Tetracalcium Aluminoferrite (C_4AF) which represents 4-8% and it accelerate the hydration of the silicates. Gypsum ($CaSO_4$) is added in small amounts during clinker grinding to control the setting time of the finished cement. When water is added to cement powder, a chemical reaction-referred to as hydration, takes place (in the paste formed) and a supersaturated solution of the hydrated compounds is formed which eventually coagulates to form an amorphous mass called gel. This is the reaction by virtue of which Portland cement becomes a bonding agent, the hydrated cement bonding firmly to the untreated cement any other aggregate or filler material present. A complete reaction of all the cement constituents with the main hydration productions as Tricalcium Disilicate ($3CaO.SiO_2.2H_2O$) is given below

• Tricalcium Silicate hydration

$2(3CaO.SiO_2) + 6H_2O \rightarrow 3CaO.2SiO_2.3H_2O = 3\ Ca\ (OH)_2$

• Dicalcium Silicate hydration

$2(2CaO.SiO_2) + 4H_2O \rightarrow 3CaO.2SiO_2.3H_2O + 3\ Ca(OH)_2$

• Tricalcium Aluminate hydration

$3CaO.\ Al_2O_3 + 6H_2O \rightarrow 3CaO.\ Al_2O_3.\ 6H_2O$

Ferric Oxide reacts with lime giving compounds analogous to those formed by Alumina; and the hydration reaction represented as follows:

$4CaO.Al_2O_3.\ Fe_2O_3 + 2Ca\ (OH)\ 2 + 10H_2O \rightarrow 3CaO.\ Al_2O_3.\ 6H_2O + 3CaO.\ Fe_2O_3.6H_2O$

The Aluminate components react only after all the gypsum added to clinker has reacted completely. When in contact with water, the gypsum reacts with aluminate compounds precipitating finally as calcium sulpho-aluminate as shown below;

$3CaO.\ Al_2O_3 + 3Ca\ SO_4 + 32H_2O \rightarrow 3CaO.\ Al_2O_3.3Ca\ SO_4.32H_2O$

The hardened cement paste consists of hydrates of the various compounds discussed above, crystals of Ca $(OH)_2$, some minor components, unhydrated cement and voids in form of gel pores and capillary pores. These voids are normally filled with water but become minimised as hydration proceeds and the products of hydration slowly deposited. The gel pores are approximately 15-20A° in diameter, while the capillary pores are estimated to be about 1.3 μm.

The grades of concrete refers to the ratio by which the ingredients of concrete i.e. cement, fine aggregate (sand) and coarse aggregate is mixed. The basic grades of concrete and its corresponding ratios of mix is shown in Table 2.2.

TABLE 2.2 CONCRETE GRADES, MIX RATIO AND CHARACTERISTIC STRENGTH.

CONCRETE GRADE	MIX RATIO	CHARACTERISTIC COMPRESSIVE STRENGTH ($\frac{N}{mm^2}$)
M-5	1:5:10	5
M-7.5	1:4:8	7.5
M-10	1:3:6	10
M-15	1:2:4	15
M-20	1:1.5:3	20
M-25	1:1:2	25
M-30	Designed	30
M-35	Designed	35
M-40	Designed	40

2.2.4 Curing

Curing plays an important role in reducing the permeability of concrete. This is particularly true for concrete containing supplementary materials as the dependence on curing increases with an increased replacement level of cement. Experiments done to determine the frost resistance of non-air-entrained high strength concrete containing silica fume reveal some shortcomings of ASTM C666, which recommends only 14 days of curing prior to first exposure to freezing and thawing cycles (Cohen et al, 1992).

According to (Thomas and Mathews, 2017), silica fumes and other pozzolanic materials may require much higher time for hydration and self-desiccation in order to cause a reduction in the amount of freezable water. It was found that the compressive strength of concrete with 50% fly ash was more adversely affected by inadequate curing.

(Ballim, 1993), suggested that increasing the duration of moist curing is a more effective way of extending the durability of concrete than increasing the cement content.

2.2.5 Pozzolan

2.2.5.1 Definition

A "pozzolan" is defined as "a siliceous or siliceous and aluminous material, which in itself possesses little or no cementing property, but will in a finely divided form - and in the presence of moisture - chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties." (Malhotra and Mehta, 1996.)

2.2.5.2 Origin of Pozzolan

The term pozzolan is derived from the name of the town Pozzuoli, Italy. It is situated near Mt. Vesuvius and is the place where the Romans more than 2,000 years ago mined the ashes deposited by the occasional eruptions of this volcano. Adding these ashes at a ratio of 2:1 to aged lime putty (aged 2+ years) they were able to construct those sturdy buildings we still admire today. Given this mineral origin, some purists consider only volcanic ashes, pumice, tuffs, etc. as pozzolans (Spence et al., 1983). But as the ashes of organic origin, like pulverized fuel ashes (PFA, mostly coal ashes) and rice hull ashes (RHA) also show enhancing properties when mixed with cement or lime, most of the times the origin is irrelevant. What counts are the properties, primarily particle size and purity (absence of carbon), and the results (Schneider et al., 2011).

2.2.5.3 Benefits of Pozzolans

Pozzolans not only strengthen and seal the concrete, they have many other beneficial features you will realize the moment you purchase them or add them to the mix. All of the below benefits apply to fly ash and rice husk ash, and most of them to silica fume as well.

Spherical Shape: Fly ash (FA) and rice hull ash (RHA) particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures.

Ball Bearing Effect: The "ball-bearing" effect of FA and RHA particles creates a lubricating action when concrete is in its plastic state.

Economic Savings: Pozzolans replace higher volumes of the more costly cement, with typically less cost per volume.

Higher Strength: Pozzolans continue to combine with free lime, increasing structural strength over time.

Decreased Permeability: Increased density and long-term pozzolanic action, which ties up free lime, results in fewer bleed channels and decreases permeability.

Increased Durability: Dense pozzolan concrete helps keep aggressive compounds on the surface, where destructive action is lessened. Pozzolan concrete is also more resistant to attack by sulfate, mild acid, soft (lime-hungry) water, and seawater.

Reduced Sulfate Attack: Pozzolans tie up free lime that otherwise could combine with sulfate to create destructive expansion.

Reduced Efflorescence: Pozzolans chemically bind free lime and salts that can create efflorescence. Denser concrete, due to pozzolans, holds efflorescence-producing compounds on the inside.

Reduced Shrinkage: The largest contributor to drying shrinkage is water content. The lubricating action of FA and RHA reduces the need for water and therefore also drying shrinkage.

Reduced Volume: As pozzolans can in certain cases substitute for up to four times the mass of cement, besides making the same amount of concrete harder than without pozzolans, less voluminous structures are able to bear the same load.

Reduced Heat of Hydration: The pozzolanic reaction between pozzolan and lime generates less heat, resulting in reduced thermal cracking when pozzolans are used to replace portland cement.

Reduced Alkali Silica Reactivity: Pozzolans combine with alkalis from cement that might otherwise combine with silica from aggregates, which would cause potentially destructive expansion.

Workability: Concrete enhanced with FA and RHA is easier to place, with less effort, responding better to vibration to fill forms more completely.

Ease of Pumping: Pumping of FA and RHA concrete requires less energy, therefore longer pumping distances are possible.

Improved Finishing: Sharp, clear architectural definition is easier to achieve with FA and RHA concrete, with less worry about in-place integrity.

Reduced Bleeding: Fewer bleed channels decreases porosity and chemical attack. Bleed streaking is reduced for architectural finishes. Improved paste to aggregate contact results in enhanced bond strengths.

Reduced Segregation: Improved cohesiveness of pozzolan concrete reduces segregation that otherwise could lead to rock pockets and blemishes.

Reduced Slump Loss: More dependable concrete allows for longer working time - especially important in hot weather.

Very low Chloride Ion Diffusion: Pozzolans make concrete more resistant to salt water (seawater).

Improved Water Tightness: The formation of expansive gels effectively seals the concrete.

Resistance to Freeze-Thaw: As water doesn't penetrate the hardened concrete, freezing can't cause destructive expansion.

Resistance to Adverse Chemical Reactions: The example of Dynastone shows how pozzolans can protect against strong acids.

CHAPTER 3
METHODOLOGY

2.1 Materials and Methods

3.2 Materials Design and Preparation

3.2.1 Ripe Plantain

One of the materials used was peel of ripe plantain which was gotten from a ripe plantain as shown in Figure 3.1.

Figure 3.1 Ripe Plantain

3.2.2 Unripe Plantain

Unripe plantain peel was gotten from unripe plantain. (See Figure 3.2)

Figure 3.2 Unripe Plantain

3.2.3 Extracting and Sun drying the peel

After getting the peels, it was chopped with knife into pieces. It was sundried for two weeks as shown in Plate 3.1

Plate 3.1 Sun-dried Plantain peels

3.2.4 Burning of Peel

The plantain peels (ripe and unripe) were burnt to ash in a furnace (Plate 3.2) at a temperature of $650^{\circ}c$.

Plate 3.2 Burning of peel in a furnace (pit)

3.2.5 Plantain Peel Ash

The plantain peel (ripe and unripe) ash was gotten from burning the peels. (Plate 3.3)

Plate 3.3 Plantain peel ash

3.2.6 Cement

As cement is the major component of concrete and usually has relatively low unit cost, the selection of its proper type and use has vital importance in obtaining the balance of its desired properties in most economical way for any particular concrete mix.

Type I/II Portland cements, which can provide sufficient levels of strength and durability, are the most common cements used by concrete users. The selection involves the exact knowledge of the connection between cement and performance required and, in particular, between kind of cement and either strength or durability or both the properties of concrete (Lea, 1970).

3.2.7 Fine Aggregate

The material, which passes 3/16" B.S. sieve size, is termed as fine aggregate. Natural sand is the fine aggregate chiefly used in concrete mix. Sand may be obtained from sea, river, lake, etc, but when used in a concrete mix, it should be properly washed and tested to ascertain that it is free from clay, silt, and such organic matters. Commonly used fine aggregate in R.C.C. work is sand. It is either round or angular in grains and is often found mixed in various gradation of fineness. The sand used for mortars should consist of sharp (angular) grains of various sizes. It is generally considered that rounded particles (grain), do not interlock sufficiently to produces strong mortars. This is defined according to ASTM Standard C 33-03

3.2.8 Coarse Aggregate

According to ASTM Standard C 33-03, Crushed hard stone and gravel are the common materials used as coarse aggregate for structural concrete. Coarse aggregate is usually obtained by crushing granites, gneiss, crystalline limestone and good variety of sand stone, etc.

The material whose particles are of such size as are retained on a 3/16" in B.S. test sieve, is termed as coarse aggregate. The maximum size may be 20 cm (9") for mass concrete work, such as dams etc, and 62.5mm (2.5") for plain concrete work. For R.C.C. Construction, the maximum is (1") although 20mm (0.75") of aggregate is commonly adopted. The size of the coarse aggregate used was 20mm. (Plate 3.4).

Plate 3.4 Coarse aggregate (granite)

3.3 Equipment

The equipment for the various tests include Slump cone, Compression testing machine, wooden moulds, rammer, weighing balance, Shovel and Head-pan.

3.4 Methods

It includes;

1. Collection of plantain peel (ripe and unripe).
2. Sun drying of the peel.
3. Preparation of the plantain peel ash.
4. Preparation of cement, coarse and fine aggregate.
5. Mixing of concrete using a mix ratio of 1:2:4.
6. Mixing of concrete with Ripe plantain and Unripe plantain peel ash (RPPA & UPPA) as an admixture in the proportion of 1.5% and 2.5%. 0% of RPPA & UPPA in the concrete as a control sample.
7. Casting the concrete in a wooden mould.
8. Determination of the workability of the freshly cast concrete.
9. Removal of the mould after 24 hours.
10. Curing of the concrete for curing age 7, 14, 21 and 28 days.
11. Determination of the compressive strength of the concrete.

3.5 Mixing and Proportioning of Concrete

3.5.1 Preliminary Information

Mix ratio - 1:2:4

Concrete Grade - M-15

Water-Cement ratio - 0.7

No of cubes per sample = 3

No of curing Days = 4 (i.e. 7, 14, 21, and 28 days)

No of proportioning = 3 (i.e. 2 for RPPA, 2 UPPA and 1 control. i.e. 0%, 1.5%, 2.5%)

Total number of cubes = 40 cubes (16 containing RPPA, 16 containing UPPA and 8 control)

3.5.2 Mix Design Calculations

Volume of a cube $= (0.15^3) \times 1 = 0.003375m^3$

Concrete Density $\rho = 2400\frac{Kg}{m^3}$

Density $\rho = \frac{mass}{volume}\frac{m}{v}$

Mass = Density $\rho \times$ Volume v

$= 2400kg/m^3 \times 0.003375m^3 = 8.1kg$

Total Mass = $8.1 \times 40 = 324$ Kg

Weight of each concrete constituent

1. Cement: $\frac{1}{7} \times 324\ kg = 46.3kg$
2. Sand: $\frac{2}{7} \times 324\ kg = 92.6kg$
3. Granite: $\frac{4}{7} \times 324\ kg = 185.1kg$

TABLE 3.1Mix design Schedule (RPPA & UPPA)

Proportion (%)	Binder(kg)		Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (kg)	Number of cubes
	Cement	RPPA				
Control (0)	9.25	0	18.5	37	6.5	8
1.5	9.25	0.75	18.5	37	6.5	8
2.5	9.25	1.25	18.5	37	6.5	8
	Cement	UPPA				
1.5	9.25	0.75	18.5	37	6.5	8
2.5	9.25	1.25	18.5	37	6.5	8
TOTAL	**46.25**	**4.0**	**92.5**	**185**	**32.5**	**40**

3.5.3 Estimates

Number of cement bag = $\frac{46.3}{50} = 0.93$ Bags, approximately 1 bag of cement.

Number of bag of sand (cement Bag) = $\frac{92.6}{50} = 1.8$ Bags, approximately 2 bags.

Number of Bag of Granite = $\frac{185}{50} = 3.7$ Bags, approximately 4 bags.

3.6 Casting of Specimens

The wooden moulds of dimension 150mm x150mm x 150mm (Plate 3.5) was used, with an engine oil which was rubbed at the inner surface of the mould so as to give a lubricating effect between the mould and the concrete after it has harden for easy removal. The mould was put at a levelled and smooth surface so as to give the cubes a smooth base. The weight of each of the constituents were taken. (Plate 3.6 & Plate 3.7). Mixing of the concrete (Plate 3.8) was done afterwards.

Plate 3.5 Wooden moulds

Plate 3.6 Weighing coarse aggregate (granite)

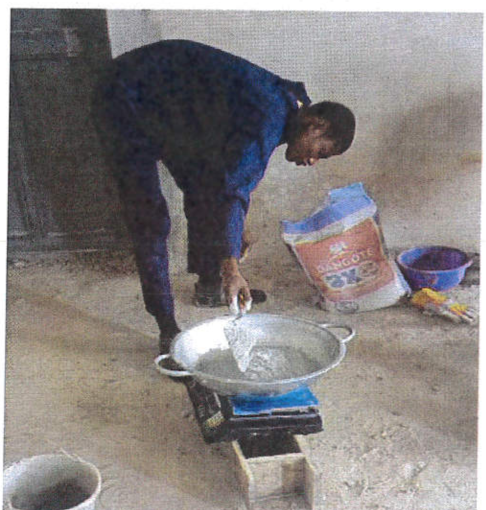

Plate 3.7 Weighing of cement

Plate 3.8 Mixing of Concrete

Concrete was poured into the moulds in three layers in such a way that each pouring was approximately equivalent with the height of the mould divided into three. Then each layer poured was compacted (Plate 3.9) using a tamping rod so as to give proper locking of the concrete and also to reduce the honeycomb due to improper compaction, each layer was tamped 25 times, equally distributed throughout the surface of the layer.

Plate 3.9 Tampering of concrete

At the last layer the concrete was poured above the height of the mould before compacting it so as to provide a sufficient level of concrete, excess concrete was then scraped off from the surface using a hand trowel, so as to give a proper levelling with the top of the mould. The surface of the cast cube was smoothening to provide a smooth surface. The proportion of the RPPA & UPPA present in the concrete and the date of casting was inscribed on the concrete (Plate 3.10). The cubes was removed after twenty-four hours to be cured for different day intervals.

Plate 3.10 Labelling concrete cube

Table 3.2 Casting Schedule of the cubes

DAY	PROPORTION	DATE	NO. OF CUBES
1	**0% (CONTROL)** **1.5% (UPPA)** **2.5% (UPPA)** **1.5% (RPPA)**	**08/07**	**32**
2	**1.5% (RPPA)**	**10/07**	**8**

3.6 Compressive strength test

Since the major aim of this research is to determine the strength characteristic of the concrete with Ripe plantain and Unripe plantain peel ash (RPPA & UPPA) used as an admixture to cement and to check the strength variation between the two (that is, with

RPPA & UPPA), hence this aspect was a major process or procedure in this research work

The term compressive strength is the capacity of material or structure to withstand axially directed forces. This is a test in which a batch of concrete will be tested for strength and durability. The specimens were tested by compression testing machine after 7 days, 14 days, 21 and 28 days curing. Load was applied gradually till the Specimens fails. The compressive strength of the concrete will be determined using the formulae below.

$$\text{Compressive strength (N/mm}^2\text{)} = \frac{\text{Ultimate compressive load (N)}}{\text{Area of cross section of specimen (mm}^2\text{)}}$$

Procedure

The crushing procedures are shown in Plate 3.11 to Plate 3.13.

- The specimens were removed from water after specified curing time and wiped off of excess water from the surface.
- The weight of each of the specimen was taken using weighing balance.
- The bearing surface of the testing machine was cleaned.
- The specimen were placed in the machine such that the load was applied to the opposite side of the cube cast.
- The specimen were aligned centrally on the base plate of the machine.
- Load was applied gradually till the specimen fails.
- The maximum load was recorded as at when failure occurred to the specimen.

Plate 3.11Weighing of Concrete cube

Plate 3.12 Crushing of cube

Plate 3.13 Failure occurring to cube during Crushing

3.7 Workability (Slump Test)

The slump test is a means of assessing the consistency of fresh concrete. It is used, indirectly, as a means of checking that the correct amount of water has been added to the mix. The test was carried out in accordance with BS EN 12350-2. The test is popular due to the simplicity of apparatus used and simple procedure.

Procedure

The test was carried out using a metal mould in the shape of a conical frustrum known as a slump cone which is opened at both ends and has an attached handle. The tool typically has an internal diameter of 100mm at the top and 200mm at the bottom with a height of 300mm. The cone was filled with fresh concrete in three stages. Each time, each layer was tamped 25 times with a 600 mm long bullet-nosed metal rod measuring 16mm in diameter as shown in Plate 3.14. At the end of the third stage, the concrete was struck off flush with the top of the cone. The cone was carefully lifted vertically upwards with twisting motion (Plate 3.15), so as not to disturb the concrete cone. The upturned slump cone was placed on the base to act as a reference, and the difference in level between its top and the top of the concrete was measured (Plate 3.16) and recorded to the nearest 5 mm to give the slump of the concrete. When the cone was removed, the slump may take one of three forms. In a true slump the concrete simply subsides, keeping more or less to shape. In a shear slump the top portion of the concrete shears off and slips sideways.

Apparatus used;

- Slump cone
- Tamping rod
- Concrete
- Hand Trowel
- Measuring Tape

Plate 3.14 Tampering of concrete

Plate 3.15 Lifting of slump cone

Plate 3.16 Measuring of slump

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 General

The results from the tests are discussed in this chapter. The tables and figures in this chapter shows the results of the tests. The details of the results are discussed below.

4.2 Chemical Analysis

Table 4.1: Chemical Composition of RPPA & UPPA

S/N	CHEMICAL COMPOSITION (%)	LEVELS DETECTED		Portland Cement (%)
		RPPA	UPPA	
1	CaO	3.162	4.067	60-67
2	SiO_2	46.367	54.000	17-25
3	Al_2O_3	2.197	3.080	3-8
4	MgO	5.887	6.633	0.1-4
5	Fe_2O_3	1.861	2.887	0.5-6
6	SO_3	0.505	0.583	1-3

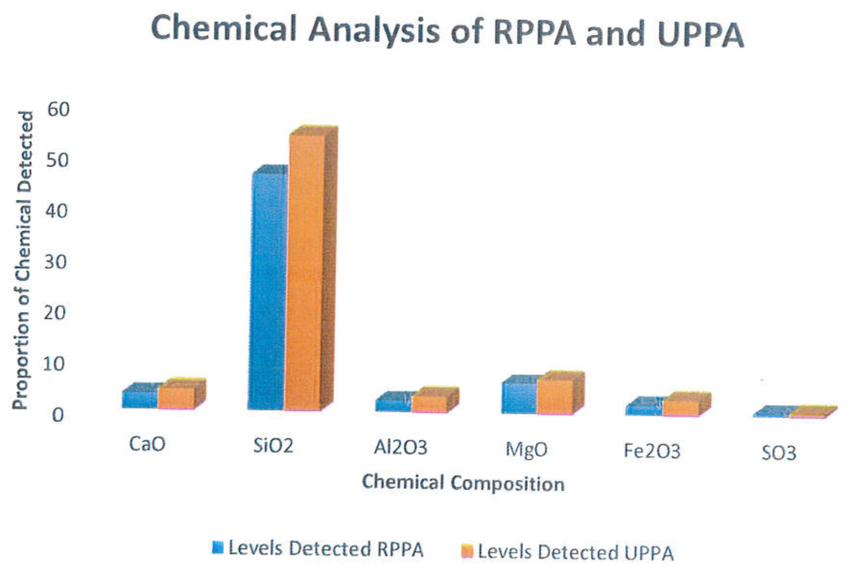

Figure 4.1: Comparison between Chemical composition of RPPA and UPPA

The results of the chemical composition analysis of the pozzolanic material used (RPPA) & (UPPA) are listed in Table 4.1. RPPA contained lesser amount of all the chemicals present in the pozzolanic material used. A relatively low content of SiO_2+Al_2O_3 could also indicate the acidic nature of the pozzolanic material.

The concept had been declared that the most important composition of pozzolan is SiO2 and it can provide contributions to pozzolanic activity in non-crystalline form (Alp *et al.*, 2009). The chemical composition of natural pozzolan is stated as 50–67% SiO2 in the German standards (DIN 51043).

The Ripe Plantain Peel Ash (RPPA) investigated contained a lesser proportion of SiO_2 than required by this standard, which implies that it may hinder the potential for SiO_2 activity to actuate the pozzolanic activity during second hydration reaction.

(Rodriguez-Camacho and Uribe-Afif, 2002) examined the performance of nine natural pozzolan in Mexican, they found that the pozzolan with 11.6-14.7% alumina was highly resistant to sulphate attack. In this regard, the materials used in this study could be expected to produce a lesser resistance to sulphate attack when used as an admixture in the cement-based composite.

4.3 Workability Test

From Table 4.2, it can be observed that the increase in the admixture of UPPA increases the slump value of concrete, while for RPPA, the slump value reduces but the slump values of both RPPA & UPPA are both higher than the control (0%). The result of the slump test as shown in Plate 4.1, gave a true slump.

Table 4.2 Effect of RPPA and UPPA on workability of Concrete (slump test)

Proportion (%)	Control (0%)	UPPA (1.5%)	UPPA (2.5%)	RPPA (1.5%)	RPPA (2.5%)
Slump Value (mm)	20	25	26	24	26

Plate 4.1 Concrete Slump (True slump)

4.4 Weight and Compressive strength of Concrete Cubes

Table 4.3 Weight and compressive strength of concrete (control) at 7, 14, 21 and 28 days

Age (days)	7	14	21	28
Weight (Kg)	8.65	8.25	8.15	8.23
Compressive strength (N/mm^2)	12.89	8.95	17.75	22.39

Table 4.4 Weight and compressive strength of concrete at 1.5% RPPA for 7, 14, 21 and 28 days

Age (days)	7	14	21	28
Weight (Kg)	7.60	7.60	8.13	8.00
Compressive strength (N/mm^2)	7.53	7.33	11.14	14.28

Table 4.5 Weight and compressive strength of concrete at 2.5% RPPA for 7, 14, 21 and 28 days

Age (days)	7	14	21	28
Weight (Kg)	8.25	8.13	7.95	8.20
Compressive strength (N/mm^2)	8.79	9.20	10.44	11.95

Table 4.6 Weight and compressive strength of concrete at 1.5% UPPA for 7, 14, 21 and 28 days

Age (days)	7	14	21	28
Weight (Kg)	8.23	7.93	8.00	8.03
Compressive strength (N/mm^2)	8.84	9.30	11.05	12.41

Table 4.7 Weight and compressive strength of concrete at 2.5% UPPA for 7, 14, 21 and 28 days

Age (days)	7	14	21	28
Weight (Kg)	7.63	8.18	8.08	8.20
Compressive strength (N/mm^2)	6.24	6.90	9.08	10.23

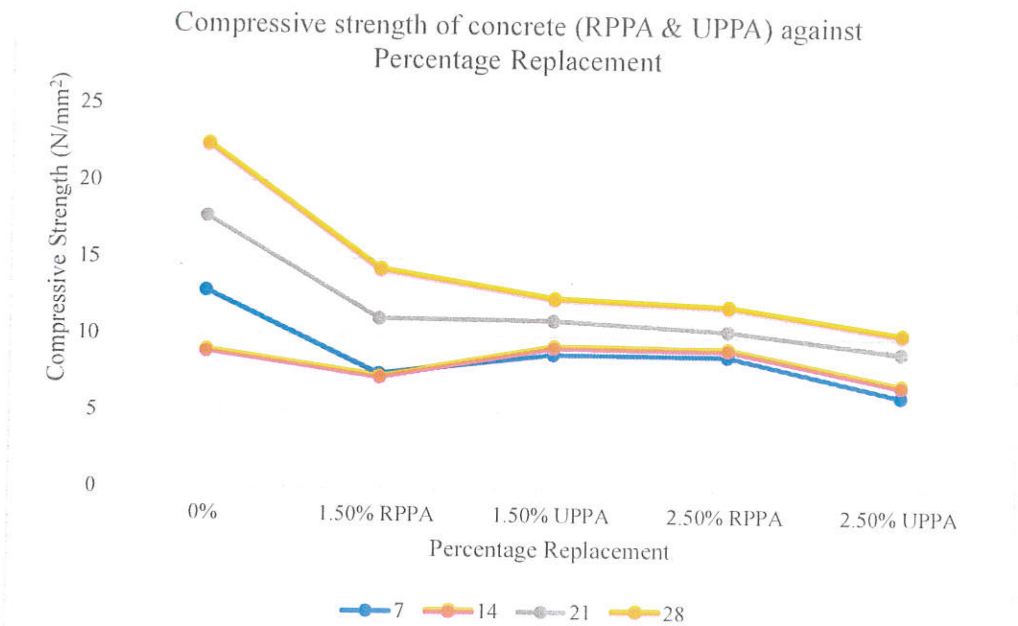

Figure 4.2: Compressive strength of concrete with different proportion of RPPA & UPPA

In Figure 4.2 shown above, the change in the compressive strength for concrete with different proportion of RPPA & UPPA as admixture is presented and the following observations were made; the compressive strength of the concrete decreases as the proportion of both RPPA & UPPA is increased in the concrete. Hence there was significant difference in the compressive strength compared with the control.

With respect to the curing age of concrete. For RPPA, as the number of curing days increases, the compressive strength increases with reduced proportion. Same goes for UPPA, as the number of curing days increases, the compressive strength increases with reduced proportion.

4.5 Density of Concrete Specimens with RPPA & UPPA

The density of concrete with different proportion of RPPA considered at different curing age is shown Table 4.8 and the chat depicting the value is shown in Figure 4.3.

Table 4.8 Density of concrete with different proportion of RPPA & UPPA at various age

Curing Age (days)	Proportion RPPA	Density (Kg/m^3)	Proportion UPPA	Density (Kg/m^3)
7	0	**2488.88**		
	1.5	**2251.85**	1.5	**2438.52**
	2.5	**2444.44**	2.5	**2260.74**
14	0	**2444.44**		
	1.5	**2251.85**	1.5	**2349.63**
	2.5	**2408.89**	2.5	**2423.70**
21	0	**2414.81**		
	1.5	**2408.89**	1.5	**2370.37**
	2.5	**2355.65**	2.5	**2394.07**
28	0	**2438.52**		
	1.5	**2370.37**	1.5	**2379.26**
	2.5	**2429.63**	2.5	**2429.63**

It was discovered that the density decreases with increase in the amount of RPPA in the concrete for 0% to 1.5%, and later increases at 2.5%. This pattern of change in density occurred for all the number of curing days. The minimum density was 2251.85 for 1.50% percentage admixture and the maximum density which is 2488.88kg/m^3 occurs at 0% percentage admixture (control).

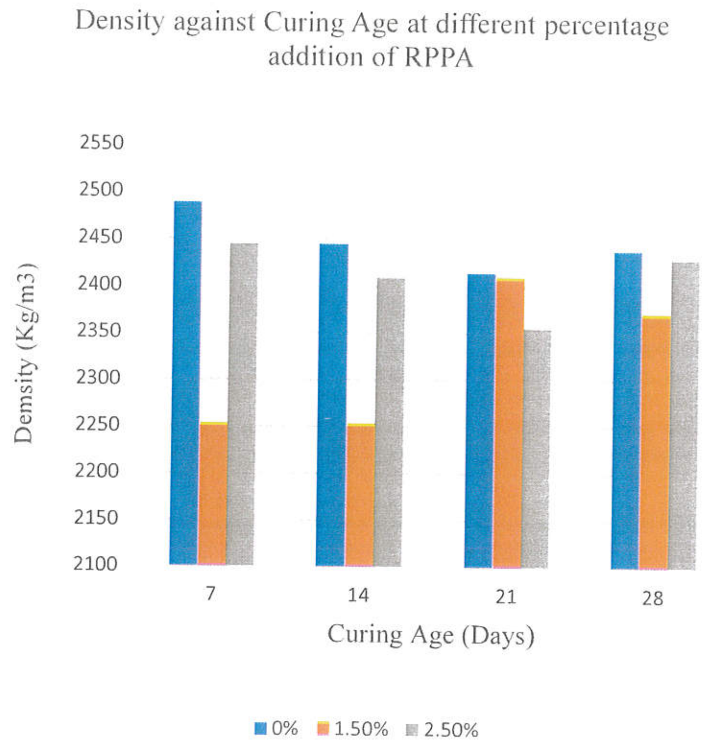

Figure 4.3 Density of concrete with different proportion of RPPA at various age

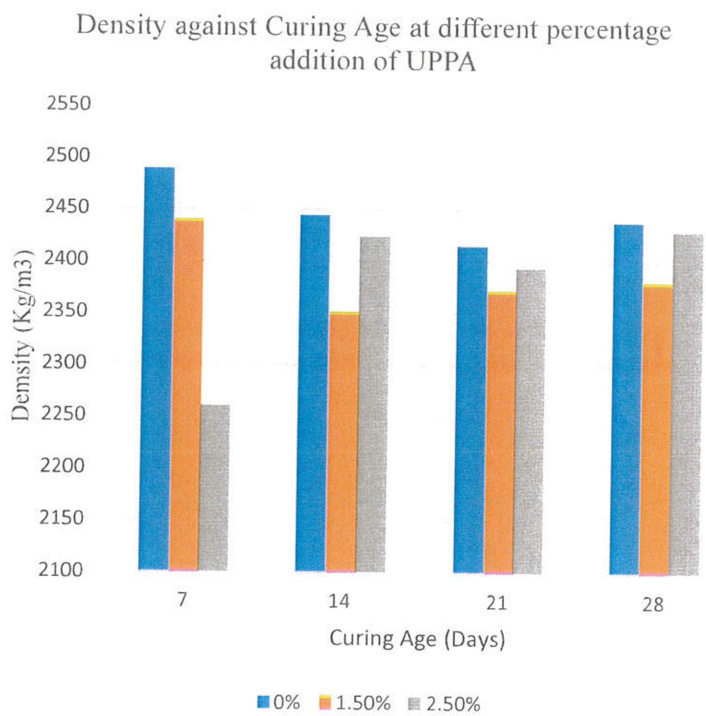

Figure 4.4 Density of concrete with different proportion of UPPA at various age

The density of concrete with different proportion of UPPA considered at different curing age is shown in Figure 4.4. It was discovered that the density decreases with increase in the amount of UPPA for proportion of 0% & 1.50% and later increased at 2.5% in the concrete. This pattern of change in density occurred for all the curing days except for 7 days curing. The minimum density was 2260.74 for 2.50% percentage admixture and the maximum density which is 2488.88kg/m^3 occurs at 0% percentage admixture (control).

Also, considering the three types of concrete based on density which are: Lightweight, Normal weight and Heavy Weight Concrete, from the knowledge that concrete having densities in the range of 300 – 1950kg/m^3 are classified as lightweight concrete; those in the range of 2200 – 2400kg/m^3 as normal weight concrete, and concrete with densities greater than 2500 kg/m^3 are regarded as heavyweight concrete (Falade et al., 2011), and since all the concrete with different proportion percentage with different curing age ranges in densities between 2251 and 2400kg/m^3, the concrete are classified as a Normal weight concrete and this helps in the optimization of concrete density to improve structural efficiency (the strength to density ratio) & reduce transportation costs.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the findings of this study, the following conclusions were drawn;

1. Compressive strength of the concrete decreased as the proportion of both RPPA & UPPA is increased in the concrete. Hence there was significant difference in the compressive strength compared with the control. It can be concluded that both Ripe Plantain Peel Ash (RPPA) and Unripe Plantain Peel Ash (UPPA) can be classified as admixtures that reduces the strength of concrete.

   From Table 4.4 and Table 4.6, RPPA has a higher compressive strength than UPPA at 28 days curing with proportion of 1.5%. Also, from Table 4.5 and Table 4.7, the compressive strength of RPPA is higher than UPPA at 28 days curing with proportion of 2.5%.

2. Due to the addition of both Ripe Plantain Peel Ash (RPPA) and Unripe Plantain Peel Ash (UPPA), the workability of the concrete increases.

3. The density of concrete with different proportion of RPPA and UPPA ranges between densities of 2240 and 2400kg/m^3 and are classified as a Normal weight concrete and this helps in the optimization of concrete density to improve structural efficiency (the strength to density ratio), reduce transportation costs, and also enhance the hydration of high-cementitious concrete mixtures with low water-binder ratios.

4. Ripe Plantain Peel Ash (RPPA) contained lesser percentage of Silica (SiO_2) & Alumina (Al_2O_3) compared to Unripe Plantain Peel Ash (UPPA). The chemical composition of natural pozzolan is stated as 50–67% SiO2 in the German standards (DIN 51043).

   The Ripe Plantain Peel Ash (RPPA) investigated contained lesser proportion of Silica (SiO_2) than required by the standard, which implies that it may hinder the potential for Silica (SiO_2) activity to actuate the pozzolanic activity during second hydration reaction. While the Unripe Plantain Peel Ash (UPPA) contained closer to the required proportion of Silica (SiO_2), which implies that it may not hinder the potential for Silica

(SiO_2) activity to actuate the pozzolanic activity during second hydration reaction.

5.2 Recommendation

From the findings of the research, Ripe Plantain Peel Ash (RPPA) & Unripe Plantain Peel Ash (UPPA) should only be used in compressive strength of concrete as admixtures that decreases the strength of concrete.

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