THE INFLUENCE OF BANANA STEM ASH AND OIL PALM STEM ASH ON THE STRENGTH CHARACTERISTICS OF CONCRETE

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CERTIFICATION

This is to certify that the research project on “THE INFLUENCE OF BANANA STEM ASH AND OIL PALM STEM ASH ON THE STRENGTH CHARACTERISTICS OF CONCRETE” was carried out by Obi Ifeanyi Kelvin with registration number (NAU/2017224004) of the department of civil engineering in partial fulfilment of the requirement for the award of Bachelor’s Degree in Civil Engineering, Nnamdi Azikiwe University, Awka, under the supervision of Engr. Prof. Aginam Chukwurah Henry of Department of Civil Engineering, Nnamdi Azikiwe University, Awka. This work has never been submitted either in part or in full for any degree in any university.

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APPROVAL PAGE

This research thesis on "The influence of banana stem ash and oil palm stem ash on the strength characteristics of concrete" was carried out by Obi Ifeanyi Kelvin with registration number (NAU/2017224004) has satisfied all the requirements of this university for the award of Bachelor's Degree (B.Eng) in Civil Engineering, Nnamdi Azikiwe University, Awka.

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DEDICATION

This research is solely dedicated to God Almighty, who gives the knowledge, wisdom and understanding, who saw me through these years and has provided and protected me, my family, lecturers, friends and well-wishers.

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ABSTRACT

This research addresses a comparative study on the influence of banana stem ash and oil palm stem ash on the strength characteristics of concrete, using substitution of banana stem ash and oil palm stem ash to know if there will be an increase or decrease in the compressive strength of concrete. Banana stem ash and oil palm stem ash were prepared by open control burning, grinded and substituted with cement at 0%, 2.5%, 5%, 7.5%, and 10% respectively, with a mix ratio of 1:2:4 at a constant water-cement ratio of 0.55. The compressive strength, particle size distribution and workability test of these concrete specimens were extensively studied. Compressive strength of 28 days curing with substitute of BSA to cement gives 26.2N/mm^2 at 2.5% of ash substitute. Compressive strength of 28 days curing with substitute of BSA to cement gives 26.9N/mm^2 at 10% of ash substitute and it is observed that the strength is increased than the conventional concrete. Compressive strength of 28 days curing with substitute of OPSA to cement gives 26.3N/mm^2 at 2.5% of ash substitute and it is observed that the strength is increased than conventional concrete. Compressive strength of 28 days curing with substitute of OPSA to cement gives 27.1N/mm^2 at 10% of ash substitute and it is observed that the strength is increased than conventional concrete. The compressive strength increased with an increase in the proportion of BSA and OPSA; therefore, the control mix (10% BSA & 10% OPSA) gave the highest strength gain. Thus, from the results obtained, it can be concluded that the use of BSA and OPSA as supplementary materials make for increase in concrete strength properties.

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CHAPTER ONE

INTRODUCTION

1.1 Background of study

Concrete is the most versatile and most widely used construction material worldwide. According to Smith (2018), concrete possesses excellent compressive strength, making it suitable for load-bearing structures as foundations and columns. It is the most used construction material these days because of its numerous merits which encircle but are not limited to its moldability, adaptable nature, fire resistance, and affordability. Concrete is used in many types of construction like houses, roads, bridges, hospitals and commercial centers, etc. Concrete is a combination of cement, coarse aggregate, fine aggregate, water, and admixtures. With the rise in demand for other basic needs of human-like clothing, energy, food, and water. Due to the large use of concrete, the demand of cement is also increasing with every passing day. The production of cement is very hazardous to the environment as it produces heat and an excessive amount of CO_2. Carbon dioxide emissions are a serious environmental problem in cement production. It is a well-known fact that the production of one-ton cement exhaust around one ton of carbon dioxide directly into the atmosphere. Similarly, the materials required to produce the cement also pollute the environment and cause the depletion of our natural resources. Other constituents of concrete can also pollute the environment like coarse aggregates, which are obtained by cutting and blasting of hills and mountains. Previously, most of the researchers have already worked a lot to reduce the use of concrete and replace concrete with such suitable materials, which give the properties like the concrete. The emphasis is being put forth on the utilization of industrial and agricultural wastes, as they are the environmental burden. The ash produced from various types of agricultural waste can be used effectively as a partial replacement of cement.

Furthermore, in a study by Johnson and Lee (2021), it was found that incorporating additives and admixtures can enhance the performance and durability of concrete. The use of agricultural waste materials, such as Banana stem ash, And Oil palm stem ash as supplementary cementing materials in concrete has gained attention in recent years due to the potential for reducing the environmental impact of concrete production. These materials are rich in silica and alumina, which are important components of cement. The use of these materials in concrete can improve the strength characteristics of concrete, as well as make it more durable and resistant to certain types of deterioration. This can be beneficial for construction projects in region where these materials are readily available. Studies have shown that these materials can also reduce the cost of concrete production, making it more affordable. Overall, research on the effects of Banana stem ash, and Oil palm stem ash on the strength characteristics of concrete is ongoing, but it has shown promising results so far.

1.2 Statement of the problem

Agricultural waste is usually treated by backfilling or open burning, which results in pollution. This material is often used to improve the standard and properties of concrete by adding concrete admixture. It offers good resistance and durability. Economic performance is also an important factor for the use of agricultural waste. This study is conducted to overcome the problem of agricultural waste disposal and improving strength properties of concrete.

1.3 Aim and objectives

The aim of this study is to analyse the influence of Banana stem ash (BSA) and Oil palm stem ash on the strength characteristics of concrete.

The objectives include;

- To investigate the use of BSA and Oil Palm Stem Ash in concrete mixes to improve concrete structure performance.
- To evaluate the effectiveness of concrete and BSA and Oil Palm Stem Ash compared to conventional concrete mix.
- To examine the impact on compressive strength of concrete.

1.4 Scope of the work

The scope of this research work encompasses the use of Banana stem ash and Oil palm stem ash as supplementary cementing materials in concrete and their effects on the strength properties of concrete.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cement

Cement is a key construction material used in various infrastructure projects such as buildings, bridges, roads and dams. It is a fine powder made from a mixture of clay, limestone, and other materials that are heated to high temperatures to create a chemical reaction known as **Calcination**. The resulting substance is then ground into a fine powder and mixed with water to create a paste that can be used as a binding agent for construction materials such as concrete.

One of the major components of cement is clinker, which is produced by heating a mixture of limestone and clay to high temperatures. This process is known as the “wet process” and it is responsible for the majority of the emissions associated with cement production.

To address this issue of emissions, researchers have explored alternative cementitious materials to mitigate the environmental impact. For instance, Mehta and Siddique (2017) discuss the utilization of fly ash, a by product of coal combustion, as a supplementary cementitious material due to its pozzolanic properties and potential for enhancing concrete performance.

2.1.1 Physical properties of cement

The physical properties of cement include its fineness, density, setting time, and soundness, among others.

- **Fineness**: Fineness or particle size of Portland cement affects Hydration rate and thus the rate of strength gain. The smaller the particle size, the greater the surface area-to-volume ratio, and thus, the more area available for water-cement interaction per unit volume. The effects of greater fineness on strength are generally seen during the first seven days. When the cement particles are coarser, hydration starts on the surface of the particles. So, the coarser particles may not be completely hydrated. This causes low strength and low durability. For a rapid development of strength, a high fineness is necessary (Mehta and Monteiro, 2013).
- **Density**: The density of cement is an important factor that affects its handling and transport, as well as its performance in concrete. Cements with higher densities are typically more difficult to handle and transport, but they can lead to higher strength development in concrete.
- **Setting time**: Cement paste setting time is affected by a number of items including: cement fineness, water-cement ratio, chemical content (especially gypsum content) and admixtures. Setting tests are used to characterize how a particular cement paste sets. For construction purposes, the initial set must not be too soon and the final set must not be too late.

  Initial set occurs when the paste begins to stiffen considerably, while, the Final set occurs when the cement has hardened to the point at which it can sustain some load.

Setting is mainly caused by C3A and C3S and results in temperature rise in the cement paste.
In False set, no heat is and the concrete can be re-mixed without adding water
Flash Set is due to absence of Gypsum. Specifically used for under water repair.

- **Soundness**: Soundness is a measure of the cement's ability to retain its volume without excessive expansion. This property is important because excessive expansion can lead to cracking and reduced strength in concrete.
- **Strength**: Cement paste strength is typically defined in three ways: compressive, tensile and flexural. These strengths can be affected by a number of items including: water cement ratio, cement-fine aggregate ratio, type and grading of fine aggregate, curing conditions, size and shape of specimen, loading conditions and age.
  The compressive strength of cement is the ability of the hardened cement paste to resist compressive stress. It is an important property that affects the performance of concrete structures (Mehta and Monteiro, 2013).

Overall, the physical properties of cement play a critical role in determining the performance of concrete and the final structure. These properties are interrelated and should be considered together when selecting cement for a particular application.

2.2 Water

Water is an essential component in the production of cement and concrete. When mixed with cement, water initiates a chemical reaction known as hydration, which results in the formation of strong, durable concrete. The amount of water used in the production of cement and concrete is known as the water-to-cement ratio. This ration is a critical factor that affects the strength and durability of concrete.

Too little water can result in a dry and crumbly mix that is difficult to work with, while too much water can lead to a weak and porous concrete that is prone to cracking and damage. The water-to-cement ratio is typically between 0.35 and 0.45 for normal concrete, and it should be adjusted based on the specific application and the characteristics of the cement and aggregate used.

2.3 Aggregates

Aggregates are materials that are added to cement to create concrete. They can be made of a variety of materials such as crushed stone, gravel, sand, and recycled concrete. The type and size of aggregate used can affect the properties of the resulting concrete, such as its strength, durability, and workability.

The use of different types of aggregates in concrete can affect the workability of the mix. For example, using larger aggregate can lead to a more cohesive and workable mix, while using smaller aggregate can lead to a more fluid and easy-to-work-with mix. The size and shape of the aggregate also affect the properties of concrete, such as its compressive strength and porosity, and its resistance to abrasion and impact.

The use of recycled aggregates in concrete can also have a significant impact on the sustainability of cement and concrete production. Recycling aggregates can reduce the demand for virgin materials, lower greenhouse gas emissions, and reduce waste sent to landfills.

Overall, aggregates are an important component in the production of concrete, and the type and size of aggregate used can affect the properties of the resulting concrete. The use of different types of aggregates and recycled aggregates can also have a significant impact on the sustainability of cement and concrete production.

2.3.1 Qualities of aggregates

Aggregates play a critical role in determining the properties of the resulting concrete. The quality of aggregates is determined by several factors, including:

- **Gradation**: Gradation is the distribution of aggregate particle sizes within a given sample. A well-graded aggregate will have a wide range of particle sizes, which can lead to better workability and improved strength in concrete.
- **Shape**: The shape of the aggregate can affect the workability and strength of concrete. Angular or elongated aggregate particles can lead to a more cohesive mix and improved strength, while rounded or smooth particles can lead to a less cohesive mix and reduced strength (Bhattacharjee, 2017).
- **Durability**: Durable aggregates are resistant to weathering, abrasion, and chemical attack. They are less likely to break down or degrade over time, which can lead to improved durability and longevity of the resulting concrete.
- **Cleanliness**: Cleanliness refers to the absence of dust, clay and other contaminants that can affect the workability and strength of concrete. Clean aggregates will lead to a more cohesive mix and improved strength.
- **Specific Gravity**: The specific gravity of an aggregate represents the ratio of its weight to the weight of an equal volume of water. A higher specific gravity means that the aggregate is denser and will typically lead to stronger concrete.
- **Absorption**: The absorption of an aggregate represents the amount of water that it can absorb. Aggregates with low absorption rates will lead to less water being required in the mix and therefore a denser concrete (Provis and Van Deventer, 2008).
- **Soundness**: Soundness is the resistance of aggregate to weathering. Aggregates that are sound will withstand the effects of freezing and thawing without significant deterioration.

Overall, the quality of aggregates can have a significant impact on the properties of the resulting concrete, including its workability, strength, and durability. It is important to use high-quality aggregates that meet specific standards to ensure the best performance of the concrete (Bhattacharjee, 2017).

2.3.2 Types of aggregates

There are several types of aggregates that can be used in the production of concrete, including:

- **Natural Aggregates**: These are aggregates that are extracted from natural sources such as crushed stone (limestone, granite, and trap rock), sand and gravel. These aggregates are typically more durable and have a lower absorption rate than other types of aggregates.
- **Recycled Aggregates**: These are aggregates that are made from recycled materials such as crushed concrete and asphalt. These aggregates are becoming increasingly popular due to their environmental benefits, such as reducing the demand for virgin materials, lowering greenhouse gas emissions, and reducing waste sent to landfills.
- **Manufactured Aggregates**: These are aggregates that are manufactured from industrial by-products such as fly ash, slag and silica fume. These aggregates can be used as a partial replacement for cement and have been found to have a number of benefits such as reducing emissions, improving the strength and durability of concrete, and reducing the cost of cement production.
- **Expanded Clay, Shale and Slate**: These aggregates are lightweight aggregates that are made by heating clay, shale, or slate to high temperatures. These aggregates are used to reduce the weight of concrete, which can be beneficial in certain applications such as roofing and flooring (Provis and Van Deventer, 2008).

Each type of aggregate has its own unique characteristics and properties, and the choice of aggregate will depend on the specific requirements of the project and the desired properties of the resulting concrete. It is important to use high-quality aggregates that meets specific standards to ensure the best performance of the concrete.

2.3.2.1 Classification based on grain size

Aggregates can be classified based on their grain size into different categories:

- **Coarse Aggregates**: These are aggregates that have a particle size larger than 0.19 inches (4.75 mm). They include gravel, crushed stone and recycled concrete. Coarse aggregates are typically used for structural applications such as foundations, bridges and roads.
- **Fine Aggregates**: These are aggregates that have a particle size smaller than 0.19 inches (4.75 mm). they include sand, crushed stone and recycle concrete also. Fine aggregates are typically used for non-structural applications such as making mortar and plaster.
- **All-in Aggregates**: These are aggregates that include both coarse and fine particle sizes. They are used in applications that require both strength and workability.

- **Graded Aggregates**: This is a type of aggregate that has a specific distribution of particle sizes. The particle sizes are graded to meet specific requirements such as workability, strength and durability.

Each type of aggregate has its own unique characteristics and properties, and the choice of aggregate will depend on the specific requirements of the project and the desired properties of the resulting concrete. It is important to use high-quality aggregates that meet specific standards to ensure the best performance of the concrete.

2.3.2.2 Classification based on origin

Aggregates can also be classified based on their origin:

- **Natural Aggregates**: These are aggregates that are extracted from natural sources such as crushed stone (limestone, granite, and trap rock), sand and gravel. They are formed by natural processes such as weathering, erosion, and sedimentation and are commonly used in construction.
- **Artificial Aggregates**: These are aggregates that are manufactured from industrial by-products such as fly ash, slag and silica fume. They are made by processing the by-products of industries such as steel and power generation, and are typically used as a partial replacement for cement.
- **Recycled Aggregates**: These are aggregates that are made from recycled materials such as crushed concrete and asphalt. They are obtained from the recycling of construction and demolition waste and are becoming increasingly popular due to their environmental benefits, such as reducing the demand for virgin materials, lowering greenhouse gas emissions and reducing waste sent to landfills.

As stated earlier, each type of aggregate has its own unique characteristics and properties, and the choice of aggregate will depend on the specific requirements of the project and the desired properties of the resulting concrete. It cannot be overemphasized that it is important to use high-quality aggregates that meet specific standards to ensure the best performance of the concrete.

2.3.2.3 Classification based on density

Aggregates can also be classified based on their density:

- Lightweight Aggregates: These are aggregates that have a lower density than normal weight aggregates. They include materials such as expanded clay, shale and slate, which are made by heating clay, shale or slate to high temperatures. They are used to reduce the weight of concrete, which can be beneficial in certain applications such as roofing and flooring.
- Normal Weight Aggregates: These are aggregates that have a typical density of around 2400 kg/m^3. They include materials such as gravel, crushed stone and recycled concrete. They are commonly used in construction for their durability and strength.
- Heavyweight Aggregates: These are aggregates that have a higher density than normal weight aggregates. They include materials such as magnetite and hematite, which are used in applications that require radiation shielding and high-density concrete.

The choice of aggregate will depend on the specific requirements of the project, the desired properties of the resulting concrete, and the environment in which the project will be built. It is important to understand the density characteristics of different types of aggregates as this can help to identify potential issues and guide decision-making in the selection and use of these materials.

2.4 Concrete

Concrete is the most widely used as a building material due to its good compressive strength. This material is used in construction projects more than any other man-made material on earth.

Concrete is a composite material that is made up of cement, water, and aggregates. When cement and water are mixed together, they undergo a chemical reaction known as hydration, which creates a paste that can be used to bind together other materials such as sand and gravel. This mixture, when hardened, forms a durable and strong material that is used in various infrastructure projects such as buildings, bridges, roads, and dams.

The properties of concrete can vary depending on the type and proportion of the materials used, the methods of mixing and placing, and the conditions under which it is cured. The strength, durability, and workability of concrete can be influenced by factors such as the water-to-cement ratio, the type and size of aggregate used, and the fineness of the cement.

The main factor that determines the strength of concrete is the ratio of water in the mix and the amount of cement used. Ordinary concrete must provide moisture for at least 28 days to maintain good hydration, which requires a suitable atmosphere. Depending on the type of cement work, good mixing, mixed water, and water mixed in certain quantities to produce concrete. Empty concrete requires proper ventilation by providing a minimum of 28 days for moisture to get the best hydration. We know that hydration treatment is necessary for concrete. Any untreated will adversely affect the strength and durability of the concrete.

Concrete can also be modified to improve its properties. The use of supplementary cementitious materials (SCM) such as fly ash, slag and silica fume, can improve the sustainability of concrete production, and also improve the overall strength and durability of concrete (Tironi, 2020).

Concrete is widely used in the construction industry because of its durability, strength, and versatility. It is an important construction material that plays a vital role in modern infrastructure, and research is ongoing to improve the properties of concrete and make it more sustainable.

2.5 Admixtures

Admixtures are substances that are added to concrete in small amounts to enhance or modify its properties. They can be added to the concrete before or during mixing to improve workability, strength, durability, and other properties of the resulting concrete.

Admixtures are becoming increasingly popular in the construction industry as they can help to improve the properties of concrete, enhance the workability of the mix, and make the concrete more sustainable. However, it's important to note that the use admixtures should be limited to the recommended dosages and guidelines to ensure that the properties of the concrete are not negatively affected.

2.5.1 Chemical admixtures

Chemical admixtures are substances that are added to concrete in small amounts to enhance or modify its properties. They are typically added to the concrete mix before or during mixing to improve workability, strength, durability, and other properties of the resulting concrete.

There are several types of chemical admixtures, including:

- **Water-reducing Admixtures**: These admixtures, also known as plasticizers, reduce the water content in the concrete mix, which can lead to an increase in strength and durability of the resulting concrete. They are used to produce a more workable concrete at a lower water-cement ratio.
- **Retarding Admixtures**: These admixtures slow down the setting time of concrete and are used to extend the time available for placing and finishing the concrete. They are useful in hot weather conditions, where the rapid setting of concrete can be a problem.
- **Accelerating Admixtures**: These admixtures speed up the setting time of concrete, which can be beneficial in cold weather conditions or when a rapid hardening is required.
- **Air-entraining Admixtures**: These admixtures introduce small bubbles of air into the concrete mix, which can improve the workability and durability of the resulting concrete, especially in freezing and thawing conditions.
- **Superplasticizing Admixtures**: These admixtures, also known as high-range water-reducing mixtures, increase the fluidity of concrete, allowing it to be placed more easily, and also increase the compressive strength of the resulting concrete.

- **Corrosion Inhibitors**: These admixtures are used to reduce the corrosion of the steel reinforcement. (ACI Committee, 2010).

2.5.2 Mineral admixtures

Mineral admixtures are materials that are added to concrete to improve its properties. Some examples of mineral admixtures include fly ash, silica fume, and ground granulated blast furnace slag (GGBS). These materials can improve the strength, durability, and workability of concrete, and can also reduce its environmental impact.

- Fly ash is a by-product of coal-fired power plants and is used as a replacement for cement in concrete. It improves the workability of fresh concrete and increases its strength and durability.
- Silica fume is a by-product of the production of silicon and ferrosilicon alloys, and is added to concrete in small amounts (typically less than 10% by mass of cement) to improve its strength and durability.
- GGBS is a by-product of the iron and steel industry and is used as a replacement for cement in concrete. It improves the strength and durability of concrete, and also reduces its environmental impact of concrete production by repurposing agricultural waste products.

In conclusion, the use of admixtures can improve the strength, durability, workability, and overall performance of concrete. Additionally, the use of certain types of admixtures can also have environmental benefits, such as reducing the amount of cement and water needed in concrete production and repurposing agricultural waste products as mineral admixtures. It is important to note that the selection and dosage of admixtures must be carefully done in order to achieve the desired results, and consult with experts in the field to ensure the best results.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the structured process for conducting this research. All the necessary calculation details are also explained in this chapter. Detailed descriptions about the material used, specimens tested are also explained in this chapter.

3.2 Methodology

The main aim of this experiment is to investigate the effect of banana stem ash and oil palm stem ash on strength properties of concrete. The cube size of 150 x 150x150 mm is used to test the compressive strength of the concrete. The coarse aggregate and the fine sand were used. Tap water supplied from the laboratory was used during the study in the mixing, curing and other processes.

Banana stem and oil palm stem were collected from Ifite-awka, Anambra state in their natural state and were allowed to air dried for few days and burnt in a burn barrel and in an open space, uncontrolled burning process in which the banana stem and oil palm stem turned into ash (black in color), and it was used as the substitution material.

Mix proportions were prepared using water cement ratio of 0.55 to achieve this experimental work keeping the coarse aggregate, fine aggregate constant in all the mixes except for the variation in the percentage of banana stem ash and the oil palm stem ash. The first mix is the reference concrete mix or control mix consisting of 100% cement then the other mixtures are prepared by integrating ashes by weight. The proportion of ash replaced ranged from 0% to 2.5%, to 5%, to 7.5% and at 10% interval; Steel moulds were used for casting test samples. The inner parts of the moulds were coated with engine oil to ensure easy de-moulding and smooth surfaces finish. Immediately after the mixing of the concrete, the wet mixture was cast into the moulds of size 150 x 150 x150 mm cube using hand trowel. They were filled in three layers and compacted using the compacting rod (25 diameter steel rods). Each layer was compacted manually by uniformly distributing 25 strokes of the steel rod across the cross section of the mould. The top of each mould was smoothened and levelled and the outside surfaces cleaned. The mould and their contents were kept in the curing room at temperature of 21°C.

After 24 hours, the specimen was demolded and subjected to water curing until the testing date. Compressive strength test was determined for 7, 14, 21 and 28 days according to British Standard Institution (2009). Cubes specimen were prepared with a water to cement ratio of 0.55 maintained throughout the experiment. And a concrete grade of M20; concrete mix design ratio of 1:2:4 used. The strength and other results on fresh concrete were also compared to specimen that did not contain the ashes as the control specimen.

3.3 Materials

The materials listed and discussed below were used in the preparation of the specimen in this study in order to achieve design objectives

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Banana stem ash
- Oil palm stem ash

3.3.1 **Cement**

Cement is a finely ground powdered product which has the potentials of reacting with water, to turn into a hard-binding matrix for aggregates. 50kg(1bag) of 42.5R BUA cement was used and it was purchased at Eke-Awka market, Anambra State from there it was conveyed to the school laboratory and was stored properly

Plate 3.1 Picture of a bag of BUA cement

3.3.2 Fine Aggregate

Fine aggregates are small size filler materials in concrete. Fine aggregates are the particles that pass through 4.75mm sieve and retain on 0.075mm sieve. The fine aggregate used was purchased in bags from Ifite-awka, Anambra state.

Plate 3.2 Picture of fine aggregate

3.3.3 Coarse Aggregate

The coarse aggregate component of a concrete mix occupies 60-70% of the volume of concrete. Coarse aggregate is often referred to as gravel, stone or granite. The coarse aggregate used in this research is crushed granite and it's of normal weight, irregular shape of 20mm diameter and conforming to BS 882: 1992 [7]. It was ensured that the coarse aggregate was air-dried to obtain saturated surface dry condition to ensure that water-cement ratio was not affected. The granite (coarse aggregate) was sourced from a local dealer at Ifite-Awka, Anambra state.

Plate 3.3 Picture of coarse aggregate

3.3.4 Water

Water is a major component in the mixing of concrete. Too little or too much water will significantly affect the mix and the overall strength of the concrete. Using the optimum weight or volume of water during the mix is very important. The water used was cleaned and free from any visible impurities. It conformed to BS 3148 (1980) requirements. Water added to a concrete mix must fill the spaces among the particles. Additional water "lubricates" the particles by separating them with a water film. Increasing the amount of water will increase the fluidity and make concrete to be easily compacted. Indeed, the total water content reduces cohesiveness, leading to segregation and bleeding. With increasing water content, concrete strength is also reduced. Therefore, a water cement ratio of 0.55 was maintained throughout the work. Portable water from the tank at the concrete tech lab was used for the concrete mix.

3.3.5 Banana stem ash

In this research, the banana stem ash was obtained at Ifite-awka, Anambra state. It was then air-dried for few days and burnt in an open space, uncontrolled burning process in which it turned into ash (black in colour). The quality and fineness of bamboo leaf ash was improved by grinding.

Plate 3.4 Banana tree in its natural habitat

3.3.6 Oil palm stem ash

In Nigeria, oil palm is a major agricultural crop and is cultivated in several states. The palm oil extracted from the fruit is a staple ingredient in many Nigerian dishes. It is also used for industrial purposes such as soap-making, cosmetics, and biofuel production. Palm kernel oil, which is derived from the seed, is widely used for cooking and in the production of confectioneries, and other food products. Additionally, the oil palm tree provides other useful products such as palm wine, baskets, and roofing materials.

Plate 3.5 Oil palm tree in its natural habitat

3.4 Preliminary calculations

The concrete mix design adopted for this research is as stated below, the design was adopted based on the availability of the material and also the aim of the experiment.

Density of concrete = 2400Kg/m3

Volume of cube sample = 0.15 x 0.15 x 0.15 = 0.003375m^3

Density of concrete = mass of concrete / volume

Mass of one cube = Density x Volume

= 2400Kg/m3 x 0.003375m3= 8.1Kg

Water/Cement ratio = 0.55

Using mix ratio = 1: 2: 4 = 1+2+4 =7

Mass of constituent of cube

Mass of cement = 1/7 x 8.1kg = 1.16Kg

Mass of fine aggregate (sand) = 2/7 x 8.1kg = 2.31Kg

Mass of coarse aggregate(granite) = 4/7 x 8.1kg = 4.63Kg

Mass of water with water/cement ratio of 0.55

Mass of water = mass of cement x 0.55

= 1.16 x 0.55 = 0.638kg

Convert from kg to ml = 0.638 x 1000 = 638ml

The percentages of banana stem ash (BSA) and oil palm stem ash (OPSA) used were 0%, 2.5%, 5%, 7.5%, 10% by weight of Portland cement.

0% BSA & OPSA substitution

Cement content= 1.16kg BSA & OPSA content= 0kg

2.5% BSA & OPSA substitution

2.5/100 x 1.16= 0.029kg

Cement content= 1.16 BSA & OPSA content=0.029kg

5% BSA & OPSA substitution

5/100 x 1.16= 0.058kg

Cement content= 1.16kg BSA & OPSA content= 0.058kg

7.5% BSA & OPSA substitution

7.5/100 x 1.16= 0.087kg

Cement content= 1.16kg BSA & OPSA content= 0.087kg

10% BSA & OPSA substitution

10/100 x 1.16= 0.116kg

Cement content= 1.16kg BSA & OPSA content= 0.116kg

Table 3.1 composition for constituent materials for the banana stem ash (BSA) concrete at 0%, 2.5%, 5%, 7.5%, 10%.

BSA %	**CEMENT %**	**BSA KG**	**CEMENT KG**	**SAND KG**	**GRANITE KG**	**WATER ml**
0%	100%	0	1.16	2.31	4.63	638
2.5%	100%	0.029	1.16	2.31	4.63	638
5%	100%	0.058	1.16	2.31	4.63	638
7.5%	100%	0.087	1.16	2.31	4.63	638
10%	100%	0.116	1.16	2.31	4.63	638

Table 3.2 composition for constituent materials for the oil palm stem ash (OPSA) concrete at 0%, 2.5%, 5%, 7.5%, 10%.

OPSA %	**CEMENT %**	**OPSA KG**	**CEMENT KG**	**SAND KG**	**GRANITE KG**	**WATER ml**
0%	100%	0	1.16	2.31	4.63	638
2.5%	100%	0.029	1.16	2.31	4.63	638
5%	100%	0.058	1.16	2.31	4.63	638
7.5%	100%	0.087	1.16	2.31	4.63	638
10%	100%	0.116	1.16	2.31	4.63	638

The weight of one cube is now multiplied by the number of specimens to be produced on a particular day.

Due to the method of mixing (hand mixing) adopted in this research, there was risk of wastage. Therefore 5% of the individual components of the concrete was added as a factor of safety.

3.5 Mixing process

Mixing was carried out by conventional hand mixing method. The materials were weighed using a weighing balance. The components were weighed accordingly to achieve the added required mix in the mix design. Since hand mixing was employed, the banana stem ash and oil palm stem ash were added after the sand and cement has been properly mixed, after that the coarse aggregate was added and all the components were mixed thoroughly with water to achieve a homogeneous constituent.

Procedure

1. The cement and fine aggregate were on a water tight non-absorbent platform until the mixture is thoroughly blended and is of uniform colour.

2. The coarse aggregate was added and mix with the cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.

3. Water was added and mixed until the concrete appears to be homogenous and of the desired consistency.

Sampling

1. The mould was carefully cleaned and oil was applied.

2. the concrete was filled in the mould in three layers approximately 50mm thick.

3. each layer was compacted with at least 25 strokes per layer using a tamping rod.

4. the top surface was levelled and smoothen with the aid of a trowel.

3.6 Curing

The tests specimen is stored under moist air for 24 hours for it to harden and after this period the specimen are marked and removed from the moulds and kept submerged in clean fresh water until taken out prior to test.

3.7 Test on concrete

- Test on fresh concrete
- Test on hardened concrete

3.7.1. Test on fresh concrete

Fresh concrete is concrete at the state when its components are fully mixed but its strength has not yet developed. This period corresponds to the cement hydration stages. The properties of fresh concrete directly influence the handling, placing and consolidation, as well as the properties of hardened concrete. ASTM makes provision for sampling of concrete. It spells out the procedure for sampling various production systems like the Slump test. The specimen must be tested within 10 minutes and must be protected from weather during testing.

3.7.1.1 Concrete slump test

Principle

The slump test result is a measure of the behaviour of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the workability of concrete.

Apparatus

1. Slump cone

2. Scale for measurement

3. Tamping rod

Procedure

The mould for the slump test is a frustum of a cone, 300mm of height. The base is200mm in diameter and it has a smaller opening at the top of 100mm.

1. The base is placed on a smooth surface and the container is filled with concrete in three layers, whose workability is to be tested.

2. Each layer is tamped 25 times with a standard 16mm diameter steel rod, rounded at the end.

3. When the mould is completely filled with concrete, the top surface is struck off by means of screening and rolling action of the tamping rod.

4. The mould must be firmly held against a base during the entire operation so that it did not move during the pouring of concrete and this can be done by means of handles and foot rests brazed to the mould.

5. Immediately after filling is completed and the concrete is levelled, the come is slowly and carefully lifted vertically, the unsupported concrete will now slump.

6. The decrease in height of the Centre of the slumped concrete is called slump.

7. The slump is measured by placing the cone just beside the slumped concrete and the tamping rod is placed over the cone so that it should also come above the area of slumped concrete.

8. The decrease in height of concrete to that of the mould is noted with scale. Usually measured to the nearest 5mm.

Note: the slumped concrete takes various shapes and according to the profile of slumped concrete, the slump is termed as collapse slump, shear slump and true slump.

Interpretation of results

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as true slump, zero, shear slump or collapse slump. If a shear, zero or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indication of ton wet a mix. Only a true slump is of any use in the test. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate. Very dry mixes; having slump 0-25mm are used in road making, low workability mixes; having slump 10-40mm are used for foundations with light reinforcement, medium workability mixes; 50-90 for normal reinforced concrete placed with vibration, high workability concrete, > 100mm.

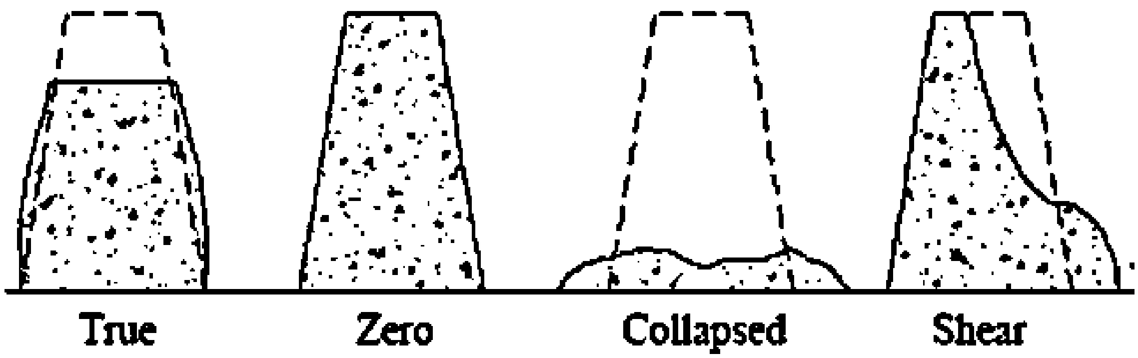

Figure 3.1 Different slump test results

Figure 3.2 Measuring slump value

3.7.2 Test on hardened concrete

The type of test that was done on concrete cubes was the compressive strength test and the cubes were tested for 7, 14, 21 and 28 days.

3.7.2.1 Compressive strength test

The compressive strength test was carried out using the compressive strength test machine a find in the test method BS 1881 pant 116, 1983. An increasing compressive strength was plat to the cube specimen until failure occurred to obtain the maximum compressive load. The specimen dimension was taken before testing.

Compressive strength =

$compresssive\ load\ P(N)$ / $Surface\ area\ A$ $(mm2)$ = $N/mm2 \ldots\ldots\ldots\ldots eqn$ (1)

Figure 3.3 Curing of concrete cube specimen

Procedure

1. The specimen was removed from water after specified curing time and wipe out excess water from the surface.

2. The dimension of the specimen was taken to the nearest 0.2m.

3. The bearing surface of the testing machine was cleaned.

4. The smoothest side of the specimen in the machine was placed in such a way that the loads were applied to the opposite sides of the cube.

5. The specimen was aligned centrally on the base plate of the machine.

6. The movable portion was rotated gently by hand for it to touch the top surface of the specimen.

7. The loads were applied gradually without shock and continuously at the rate of 140Kg/cm/minute till the specimen failed.

8. The maximum load was recorded and unusual features in the type of the failure was noted.

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Results

This chapter comprises of the results and analysis of all tests done in the process of this project. These tests include; particle size distribution of sand, banana stem ash and oil palm stem ash, workability test, and compressive strength test.

4.1.1 Particle size distribution

Figure 4.1, 4.2, 4.3, and 4.4 reveals the particle size distribution analysis carried out on coarse aggregate, fine aggregate; sand and both banana stem ash and oil palm stem ash obtained from Ifite-awka, in accordance with the guidelines specified by BS 1377; part 2, 1990.

i. Using uniformity coefficient (Cu)= D60 **/** D10

ii. Coefficient of curvature (Cc)= $D30^2$ **/** **(**D60 x D10)

Table 4.1 Particle size distribution analysis for coarse aggregate

Sieve size (mm)	Weight retained (g)	Percentage weight retained (g)	Cumulative percentage retained (%)	Cumulative percentage passing (%)
31.5	0	0	0	100
26.5	10.78	1.08	1.08	98.92
19	37.88	3.79	4.87	95.13
14	293.46	29.35	34.22	65.79
12.5	610.44	61.04	95.26	4.745
10	47.45	4.745	100.00	0
4.75	0	0	0	0

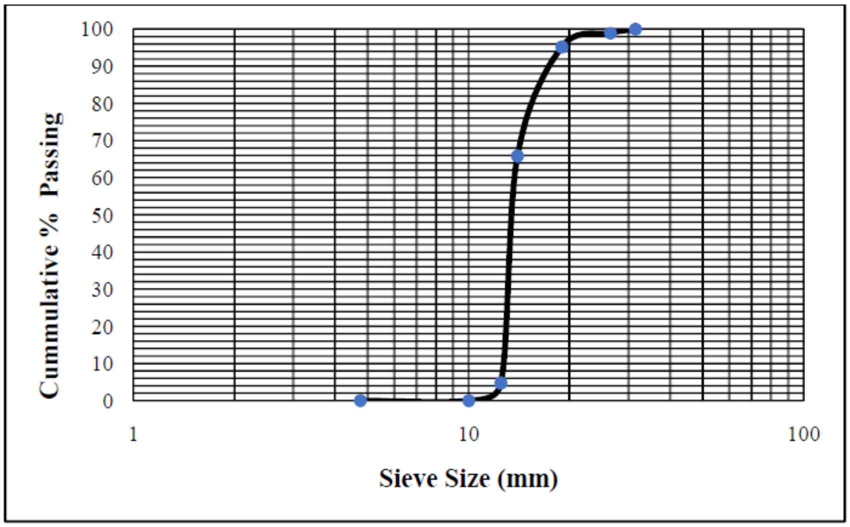

Figure 4.1 Particle size distribution analysis for coarse aggregate

Analysis from the figure 4.1:

A. Uniformity coefficient for fine aggregate (coarse aggregate)

Cu=D60 / D10= 16 / 13= 1.23

B. Coefficient of curvature Cc= $D30^2$ / D60 x D10= (14.5^2 / 16 x 13)= 1.01

Table 4.2 Particle size distribution analysis for sand (fine aggregate)

Sieve size (mm)	**Weight retained (g)**	**Percentage weight retained (g)**	**Cumulative percentage retained (%)**	**Cumulative percentage passing (%)**
2.00	4.73	0.95	0.95	99
1.18	21.86	4.37	5.32	94.68
0.60	86.72	17.34	22.66	77.34
0.425	112.57	22.51	45.18	54.83
0.30	162.86	32.57	77.75	22.25
0.15	97.80	19.56	97.31	2.70
0.075	4.86	0.97	98.28	1.72
0	8.61	1.72	100	0

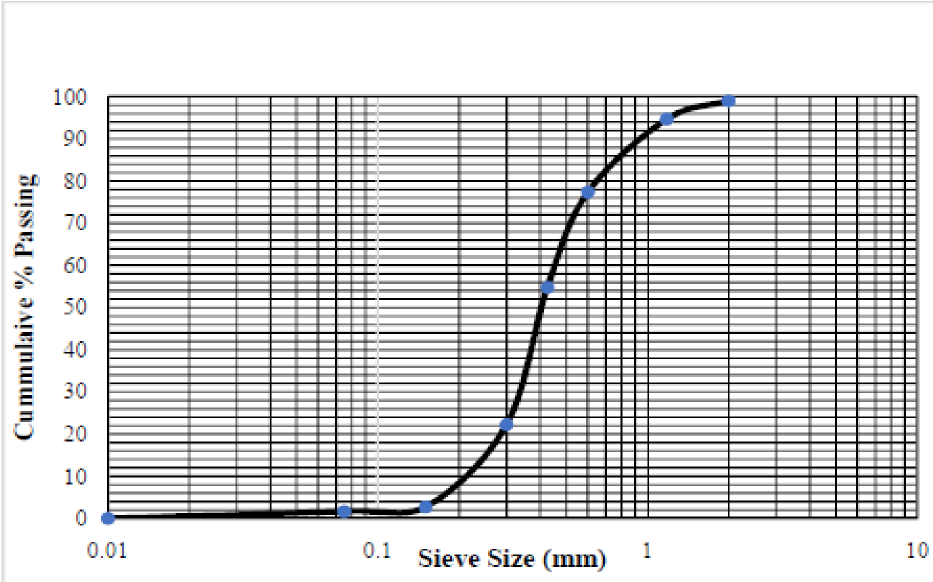

Figure 4.2 Particle size distribution for sand (fine aggregate)

Analysis from figure 4.2:

A. Uniformity coefficient for sand (fine aggregate)

Cu= D60 / D10= 0.45 / 0.21= 2.14

B. Coefficient of curvature Cc= $D30^2$ / D60 x D10= (0.33^2) / 0.45 x 0.21= 1.15

Table 4.3: Particle size distribution analysis for banana stem ash

Sieve size (mm)	Weight retained (g)	Cumulative retained (g)	Cumulative percentage retained (%)	Cumulative percentage passing (%)
2.00	0.3	0.3	0.1	99.9
1.18	8.2	8.5	3.0	97.0
0.60	20.3	28.8	10.2	89.8
0.425	122.0	150.8	53.4	46.6
0.30	40.2	191.0	67.7	32.3
0.15	66.1	257.1	91.1	8.9
0.075	20.4	277.5	98.3	1.7
Tray	4.8	282.3	100	0.00

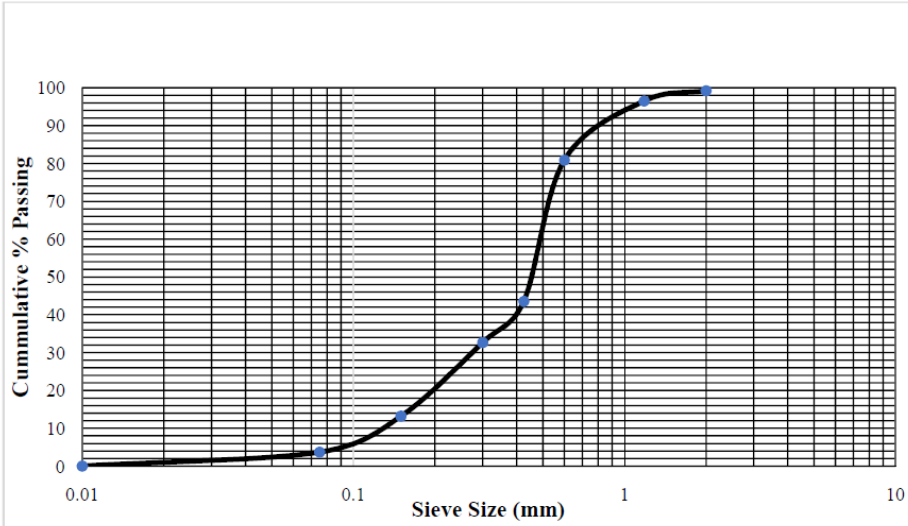

Figure 4.3 Particle size distribution analysis for banana stem ash

Analysis from figure 4.3:

A. Coefficient of uniformity for banana stem ash

Cu= D60 / D10= 0.48 / 0.14= 3.4

B. Coefficient of curvature (Cc)= $D30^2$ / D60 x D10= (0.28^2) / 0.49 x 0.14= 1.2

Table 4.4 Particle size distribution analysis for oil palm stem ash

Sieve size (mm)	**Weight retained (g)**	**Cumulative retained**	**Cumulative percentage retained (%)**	**Cumulative percentage passing (%)**
2.00	2.3	2.3	0.8	99.2
1.18	7.6	9.9	3.5	96.5
0.60	43.9	53.8	19.1	80.9
0.425	105.4	159.2	56.4	43.6
0.30	30.7	189.9	67.3	32.7
0.15	55.2	245.1	86.8	13.2
0.075	26.8	271.9	96.3	3.7
Tray	10.4	282.3	100	0.00

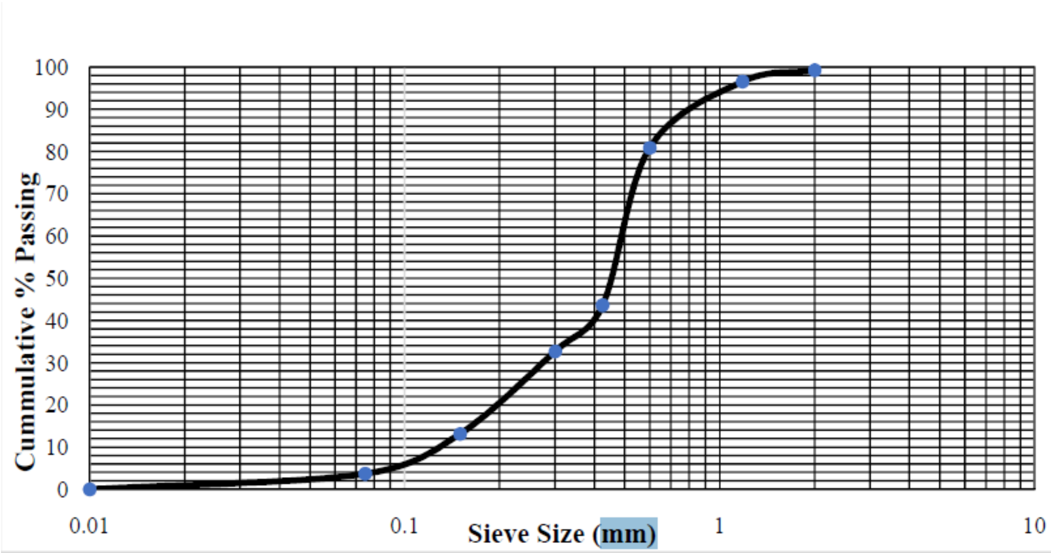

Figure 4.4 Particle size distribution analysis for oil palm stem ash

Analysis from figure 4.4

A. coefficient of uniformity for oil palm stem ash

Cu= D60 / D10= 0.49 / 0.15= 3.3

B. Coefficient of curvature (Cc)= $D30^2$ / D60 x D10= (0.28^2) / 0.49 x 0.15= 1.1

4.1.2 Slump test

Table 4.5: Workability test of concrete for banana stem ash

Mix Proportion (%)	Height of Slump Cone (mm)	Height of Collapse (mm)	Slump Value (mm)	Water Cement Ratio (mm)
0	300	237	63	0.55
2.5	300	245	55	0.55
5	300	250	50	0.55
7.5	300	257	43	0.55
10	300	260	40	0.55

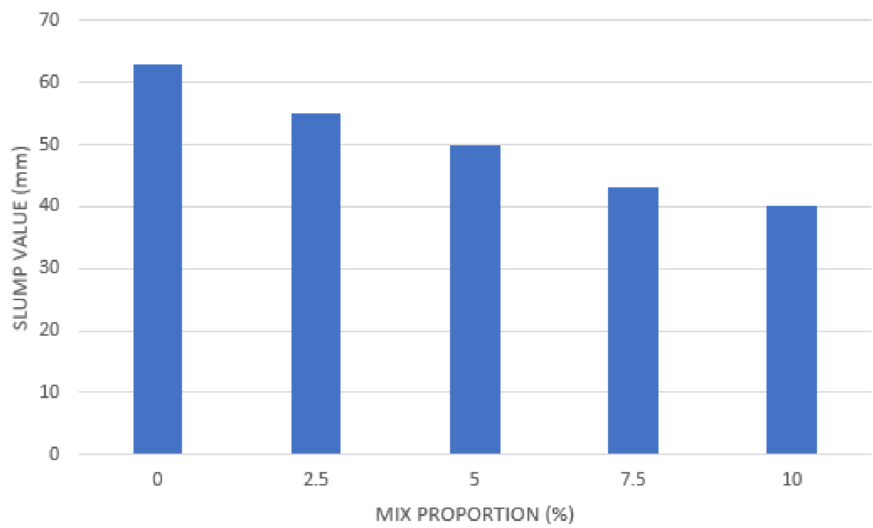

Figure 4.5 Workability test of concrete for banana stem ash

The variation of workability of fresh concrete is measured in terms of slump and reported in the Table 4.5 and Figure 4.5. With a water/cement ratio of 0.55, the concrete slumps were recorded for these mixes. The overall workability value of the concrete produced with banana stem is less compared to conventional concrete. It was observed that the workability of concrete decreased as the percentage of banana stem ash increased. The highest slump was obtained at 0% banana stem ash replacement for specimens from both towns, this indicates that RHA has a significant effect on the workability of concrete.

Given the slump value range of 25-50mm, concrete within this range is regarded as low slump, it is relatively stiff but has slightly better workability compared to very low slump mixes. It requires more effort for placement and compaction. Low slump concrete can be suitable for certain applications where formwork stability is required, such as vertical or overhead placements.

For slump value range of 50-100mm, concrete with a moderate slump value is considered to have good workability. It flows relatively easily and can be easily placed and compacted. Moderate slump concrete allows for proper filling of formwork, better compaction, and improved consolidation. It is commonly used in general construction applications

Table 4.6: Workability test of concrete of oil palm stem ash

Mix Proportion (%)	Height of Slump Cone (mm)	Height of Collapse (mm)	Slump Value (mm)	Water Cement Ratio (mm)
0	300	235	65	0.55
2.5	300	242	58	0.55
5	300	245	55	0.55
7.5	300	250	50	0.55
10	300	255	45	0.55

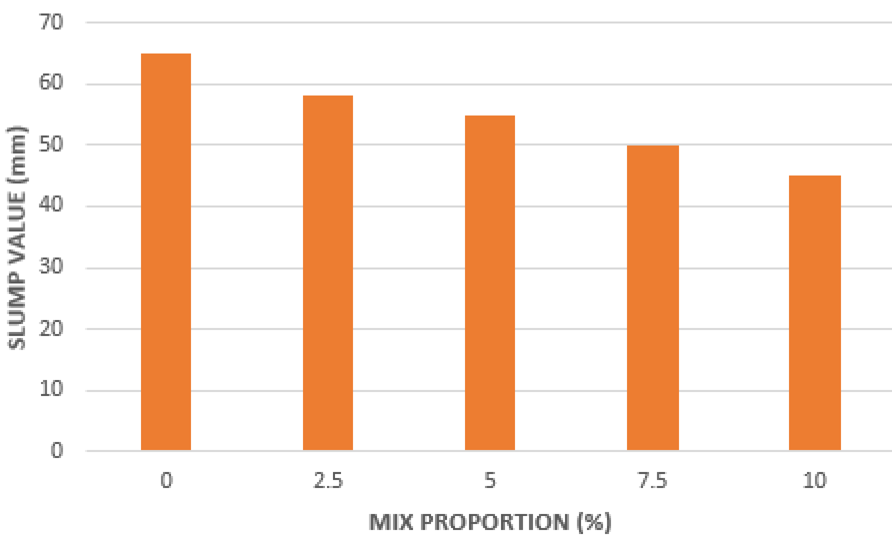

Figure 4.6 Workability test of concrete for oil palm stem ash

Table 4.7: Values of slump and how they affect the strength of concrete (Concrete: Microstructure, properties, and materials; 2013)

S/N	TYPE OF SLUMP	SLUMP VALUE
1	Very low slump	0-25 mm
2	Low slump	25-50 mm
3	Moderate slump	50-100 mm
4	High slump	100-150 mm

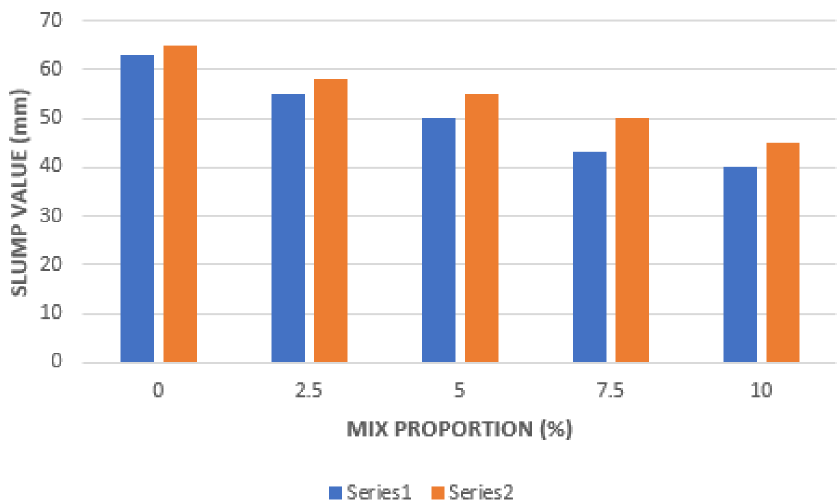

Figure 4.7 Comparing workability test of concrete for banana stem ash and oil palm ash

- Series 1: Banana stem ash
- Series 2: Oil palm stem ash

From figure 4.7, it is observed that concrete specimen produced from oil palm stem ash has higher workability than concrete specimen produced from banana stem ash.

4.1.3 Ccompressive strength of concrete

Compressive strength of concrete for banana stem ash and oil palm stem ash

Table 4.8: Compressive strength of concrete for banana stem ash and oil palm ash

Mix Proportion (%)	Curing Time (days)	Cross Sectional Area (mm2) (150×150)	Average Crushing Strength (N) for Banana stem ash	Average Compression Strength (N/mm^2) for Banana stem ash	Average Crushing Strength (N) for Oil palm stem ash	Average Compression Strength (N/mm^2) for Oil palm stem ash
Control (0%)	7	22,500	445500	19.8	445500	19.8
	14	22,500	463000	20.5	472800	21.0
	21	22,500	504700	22.4	504750	22.4
	28	22,500	589500	26.2	578590	25.7
2.5%	7	22,500	456500	20.2	467000	20.7
	14	22,500	477500	21.2	474550	21.1
	21	22,500	535500	23.8	539730	23.9
	28	22,500	589550	26.2	593500	26.3
5%	7	22,500	459700	20.4	465000	20.6
	14	22,500	481760	21.4	495000	22.0
	21	22,500	545250	24.2	546800	24.3
	28	22,500	598000	26.5	599590	26.6
7.5	7	22,500	475250	21.1	479500	21.3
	14	22,500	482500	21.4	499500	22.2
	21	22,500	549000	24.4	562500	25.0
	28	22,500	599250	26.6	602550	26.7
10%	7	22,500	480500	21.3	482520	21.4
	14	22,500	485200	21.5	499250	22.2
	21	22,500	560250	24.9	571740	25.4
	28	22,500	605550	26.9	609850	27.1

Table 4.8 shows the compressive strength results of concrete cubes at different curing ages 7, 14, 21, and 28 days for the mixed ratio of 1:2:4 , with 0.55 water-cement ratio, mixed with the variation of banana stem ash and oil palm stem ash.

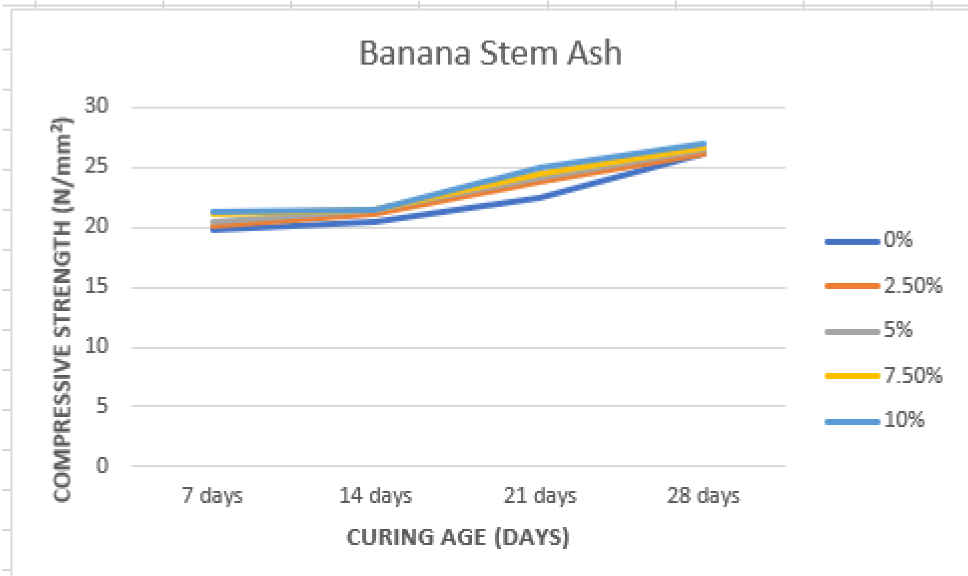

Figure 4.8 Compressive strength against Age of concrete for Banana stem ash specimen

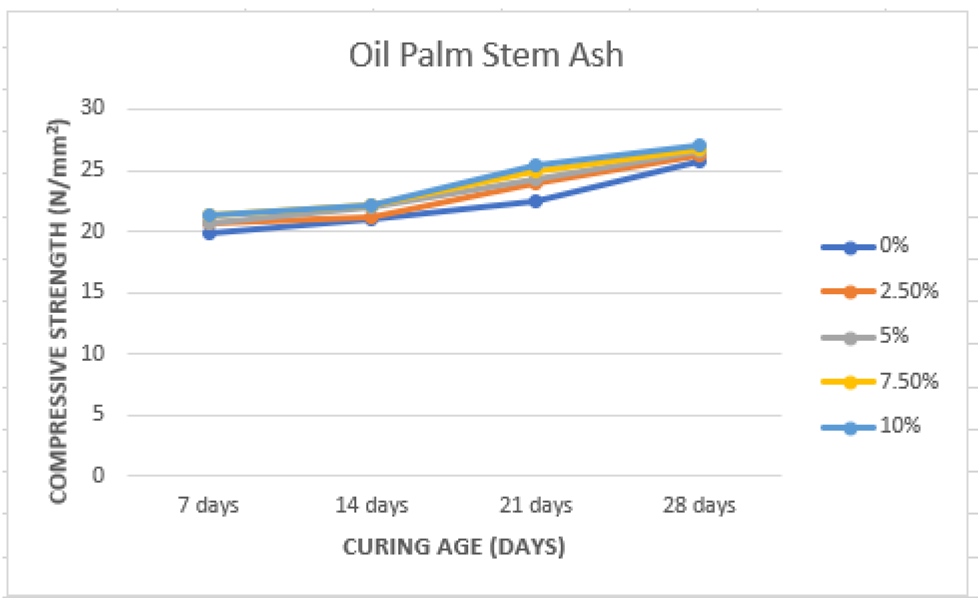

Figure 4.9 Compressive strength against Age of concrete for Oil palm stem ash specimen

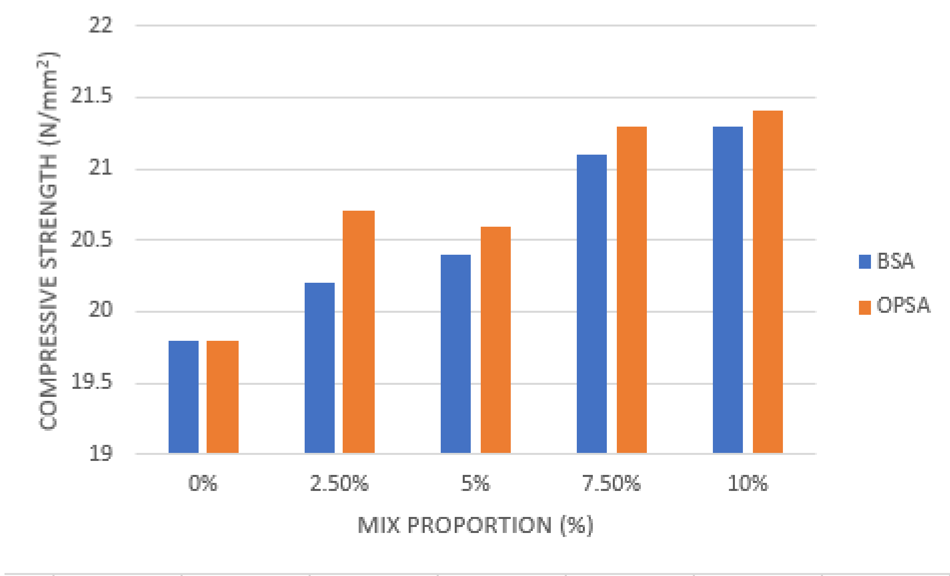

Figure 4.10 Comparison of the compressive strength of concrete specimens on the 7th day of curing for BSA and OPSA

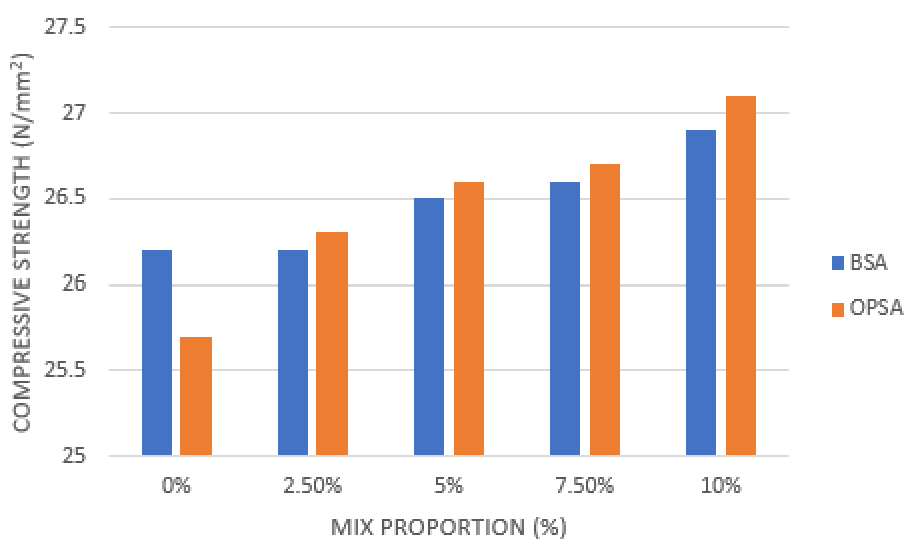

Figure 4.11 Comparison of the compressive strength of concrete on the 28th day of curing for BSA and OPSA

4.2 Effects of curing time on compressive strength

Table 4.8 shows the results of the experiment on effect of BSA and OPSA on the strength properties of concrete. These specimens were prepared with a mix ratio of 1:2:4, and a constant water-cement ratio of 0.55.

It was observed that on the 28th curing day, the compressive strength for BSA specimens at 0%, 2.5%, 5%, 7.5%, and 10% mix proportions was 26.2 N/mm^2, 26.2 N/mm^2, 26.5 N/mm^2, 26.6 N/mm^2, and 26.9 N/mm^2 respectively. However, it was observed that they exceeded the conventional concrete design strength target of 20 N/mm^2 that is attributed to 1:2:4 mix ratio.

While for OPSA specimens, on the 28th curing day, the compressive strength at 0%, 2.5% and 5%, 7.5%, and 10% mix proportions 25.7 N/mm^2, 26.3 N/mm^2, 26.6 N/mm^2, 26.7 N/mm^2, and 27.1 N/mm^2 respectively. It was observed that the strength of these specimens on the 28th day of curing exceeded the conventional concrete design strength target of 20N/mm^2 which is attributed to 1:2:4 mix ratio.

Concrete with a design strength of 20 N/mm^2 to 30 N/mm^2 can be used in all structural work of building construction in reinforced concrete beam, column, foundation, slab and other reinforced concrete structures; therefore, both specimens would satisfy these purposes.

The result illustrated in Figure 4.8 and Figure 4.9 shows that compressive strength of concrete increases at increasing curing days for both concrete specimens of 0%, 2.5%, 5%, 7.5%, and 10% mix proportion. It was observed that the 28th day curing period had specimens of the highest compressive strength.

4.3 Chemical composition of banana stem ash (BSA)

Banana stem ash is the residue obtained from burning or incinerating the stems of banana plants. It primarily consists of inorganic compounds and minerals. The exact composition may vary depending on factors such as the banana variety, soil considerations, and processing methods. Here are some of the typical components found in banana stem ash:

1. Potassium (K): Banana stems are known to be rich in potassium, and the ash obtained from burning them also contains a significant amount of potassium compounds.

2. Phosphorus (P): Phosphorus is another important nutrient found in banana stem ash, although in smaller quantities compared to potassium. Phosphorus is involved in various biological processes and is crucial for plant metabolism.
3. Calcium (Ca): Banana stem ash may contain calcium compounds. Calcium plays a vital role in the growth and structure of plants and is necessary for cell wall formation.
4. Magnesium (Mg): Magnesium is a minor component present in banana stem ash. It is an essential nutrient involved in various plant functions, such as photosynthesis and enzyme activation.
5. Silica (Si): Silica is often found in plant residues, including banana stem ash. It provides structural support and can benefit plants by enhancing their resistance to diseases and pests.

4.4 Chemical composition of oil palm stem ash

Oil palm stem ash is the residue obtained from burning the stems of oil palm trees (Elaeis guineensis). Here are some of the typical components found in oil palm stem ash:

1. Potassium (K): Oil palm stem ash is known to be rich in potassium compounds. Potassium is an essential nutrient for plant growth and is involved in various physiological processes.
2. Calcium (Ca): Calcium compounds are another significant component of oil palm stem ash, calcium plays a crucial role in cell wall formation, plant structure, and nutrient uptake.
3. Phosphorus (P): Phosphorus is present in smaller quantities in oil palm stem ash compared to potassium and calcium. However, it is an important nutrient involved in plant metabolism and energy transfer.
4. Magnesium (Mg): Oil palm stem ash may contain magnesium compounds. Magnesium is an essential nutrient for photosynthesis, enzyme activation, and overall plant health.
5. Silicon (Si): Silicon is often found in plant residues, including oil palm stem ash. It can enhance plant resistance to diseases, pests, and abiotic stresses.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A research has been carried out to study the effect of banana stem ash and oil palm stem ash on the strength properties of concrete. From the results and analysis of the various test results presented earlier, the following conclusions are drawn from the study:

1. Concrete workability is inversely proportional to the percentage of the BSA and OPSA content at a constant water-cement ratio for all specimens
2. The compressive strength of the concrete specimens increases with an increase in the proportion of BSA and OPSA.
3. The compressive strength of the concrete is directly proportional to the curing period. This was observed from 7 days, 14 days, 21 days and 28 days specimens from both materials.
4. The control mix (10% BSA and OPSA) gave the highest compressive strength at all the curing days.
5. Concrete specimens of 0%, 2.5%, 5%, 7.5%, and 10% mix proportion can be used in all structural work of building construction in reinforced concrete beam, column, foundation, slab and other reinforced concrete structures (CivilSir, 2022).
6. BSA and OPSA contribute to the strength and durability of the concrete matrix.

5.2 Recommendation

From the research and conclusion, the following recommendations are made:

1. Optimizing of the ash content to about 20-30% could provide significant improvements in concrete properties.
2. It is recommended to control the particle size distribution of the ash to optimize its properties
3. It is recommended to conduct testing on the ash material before use, and to implement quality control measures during concrete production and placement.
4. I recommend that a mix ratio of 1:2:4 and a water-cement ratio of 0.55 should be maintained while the percentage of BSA and OPSA content should be increased in order to ascertain if the resulting strength will be greater than or equal to the control mix strength.

5. The curing days should be investigated to see the potential use of BSA and OPSA on compressive strength of concrete.
6. I recommend that this experiment should be conducted at varying water-cement ratio to check the corresponding results.
7. Further research is required to investigate chemical composition of BSA and OPSA to better understand the effects on strength properties of concrete.

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