INFLUENCE OF BAMBOO LEAF ASH (BLA) AND COCONUT FIBRE ASH (CFA) ON THE STRENGTH PROPERTIES OF CONCRETE

BY

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SUPERVISOR: ENGR. PROF. C.H AGINAM

MAY, 2023

CERTIFICATION

This is to certify that this research work “Influence of Bamboo Leaf Ash (BLA) And Coconut Fibre Ash (CFA) on the Strength Properties of Concrete” was carried out by OKORIE CHINAZA CHARLESwith the registration number(NAU/2017224025) in the Department of Civil Engineering, Nnamdi Azikiwe University, Awka, Anambra Stateand that all the information used as contained in the work is a reflectionof my personal research. All other sources of information obtained from other literarypublication have been duly acknowledged.

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APPROVAL PAGE

This is to certify that all the information given in this project "Influence of Bamboo Leaf Ash (BLA) And Coconut Fibre Ash (CFA) on the Strength Properties of Concrete" has been assessed and approved by the department of Civil Engineering, Nnamdi Azikiwe University, Awka, Anambra state.

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DEDICATION

This project work is dedicated to Almighty God for his infinite mercy and kindness over my life. I equally dedicate this work to my lovely parents, who serve as a real source of inspiration towards my academic pursuit and my siblings for their immense contribution.

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ABSTRACT

Concrete is being widely used in all infrastructures and its material is mainly very expensive for the construction. The Bamboo sticks are unutilized in the concrete work and hence their usage may help to decrease the cost of construction. The use of waste materials in concrete production is becoming worldwide practice. The assessment of the activity of cement materials is becoming increasingly important because of the need for more sustainable cementing product. The early work has been carried out with the partial replacement of bamboo leaf ash and coconut fibre ash with concrete in order to increase the tensile strength of concrete and compressive strength has been decreased. Now we are doing substitution of bamboo leaf ash and coconut fibre ash with concrete to know if there will be an increase or decrease in the compressive strength of concrete. The use of bamboo leaf ash and coconut fibre ash as a substitute for cement is used in concrete in order to know the compressive strength. Compressive strength of 28 days curing with substitute of BLA to cement gives 20.25N/mm^2 at 2.5% of ash substitute and it is observed that the strength is decreased than conventional concrete. Compressive strength of 28 days curing with substitute of BLA to cement gives 16.77N/mm^2 at 10% of ash substitute and it is observed that the strength is decreased than conventional concrete. Compressive strength of 28 days curing with substitute of CFA to cement gives 20.01N/mm^2 at 2.5% of ash substitute and it is observed that the strength is decreased than conventional concrete. Compressive strength of 28 days curing with substitute of CFA to cement gives 18.60N/mm^2 at 10% of ash substitute and it is observed that the strength is decreased than conventional concrete. The substitution is done with the following percentages of 0%, 2.5%, 5%, 7.5% and 10% with bamboo leaf ash and coconut fibre ash separately. Thus, from the results obtained, it can be concluded that the use of BLA and CFA as a supplementary for cement decreases its strength.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Government and groups of different levels all over the world find it difficult to provide shelter for its citizenry, shelter has remained a basic necessity of man and the provision of decent shelter at a very reasonable cost is really a major problem all over the world. This problem is caused by unavailability and overall high cost of construction materials. The construction industry has been faced with ongoing and sophisticated demands, which calls for the most efficient use of available resources. Different parts of the structure of the modern facilities are now so technically specialized that they have to design by many experts.

In Europe after the end of the Second World War, cement was scarce and not enough for the rebuilding the war-turn countries of Europe. This led to the use of fly ash as a partial substitute for cement in concrete production to cope with the problem of scarcity of cement at that time (Faber, 1987 ;). It was then discovered that fly ash contained pozzolana and has potentials of other valuable properties for good concrete practice.

Research indicates that most materials that are rich in amorphous silica can be used in partial replacement of cement (Ngbonkwo, 1982 ;). It has also been established that amorphous silica found in some pozzolanic materials reacts with lime more readily than those of crystalline form. Use of such pozzolanas can lead to increased compressive and flexural strengths. The American society of testing materials (ASTM) defines Pozzolans as siliceous or aluminous materials which possess little or no cementitious properties but will, in the presence of moisture, react with lime [$Ca(OH)_2$] at ordinary temperature to form compounds with cementitious properties. Examples of pozzolans include class C fly ash, silica fume and rice fibre ash. Pozzolans contain some percentages of CaO, blast furnace slag and silica fumes. ASTM C 618 -78 specifies that any pozzolana that will be used as a cement as binder in concrete requires a minimum of 70 % silica, alumina and ferric oxides. BS 3892: 1965 parts 1 and 2 specify a maximum loss on ignition of 12%, maximum MgO content of 4% and SO_3 of 2.5% respectively.

The use of bamboo leaf ash and coconut fibre ash as pozzolans in concrete can help in waste reduction and pollution control. If, it is proven that it can improve concrete properties. This paper provides an experiment study to evaluate the improvement of concrete using bamboo leaf ash and coconut fibre ash.

1.2 Statement of the Problem

Pollution associated with cement production, has compelled a search for an alternative binder which can be used sorely or in partial replacement of cement in concrete production.

More so, disposal of agricultural waste materials such as rice fibre, bamboo leaf, corn cob, groundnut fibre, and coconut fibre have constituted an environmental challenge, hence the need to convert them into useful materials to reduce their negative effect on the environment. Cost of building material such as cement, needs to be reduced to make housing affordable for teeming population of people on earth; hence the need for this research.

1.3 Aim and Objectives

1.3.1 Aim

The aim of this work is to evaluate the strength improvement of concrete using bamboo leaf ash and coconut fibre ash as an admixture.

1.3.2 Objectives

The objective of this study is to:

(i) Prepare concrete cubes containing 0%, 2.5%, 5%, 7.5 and 10% cement substitution with bamboo leaf ash and coconut fibre ash to be tested for compressive strength at 7, 14, 21 and 28 days water curing.

(ii) Analyze the results with tables and graph to determine the rate of hydration and strength gain for the various substituted quantities.

(iii) Obtain the oxide composition of the bamboo leaf ash and coconut fibre ash to analyze their pozzolanic properties.

1.4 Scope of the Work

Scope of this work involves production of concrete cubes of 150mm x 150mm x 150mm containing various percentages of bamboo leaf ash and coconut fibre ash as substitutes for cement, and testing them for compressive strength with the help of universal testing equipment for the purpose of determining their effect on concrete strength. No other agricultural waste will be used except for bamboo leaf ash and coconut fibre ash. This study will help Civil engineers to have a better understanding on the use of bamboo leaf ash and coconut fibre ash which are agro-waste products, as admixtures to improve the strength properties of concrete and also, the use of bamboo leaf ash and coconut fibre ash as alternative admixtures in concrete will help reduce the cost of other admixtures since they are readily available and can be obtained at a cheaper rate.

1.5 Methodology

In carrying out of the research work, the method adopted is in this sequence.

- Procurement of materials.
- Preparation of the bamboo leaf ash and coconut fibre ash
- Testing of the materials.
- Casting of the cubes.
- Curing of the cubes.
- Testing for the compressive strength of the specimen.

CHAPTER TWO

LITERATURE REVIEW

2.0 Review of Previous Works on This Topic

Concrete is one of the major construction material used, which is next to the consumption of water by mankind. It is estimated that six billion tonnes of concrete is produced every year throughout the world. This is due to the availability of the abundance of raw materials, low relative cost and adoptability of concrete forming various shapes. The extraction of raw materials causes depletion of resources. In recent times, the environmentalists are more concerned regarding the cement manufacture. One tonne of cement manufacture emits approximately one tonne of CO_2 into the atmosphere. This causes greenhouse effect and global warming of the planet. Hence an emission of six billion tonnes of CO_2 every year which causes an environmental impact. The way to reduce the environmental impact is the use of supplementary cementitious materials. These alternative materials are generally selected on the basis of additional functionality that they offer and their cost effectiveness. Typical examples are fly ash, slag cement formerly called ground granulated blast furnace slag, silica fume, rice fibre and egg shell, one such material is Areca nut fibre ash. The applications of bamboo leaf ash (BLA) and coconut fibre ash (CFA) are replaced in varying proportions to the cement depending on their chemical composition. The use of these materials in concrete, apart from the environmental benefits, also produces good effects on the properties of final products. One of the waste materials used in the concrete industry is coconut fibre ash (CFA). Most of the aggregates used in our country are river sand as fine aggregates and crushed rock of quarries as coarse aggregates. Fine aggregates used for concrete should conform to the requirements for the prescribed grading zone. Natural or river sand may not conform to all the above requirements and may have to be improved in quality. The sand mining from our rivers have become objectionably excessive in view of both economy and environment. It has now reached stage where it is killing all our rivers day by day. Hence sand mining has to be discouraged so as to save the rivers of our country from total death. The problem of how to meet the increasing demand and cost of concrete in sustainable manner is a challenge in the field of civil engineering and environmental.

Because of environmental and economic reasons it requires thinking about the use of industrial wastes and naturally available waste material as alternative materials in concrete production, which not only reduces the cost of production of concrete but also controls the pollution relatively.

Concrete is the most widely employed material in the world, being used from road construction to skyscrapers. However, cement production is responsible for 5% of the annual anthropogenic global carbon dioxide (CO_2) production – each ton of concrete produced generates about 1 ton of CO_2. To reduce the detrimental impacts of the cement industry, researchers investigate an alternative to cement known as supplementary cementitious materials (SCM) – a vast group of materials that possess cementing properties and also contribute to the reduction of environmental problems. Agricultural wastes, for example, can be used as SCM, as shown by many researchers. Besides having pozzolanic properties, which favors their application as cement replacement, agricultural waste attract interest due to its great generation around the world, only smaller than that of industrial waste. Among the investigated agro-wastes in civil construction, there is bamboo leaf ash, coconut fibre ash, rice fibre ash, sugarcane bagasse ash, and wheat straw ash. These plants belong to the Poaceae family and are known to accumulate silica during their lifetime, thus presenting silicon (Si) content higher than calcium (Ca) content. Like other agricultural wastes from the Poaceae family, bamboo ashes can also be an alternative for cement replacement. Distributed worldwide through about 1600 species, bamboo is the fastest-growing among other plants even without fertilizers and pesticides and its great O_2 release which is 35% greater than trees supports bamboo use in comparison to other plants. Although it's many advantages, there is no published paper until now concerned only to review the use of bamboo ashes as SCM in concrete production and displays its pros and cons. Chemical and physical properties of concrete made with bamboo ashes usually appear secondary in large-scale reviews of agro-waste materials used in civil construction. Therefore, to fill this gap, this systematic review aims to answer the research question: "what are the chemical properties of bamboo ashes, and what are the mechanical and physical properties of concrete and mortar samples containing bamboo ashes as partial cement replacement?". By evaluating bamboo ashes potential use as partial cement replacement in the construction industry, this work will contribute to the scientific community synthesizing the literature regarding using bamboo ashes as SCM and rising new research topics.

2.1 Ingredients of Concrete

These are the ingredient of concrete material:

- Cement
- Water
- Aggregate

2.2 Cement

Cement is a finely ground powdered product which has the potentials of reacting with water, mixed with it, to turn into a hard-binding matrix for aggregates. Modern cement is accredited to Joseph Aspdin, a leads builder and bricklayer, who ground limestone and finely divided clay into a slurry and burnt the mixture in a kiln until CO_2 was expelled. The product so formed was ground into powder with gypsum added. Isaac Charles Johnson in 1845 also burnt a mixture of clay and chalk to a clinkering stage to make a better Portland cement. By 1851 factory production of cement had started.

Today, Portland cement is produced in different types and brands with standardized specification all over the world. Aside from Portland cement other types of cements are also produced today; among these are high alumina cement, blast furnace slag cement and Pozzolanic cement.

2.2.1 Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement, good cement is supposed to have the following physical properties;

I. Soundness of Cement

Soundness refers to the ability of cement to not shrink upon hardening; good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

II. Consistency of Cement

The ability of cement paste to flow is consistency. It is measured by vicat test.

III. Strength of Cement

There are three types of strength in which cement are measured; compressive, tensile and flexural. Various factors affect the strength, such as water-water ratio, cement – fine aggregate ratio, curing conditions size and shape of a specimen, manner of molding and mixing, loading conditions and age.

IV. Setting Time

Cement sets and hardens when water is added. This setting time can vary depending on multiple factors such as admixtures, chemical content, cement – water ratio and fineness of cement. Cement used in construction should have an initial setting time that is not too low & a final setting time not too high.

V. Loss of Ignition

Heating a cement sample at 900^{o}c – 1000^{o}c (i.e., until a constant weight is obtained) causes weight loss. This loss of weight upon heating is calculated as loss of ignition. Improper and prolonged storage or during transport or transfer may lead to pre-hydration and carbonation, both of which might be indicated by increased loss of ignition.

VI. Bulk Density

When cement is mixed with water, the water replaces areas where there would normally be air. Because of that, the bulk density of cement is not very important. Cement has a varying range of density depending on the cement composition percentage.

VII. Heat of Hydration

When water is added to cement, the reaction that takes place is called Hydration. Hydration generates heat, which can affect the quality of the cement and also beneficial in maintaining curing temperature during cold weather. On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress. The heat of hydration is affected most by C_3S and C_3A present in cement and also by water-cement ratio, fineness and curing temperature. Calculation of heat of hydration of Portland cement is to determine the difference between the dry and partially hydrated cement.

VIII. Fineness of Cement

The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

2.2.2 Chemical Properties of Cement

The raw materials for cement production are limestone (Calcium) sand or clay. (Silica) bauxite and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

I. Tricalcium Aluminate (C_3A)

Low content C_3A makes the cement sulfate resistant. Gypsum reduces the hydration of C_3A, which liberates a lot of heat in the early stages of hydration. C_3A does not provide any more than a little amount of strength.

II. Magnesiz (MgO)

The manufacturing process of Portland cement uses mangnesia as a raw material in dry process plants. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO – based cement also causes less CO_2 emission. All cement is to a content of 6% MgO.

III. Sulphur Trioxide

Sulfur trioxide in excess amount can make cement unsound.

IV. Iron Oxide/Ferric Oxide

Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

V. Free Lime

Free lime, which is sometimes present in cement, may cause expansion

VI. Silica fumes

This is added to cement concrete in order to improve a variety of properties especially compressive strength, abrasion resistance and bond strength. Though setting time is prolonged by the addition of silica fume. It can grant exception high strength. Hence, Portland cement containing 5 – 20% silica – fume is usually produced for Portland cement projects that require high strength.

VII. Alumina

Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical – resistant. It also quickens the setting but weakness the cement.

2.3 Water

Water is a substance composed of the chemical elements' hydrogen and oxygen and existing in gaseous, liquid and solid states. It is one of the most plentiful and essential of compounds. A tasteless and odorless liquid at room temperature, it has the important ability to dissolve many other substances. In small quantities water appears colorless, but water actually has an intrinsic blue color caused by slight absorption of light at red wavelengths. Water is so vital for all known forms of life, even though it provides no calories or organic nutrients.

Water, ice and snow are also central to many sports and other forms of entertainment, such as swimming, pleasure boating, boat racing, surfing sport fishing, diving, ice skating and skiing. Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. Water causes the hardening of concrete through a process called hydration. The role of water is important because the water to cement ratio is the most critical factor in the production of perfect concrete.

2.4 Aggregates

These are the inert materials that are mixed in fixed proportions with a binding material to produce concrete. These act as fillers or volume increasing components on one hand and are responsible for the strength, hardness, and durability of the concrete on the other hand. Aggregate takes up 60% - 90% of the total volume of concrete. Thus, concrete properties are highly affected by physical properties of its aggregate such as aggregate size distribution. Shape and grading of aggregates can significantly influence concrete workability. Poorly shaped and poorly graded aggregates generally show a lower packing density than well shaped and well graded aggregates, as a result more paste being required to fill the voids between aggregates.

As the more paste volume needed to fill the voids is reduced, the fluidity of the paste must be increased to maintain a given workability level. As poorly shaped aggregates show increased inter particle friction, resulting in reduced workability. The concrete mixtures having poorly shaped and poorly graded aggregates often require higher water and cementitious materials requirements than those with well-shaped and well-graded aggregates to maintain the same workability. The right selection of aggregates can minimize the increased water and cementitious materials contents needed to ensure adequate workability.

2.4.1 Qualities of Aggregates

I. It should be chemically inert i.e. they should not react with cement or any other aggregate or admixture.

II. It should possess sufficient toughness to bear impact and vibratory loads

III. It should be capable of producing an easily workable plastic mixture on combining with cement and water.

IV. It should be free from impurities; inorganic or organic in nature, which will affect adversely on its quality.

V. It should be strong enough to bear compressive and normal tensile loads in the ordinary mixture.

VI. It should possess sufficient hardness to resist scratching and abrasion in the hardened state.

2.4.2 Types of Aggregates

This is classified on the basis of their grain size, origin and density.

2.4.2.1 Classification based on grain Size:

I. Fine aggregates: The grain size lies between 4.75mm to 0.15mm. They pass-through from sieve with the mesh size of 4.75mm and are retained on a sieve of 0.15 mesh size. Sand is the most universally available natural fine aggregate.

II. Coarse aggregates: They are those that are retained on the sieve of mesh size 4.75mm, their upper size is generally around 7.5mm. Gravels from river bed are the best coarse aggregates in the making of common concrete. Situations may require suitable rock types to be crushed to the desired particle sizes for making coarse aggregates.

2.4.2.2 Classification based on origin:

I. Natural: They are those types of fine and coarse aggregates that are available in almost ready to use form, from natural resources. Examples are sand from river beds, pits and beaches, and gravels from river banks.

II. Bye Product: They are materials obtained as wastes from some industrial and metallurgical engineering operations which possess suitable properties for being used as aggregate. Examples are cinder obtained from burning of coal in locomotives and kilns and also slag is obtained from blast furnaces as scum is the best example from this category.

III. Processed: These form a special class in aggregates. Examples include; burnt clay, shale, vermiculites and perlite. They are essential ingredients of lightweight concrete.

2.4.2.3 Classification based on density:

I. Standard or normal: These types of aggregates give strength and weighting to the concrete of around 2300 to 2500kg/m^3

II. High Density: These ones are used in standard proportions yield in heavy weight concretes. Such concretes are especially useful as shields against x-rays and radiations in the atomic power plant. Examples are Baryle – a natural mineral with a specific gravity of 4.3 is an example.

III. Light Weight: They are natural and artificial materials of very low density so that the resulting concrete is also quite light in weight, generally within a range of 350 to 750kg/m^3.

They are specially used in sound proofing and fire proofing constructions. They are also used extensively in the manufacture of light weight pre-cast concrete blocks.

2.5 Concrete

Concrete in construction, structural material consisting of a hard, chemically inert particulate substance, known as aggregate (usually sand and gravel), that is bonded together by cement and water. Among the ancient Assyrians and Babylonians, the bonding substance most often used was clay. The Egyptians developed a substance more closely resembling modern concrete by using lime and gypsum as binders. Lime (Calcium oxide), derived from limestone, chalk or Oyster shells, continued to be the primary Pozzolanic, or cement - forming agent until the early 1800s. In 1824 an English inventor, Joseph Aspdin, burned and ground together a mixture of limestone and clay. This mixture, called Portland cement, has remained the dominant cementing agent used in concrete production. Concrete is characterized by the type of aggregate or cement used, by the specific qualities it manifests, or by the methods used to produce. Many other non-cementitious types of concrete exist with other methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concretes that use polymers as a binder. Concrete is distinct from mortar. Whereas, concrete is itself a building material, mortar is a bonding agent that typically holds bricks, tiles and other masonry units together. When aggregates are mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and mold into shape.

Concrete is one of the most frequently used building materials. Its usage worldwide is twice that of steel, wood, plastics and aluminum combined. Concrete is a brittle material, which exhibit low resistance to tensile stress. The failure of concrete at very low tensile force is attributed to the spreading of micro cracks, which are inherent in concrete due to heat formations in cement hydration. The compressive strength of concrete is generally dependent on the water to cement ratio, degree of compaction, ratio of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate (Ahmed., 2019). Concrete can be classified as a multi-phase composite material made up of three phases; namely the mortar, mortar/aggregate interface, and the coarse aggregate phase. The cause of failure is manifested by crack growth in the concrete. For normal concrete, the crack growth is mainly near the cement paste or at the aggregate/cement paste interfacial zone. The strength of concrete at the interfacial zone mostly depends on the integrity of the cement paste and the nature of the coarse aggregate.

2.6 Admixture

An admixture is a substance which can be added to concrete to achieve or modify its properties. Admixtures are added to the concrete, in addition to cement, water and aggregate, typically immediately before or during the mixing process. Admixtures are used to improve the behavior of concrete under a variety of conditions. The properties commonly modified using admixtures are setting time, workability, air - entrainment, dispersion etc. The admixture is generally added in relatively small quantity ranging from 0.005% to 2% by weight of cement. Overuse of admixtures has detrimental effects on the properties of concrete. Admixtures are natural or manufactured chemicals added to concrete before or after mixing.

They are used to mitigate difficult construction situations or to give fresh or set concrete certain properties. Admixtures can augment the workability, durability and strength of concrete, and resolve challenges presented by hot and cold temperatures, early-strength requirements or low water-to-cement specifications. Admixtures are of two main types: Chemical and Mineral.

2.6.1 Chemical Admixtures

Chemical admixture reduces the cost of construction; modify properties of hardened concrete, ensure quality of concrete during mixing, transporting, placing, curing and overcome certain emergencies during concrete operations. Some classifications;

2.6.1.1 Accelerating Admixtures:

These admixtures when added to concrete, mortar or grout increases the rate of hydration of hydraulic cement, shortens the time of set, and accelerates the hardening or development of strength of concrete / mortar. These admixtures function by interaction with C_3S (Tri-calcium silicate) component of the cement thus increasing the reaction between cement and water.

2.6.1.2 Retarding Admixtures:

This type of chemical admixture decreases the initial rate of reaction between cement and water and thereby retards the setting of concrete. It functions by coating the surface of C_3S (Tri calcium silicate) components, thus, delaying this reaction with the water. Reaction products are slow to form as such the setting and hardening of concrete are delayed reducing early compressive strengths. Since the rate of stiffening of concrete can be too fast in certain tropical climatic conditions, sufficient time for the concrete is required for transportation and placement before setting. In such conditions retarding admixtures can be very useful.

Retardation in setting time up to 8-10 hours is possible by suitable use of retarders. The delay in hardening caused by the retarders can be exploited to obtain an architectural finish of exposed aggregate: the retarder is applied to the interior surface of the formwork so that the hardening of the adjacent cement is delayed. This cement can be brushed off after the formwork has been struck so that an exposed aggregate surface is obtained.

2.6.1.3 Water Reducing Admixtures:

A material, which either increases workability of freshly mixed concrete without increasing water cement ratio or maintains workability with a reduced amount of water, is termed as water reducing admixture. As their name implies, the function of water reducing admixture is to reduce the water content of the mix, usually by 5 to 10%, sometimes (in concrete of very high workability) up to 15%.

Thus, the purpose of using a water reducing admixture in a concrete mix is to allow a reduction in the water cement ratio while retaining the desired workability or, alternatively, to improve its workability at a given water cement ratio. The actual reduction in water depends on dose of admixtures, cement content, type of aggregate used, ratio of cement, fine and coarse aggregate etc. Therefore, the trial mixes containing an actual material to be used on the job are essential to achieve optimum properties.

2.6.2 Mineral Admixtures

Some classifications;

2.6.2.1 Pozzolana admixtures:

The pozzolanic materials are essentially a siliceous or aluminous material which itself possessing cementitious properties, which will in finely divided form and in the presence of water, react with calcium hydroxide liberated in the hydration process to form compounds possessing cementitious properties. The pozzolanas can be replaced with cement by 10 to 35%. The substitution produces cement that is more permeable but more resistant to the action of salt, sulphate, or acid water. Strength gain is usually slower than normal concrete. The pozzolanic materials used as admixtures are: Natural pozzolana which are; Clay, Shale, Diatomaceous earth, Volcanic tuffs and Opaline cherts etc. while Artificial pozzolana are Fly ash, Surk,, Blast furnace slag, Silica fume, Rice fibre ash and Metakaolin etc.

2.6.2.2 Grouting admixtures:

Under different conditions grout mixtures of different qualities are required. Sometimes grout mixtures will be required to set quickly and sometimes will have to be in a fluid form for a longer period. Various admixtures used for grouting purposes are: Accelerators, Retarders, Plasticizers, Gas forming agents and Workability agents.

2.6.2.3 Bonding admixtures:

Bonding admixtures are usually water emulsions of organic materials including rubber, polyvinyl chloride, polyvinyl acetate, acrylics, styrene butadiene copolymers, and other polymers. They are added to Portland cement to increase the bond strength between old and new concrete.

Flexural strength and resistance to chloride-ion ingress are also improved. They are added in proportions equivalent to 5% to 20% by mass of the cementing materials; the actual quantity depending on job conditions and type of admixture used. Some bonding admixtures may increase the air content of mixtures. Non re-emulsifiable types are resistant to water, better suited to exterior application and used in places where moisture is present.

The ultimate result obtained with a bonding admixture will be only as good as the surface to which the concrete is applied. The surface must be dry, clean, sound, free of dirt, dust, paint, and grease, and at the proper temperature. Bonding agents should not be confused with bonding admixtures. Admixtures are an ingredient in the concrete; bonding agents are applied to existing concrete surfaces immediately before the new concrete is placed. Bonding agents help “glue” the existing and the new materials together. Bonding agents are often used in restoration and repair work; they consist of Portland cement or latex modified Portland cement grout or polymers such as epoxy resins.

2.6.2.4 Colouring admixtures

Natural and synthetic materials are used to colour concrete for aesthetic and safety reasons. Red concrete is used around buried electrical or gas lines as a warning to anyone near these facilities. Yellow concrete safety curbs are used in paving applications. Generally, the amount of pigments used in concrete should not exceed 10% by weight of the cement. Pigments used in amounts less than 6% generally do not affect concrete properties.

2.6.2.5 Corrosion inhibiting admixtures

These admixtures work for many years after the concrete has set, increasing the corrosion resistance of reinforcing steel to reduce the risk of rusting steel causing the concrete to crack and scale. The commonly used corrosion inhibiting admixtures are sodium benzonite and sodium nitrate.

CHAPTER THREE

MATERIALS AND METHOD

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. The structured experiments and testing were conducted in the Concrete Laboratory at Nnamdi Azikiwe University, Awka.

3.2 Methodology

The main aim of this experiment is to investigate the potential use of bamboo leaf ash and coconut fibre ash as a substitute material for cement. The cube size of 150mm x 150mm x150 mm is used to test the compressive strength of the concrete. The coarse aggregate and the fine aggregate were used. Tap water supplied from the laboratory was used during the study in the mixing, curing and other processes. Bamboo leaf and coconut fibre were collected from Nnamdi Azikiwe University, Awka, Anambra state in their natural state and were allowed to air dry for a few days and burnt in a burn barrel and in an open space, uncontrolled burning process in which the bamboo leaf and coconut fibre turned into ashes (black in color), and they were used as a substitute 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 bamboo leaf ash and coconut fibre 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 substituted ranged from 0%, 2.5%, 5%, 7.5% and 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 150mm x 150mm 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 and relative humidity not less than 70. 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 specimens 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
- Bamboo leaf ash
- Coconut fibre 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 Agu-Awka building materials market, Anambra state. It was spread in the laboratory to air dry.

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 Agu-Awka building materials market, 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 Bamboo Leaf Ash:

The bamboo leaf was obtained mostly behind stream. In this research the bamboo leaf was obtained at Ukwulu, Anambra state in a cold area as shown in plate 3.4. The leaf was then air dried for few days and burnt in an open space, uncontrolled burning process in which the leaf turned into ash (black in color). The quantity and fineness of Bamboo leaf ash was improved, by grinding until the median particles sizes were 225 microns

Plate 3.4 Bamboo leaf in its natural state

3.3.6 Coconut Fibre Ash:

Coconut fibre commonly known as coconut fibre is a natural fibre extracted from the outer fibre of coconut and it is mostly used in products such as floor mats, doormats brushes and mattresses etc. This material was obtained locally from Ukwulu in Dunukofia Local Government Area, Anambra State. It was properly sundried before it was burnt to ash.

Plate 3.5 Coconut fibre in its burnt state (ash).

3.4 Equipment

The equipment used were:

3.4.1 Universal testing machine

A universal testing machine (UTM) is a test machine used to test the mechanical properties of a sample by applying a tensile, compressive or transverse load. A universal test machine is designed to meet a wide range of tests by simply switching out different grips and fixtures.

Plate 3.6 Picture of a universal testing machine.

3.4.2 Measuring cylinder.

A graduated cylinder, also known as a measuring cylinder or mixing cylinder is a common piece of laboratory equipment used to measure the volume of a liquid. It has a narrow cylindrical shape. Each marked line on the graduated cylinder represents the amount of liquid that has been measured.

3.4.3 Burn barrel

Burn barrel means a metal container used to hold combustible of flammable waste materials so that they can be ignited outdoors for the purpose of disposal.

Plate 3.7 Picture of a burn barrel.

3.4.4 Concrete cube mould.

A concrete cube mold holds concrete during the curing process and can be easily dismantled so the molded concrete cube can then be either lab tested or kept in curing tank for quality control purposes.

Plate 3.8 Picture of concrete cube moulds containing fresh concrete.

3.4.5 Curing tank.

The concrete curing tanks are constructed of galvanized steel or heavy plastic. They are used for lab or field curing of concrete beams, cylinders, or other concrete specimens.

Plate 3.9 Picture of a curing tank containing concrete cubes left for curing

3.4.6 Tamping rod.

Tamping rods are dimensionally accurate rods used to tamp fresh concrete into concrete cylinder moulds and grout sample boxes to eliminate voids and excess air. It is used for compacting concrete into cube molds.

3.4.7 Weighing balance.

A weighing balance is an instrument which is used to determine the weight or mass of an object. These are also known as mass scales, weight scales, mass balance and weight balance.

Plate 3.10 Picture of a weighing balance.

3.4.8 Shovel.

Shovel is a tool used to dig as well as move loose, granular materials from one spot to another. In concrete work shovel is used to mix material components of the concrete.

Plate 3.11 Picture of a shovel

3.4.9 Trowel.

Trowel is a small tool with a flat blade that is used to smoothen a surface after the concrete has begun to set.

Plate 3.12 Picture of a trowel

3.5 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/m^3

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

Area of specimen = 150mm x 150mm = 22500mm^2

Density of concrete = mass of concrete / volume

Mass of one cube = Density x Volume = 2400Kg/m^3 x 0.003375m^3= 8.1Kg

Water/Cement ratio = 0.55

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

Compressive strength = P/A

Where:

P = Maximum load applied to the specimen (KN)

A = Surface area in contact with the plate (mm^2)

Compressive strength = $\frac{\text{compressiveload (N)}}{\text{Surfacearea (A) (mm2)}} = N/mm^2 \ldots \ldots \ldots \ldots eqn$ (1)

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 = 4.36Kg

<u>Mass of water with water/cement ratio of 0.55</u>

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 coconut fibre ash (CFA) and bamboo leaf ash (BLA) used were 0%, 2.5%, 5%, 7.5% and 10% by weight of Portland cement.

0% CFA& BLA replacement:

Cement content = 1.16kg CFA& BLA content= 0kg

2.5% CFA& BLA substitution = 2.5/100 x 1.16kg = 0.029kg

Cement content = 1.16kg CFA& BLA content= 0.029kg

5% CFA& BLA substitution = 5/100 x 1.16kg = 0.058kg

Cement content = 1.16kg CFA& BLA content= 0.058kg

7.5% CFA& BLA substitution = 7.5/100 x 1.16kg = 0.087kg

Cement content = 1.16kg CFA& BLA content= 0.087kg

10% CFA& BLA substitution = 10/100 x 1.16kg = 0.116kg

Cement content = 1.16kg CFA& BLA content= 0.116kg

The above calculations can be shown in the table below

Table 3.1 compositions for constituent materials for the bamboo leaf ash (BLA) concrete at 0%, 2.5%, 5%, 7.5% and 10%.

BAMBOO LEAF ASH %	**CEMENT %**	**BAMBOO LEAF ASH 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 compositions for constituent materials for the coconut fibre ash (CFA) concrete at 0%, 2.5%, 5%, 7.5% and 10%.

COCONUT FIBRE ASH %	CEMENT %	COCONUT FIBRE ASH 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 were added as a factor of safety.

3.6 Mixing Process

Mixing was carried out by the 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 bamboo leaf ash and coconut fibre 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 homogenous 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 leveled and smoothened with the aid of a trowel.

3.7 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.

3.8 Tests on Concrete

- Test on fresh concrete
- Test on hardened concrete

3.8.1. 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.

3.8.1.1 Concrete slump test

Principle

The concrete slump test is on empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete and this test was carried out in accordance with ASTM C143-05a. This test is popular due to the simplicity of apparatus used and simple procedure.

Apparatus

1. Slump cone

2. Ruler

3. Tamping rod

4. Spirit level

5. Trowel

Procedure

The mould for the slump test is a frustum of a cone, 300mm of height. The base is 200mm 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 screeding 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 cone 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 a ruler. 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 slump, 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.

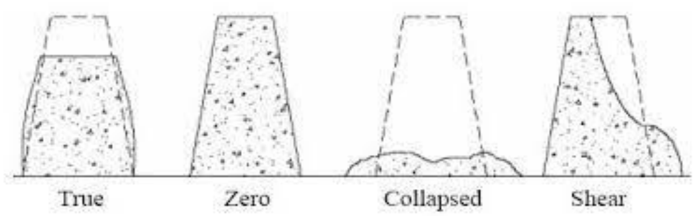

Figure 3.1 Different slump test results

3.8.2 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

3.8.2.1 Compressive strength test

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one can judge whether concreting has been done properly or not. The compression test was conducted by using compressive test machine at the Concrete Laboratory of Civil Engineering of Nnamdi Azikiwe University, Awka. The specimen dimension was taken before testing.

Procedure

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.

2. Take the dimension of the specimen to the nearest 0.2m.

3. Clean the bearing surface of the testing machine.

4. Place the smoothest side of the specimen in the machine in such a way that the loads shall be applied to the opposite sides of the cube.

5. Align the specimen centrally on the base plate of the machine.

6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

7. Apply the loads gradually without shock and continuously at the rate of 140Kg/cm/minute till the specimen fails.

8. Record the maximum load and note any unusual features in the type of the failure.

Note

- Average of their specimens gives the crushing strength of concrete.
- The maximum compressive load at the failure divided by the area of the specimen gives the compressive strength of concrete.

3.9 Sieve Analysis of Fine Aggregate

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

3.9.1 Apparatus Used

1. A set of IS sieves of sizes – 4.75mm, 2.00mm, 1.18mm, 850µm, 600µm, 425µm, 300µm, 100µm and 75µm.
2. Sensitive weighing balance

3. Mechanical shaker device
4. Wire brush and other miscellaneous apparatus

3.9.2 Procedure to Determine Particle Size Distribution of Aggregate

1. The test sample is dried to a constant weight temperature of 110 + 5°C and weighed.
2. The sample is sieved using a set of IS sieves agitated by the mechanical shaker.
3. On completion of sieving, the material on each sieve is weighed.
4. Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.
5. Fineness modulus is obtained by adding cumulative percentage of aggregates retained on each sieve and dividing the sum by 100.

3.9.3 Reporting of Results

The results should be calculated and reported as

1. The cumulative percentage by weight of the total sample.
2. The percentages by weight of the total sample passing through one sieve and retained on the next smaller sieve, to the nearest 0.1%. The results of the sieve analysis can be recoded graphically on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller than the specified diameter as ordinate. The values gotten from % on sieve are been added up to get 100, then you subtract 100 from the entire percentage on sieve to get % passing sieve.

3.10 Precautionary Measures

The precautionary measures that are carried out in this research were as follows;

- Wear adequate safety equipment such as waterproof gloves, a sturdy jacket, waterproof trousers and long boots.
- Ensure that all the internal surfaces of the metallic mold are cleaned by applying a release agent (condemn oil) so that the concrete is not damaged during the losing of the moulds.
- During casting, ensure that the concrete was properly compacted to avoid voids.
- Avoid error due to parallax during the slump test, when measuring the difference in height between the cone height band the slumped concrete with a measuring tape.

- Ensure that during the slump test that the frustum was firmly connected to its base to avoid any form of movement during tamping.
- Ensure that the concrete cubes and beams were fully submerged inside the water to facilitate good curing.
- Occasionally change the curing water when it got contaminated to terminate any chances of concrete being attacked by any form of impurity.
- The water in the curing tank was highly alkaline so ensure to use waterproof gloves when handling cubes in the tank.
- During the crushing test, ensured that the pointer in the machine deflected from a zero point to the maximum strength of the concrete specimen.
- Ensured that the concrete cubes were placed with the surfaces in contact with the platens of the crushing machine.
- Above all, ensure that all measurements are carefully carried out.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, various tests conducted on the specimen and results will be looked into. The present study aims to investigate the oxide composition of coconut fibre ash (CFA) and bamboo leaf ash (BLA) used, workability and compressive strength of coconut fibre ash (CFA) and bamboo leaf ash (BLA) as a substitute for ordinary Portland cement in concrete.

The cube specimens were cured and results were collected for 7, 14, 21 and 28 days with 2 specimens crushed for each day and the average of the two values taken. The mix ratio of the concrete is 1:2:4 and the size of aggregate used is 12mm with a water cement ratio of 0.55 maintained throughout the experiment. All the test methods were done as described in the chapter three of this thesis.

4.2 Chemical composition of coconut fibre ash (CFA) and bamboo leaf ash (BLA)

The result of the chemical analysis carried out on the coconut fibre ash (CFA) shows that its chemical composition constituted some metallic and nonmetallic oxides in different proportions. The various constituents were analyzed in accordance with ASTM C 618 -78. Table 4.1 shows the main elements (expressed as oxides) present in bamboo leaf ash (BLA) and coconut fibre ash (CFA).

Table 4.1 shows the oxide composition of CFA and BLA respectively.

Oxide	Percentage concentration (%)	
	CFA	BLA
CaO	57.101	12.51
SiO_2	8.035	51.99
Al_2O_3	2.122	10.10
Fe_2O_3	1.191	6.85
MgO	7.915	2.10
SO_3	3.32	2.74
K_2O	15.101	3.39

From the table, CFA contains 8.035% of SiO_2, 2.122% of Al_2O_3 and 1.191% of Fe_2O_3. This gives 11.348% of $SiO_2 + Al_2O_3 + Fe_2O_3$ which is below the ASTM C 618-78 requirement of 70% minimum for pozzolana. 8.035% of SiO_2 is less than 35% min of SiO_2 percent by mass required to classify it as a pozzolana. 7.915% of MgO is greater than 5% max required. 3.32% of SO_3 is more than 3% max of SO_3. It can therefore be said that the CFA used even though it possesses all the oxides composition of a pozzolana but the oxide percentages doesn't tally with ASTM C 618 -78 requirement.

4.3 Dry Sieve Analysis Results of Fine Aggregate Used

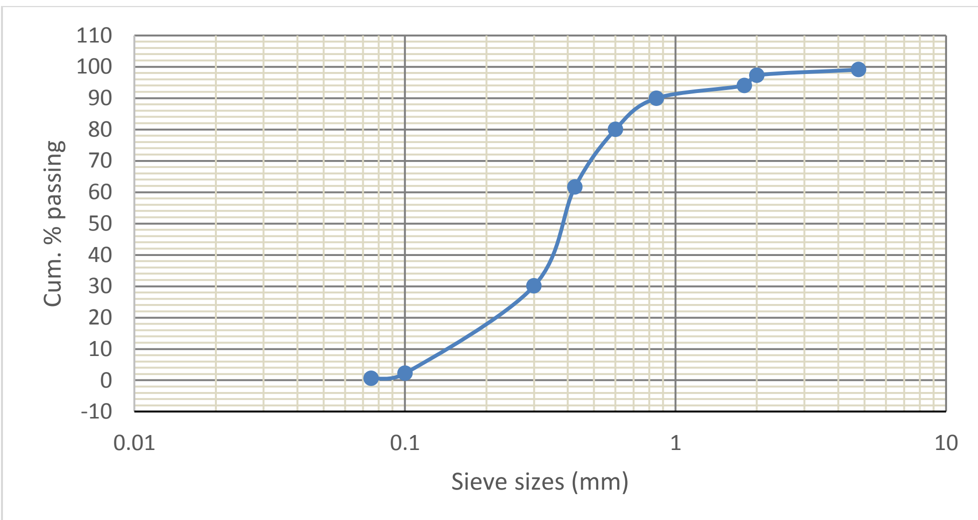

Figure 4.1: Particle size distribution analysis of fine aggregate

Calculations

Cumulative weight retained % = $\frac{\text{Cumulativeweightretained}}{\text{Totalweightofsample}} \times 100\%$

Cumulative weight passing % = 100% - Cumulative weight retained

D60 = particle size at which 60% of the particles are finer.

D30 = particle size at which 30% of the particles are finer.

D10 = Particle size at which 10% of the particles are finer.

From the particle size distribution graph of fine aggregate (sand);

D_{10} = 0.25 D_{30} = 0.35 D_{60} = 0.40

Cc = Coefficient of curvature = $D\,(_{30})^2/D_{10}$ X D_{60} = $0.35^2/$ (0.25 x 0.40) = 1.225mm

Cu = Uniformity coefficient = D_{60}/D_{10} = 0.40/0.25 = 1.6mm

For a well graded sand and gravel, Cc should lie between 1 and 3. But if its value is less than 1, it will be poorly graded. The value of Cc was 1.225mm and this means the sand is well graded.

Also if;

Cu <5 = very uniform

Cu = 5 = medium uniform

And Cu was gotten to be 1.6mm, so the sand is very uniform.

4.4 Workability Test Results

The results of the slump tests indicating the workability of the concrete for different percentage substitute of Portland cement with coconut fibre ash (CFA) and bamboo leaf ash (BLA) is shown in Table 4.3 and 4.4. Tests were done according to BS EN 12350-2 (16).

Table 4.3: Slump test result for Bamboo Leaf Ash (BLA)

SUBSTITUTE OF BLA (%)	SLUMP (mm)
0	81
2.5	77
5	74
7.5	68
10	63

Table 4.4: Slump test result for Coconut Fibre Ash (CFA)

SUBSTITUTE OF CFA (%)	SLUMP (mm)
0	82
2.5	71
5	64
7.5	58
10	52

From table 4.3 and 4.4 above, reduction in workability is evident with the increase in Bamboo leaf ash (BLA) and coconut fibre ash (CFA). The concrete slump decreases as the percentage of the BLA and CFA increased in the mixes. The table shows loss from 81 mm to 63mm when the BLA is included for 10%. While 82 mm to 52 mm when the CFA is included for 10%. This indicates that the moisture content of the mixture has decreased. When adding 2.5% - 5% of BLA and CFA, the slump loss is not so significant.

Hence, the more the BLA and CFA content, the more stiffened the mixture becomes. Super plasticizer may be used as water reducing agent in order to obtain high workability from coconut fibre and bamboo leaf according to earlier researchers.

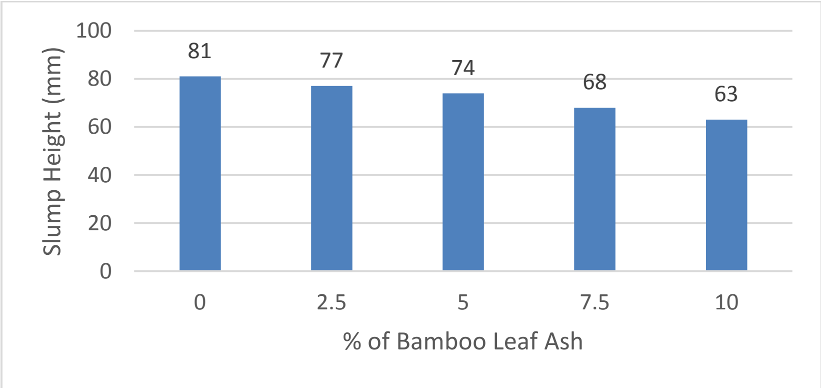

Figure 4.2 Slump Height Vs % of BLA

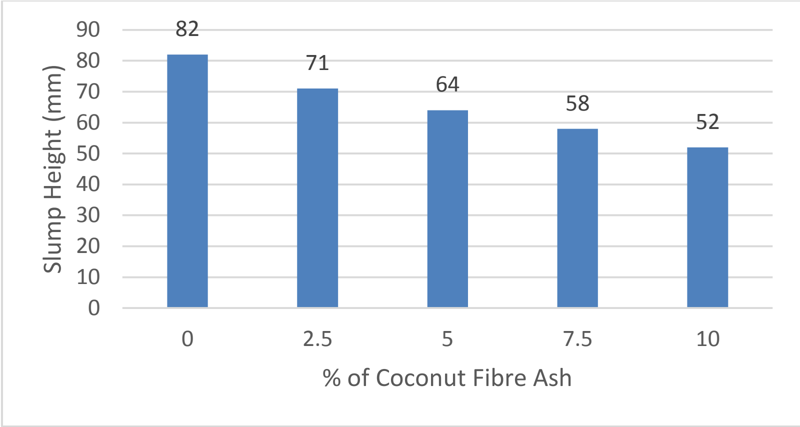

Figure 4.3 Slump Height Vs % of CFA

4.5 Compressive Strength Test Results

Compressive strength was assessed at the ages of 7, 14, 21 and 28 days of curing on 150 mm by 150mm by 150mm cube mortar specimens, as per means of compression testing machine at standard loading rate. The machine automatically stops when failure occurs and then displays the failure load. The compressive strength development in Portland cement and different percentages of CFA and BLA mortar specimens with curing period is shown in table 4.5 and 4.7

Table 4.6 Average Compressive Strength of Bamboo Leaf Ash Concrete at Different Ages

s/n	% Substituted	BLA			
		7 days	14 days	21 days	28 days
1	0	16.85	16.49	17.37	20.04
2	2.5	17.57	18.10	19.25	20.25
3	5	17.45	18.54	17.65	19.66
4	7.5	14.85	17.95	20.78	17.79
5	10	13.44	15.17	16.82	16.77

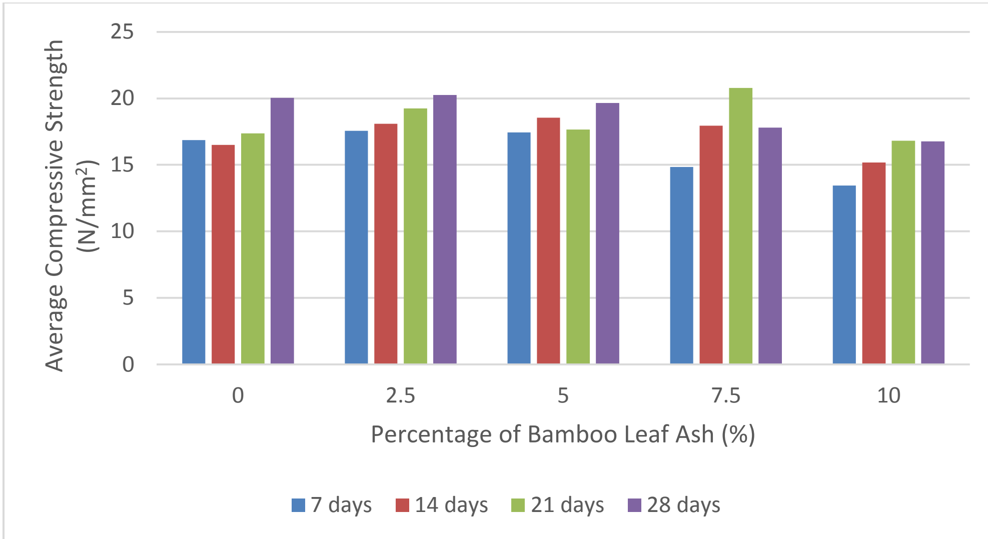

Figure 4.4 Average Compressive Strength (N/mm^2) Vs. Percentage of BLA

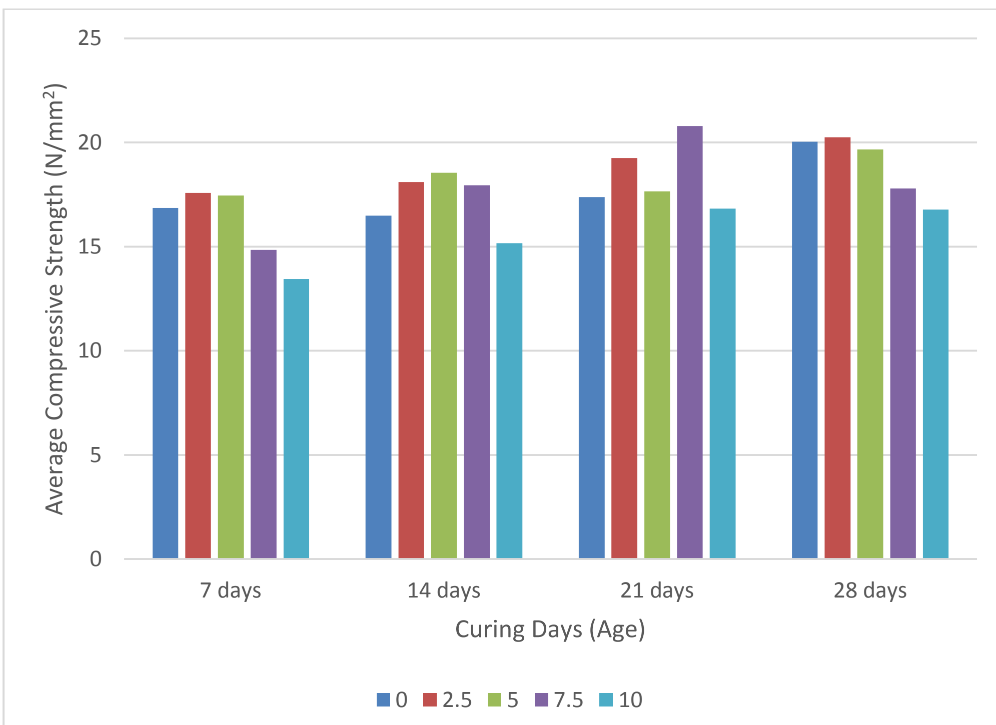

Figure 4.5 Average Compressive Strength (N/mm^2) Vs. Curing Days (Age)

Table 4.8 Average Compressive Strength of Coconut Fibre Ash Concrete at Different Ages

s/n	% Substituted	CFA			
		7 days	14 days	21 days	28 days
1	0	17.90	17.25	18.15	19.34
2	2.5	18.72	18.74	19.13	20.01
3	5	19.83	20.21	16.62	22.17
4	7.5	14.74	15.80	18.75	20.02
5	10	14.40	15.43	16.01	18.60

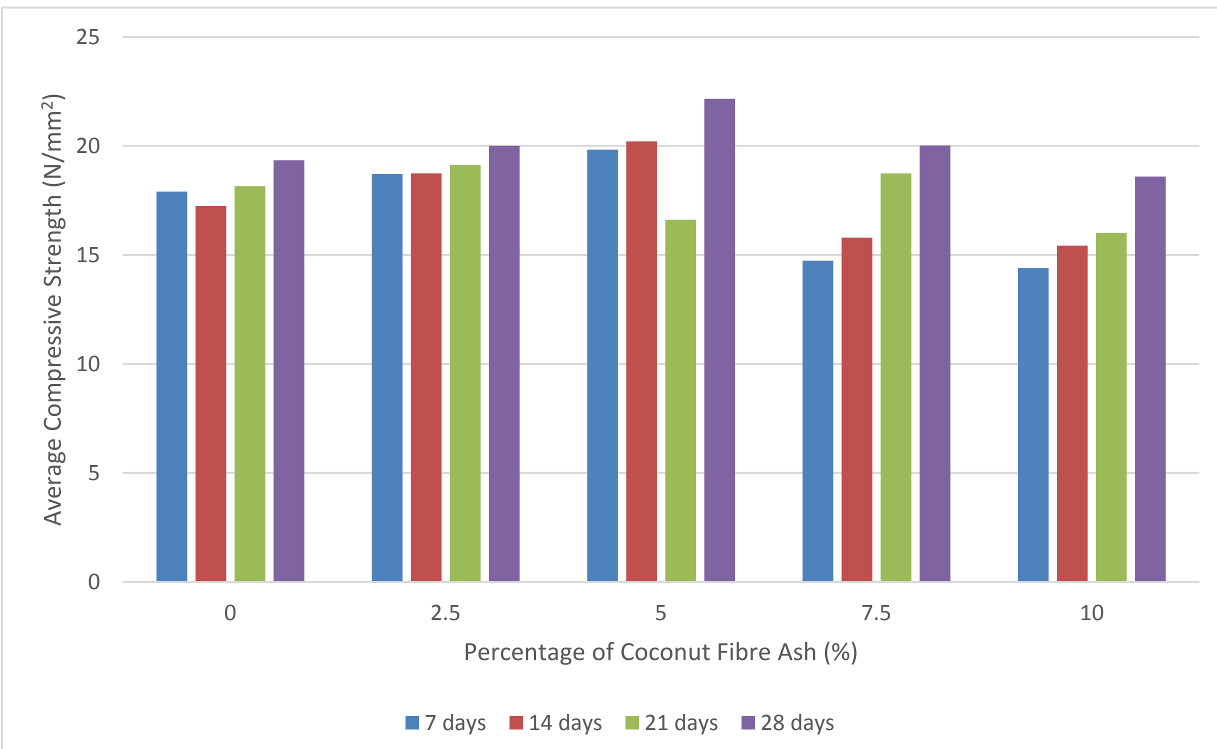

Figure 4.6 Average Compressive Strength (N/mm^2) Vs. Percentage of CFA

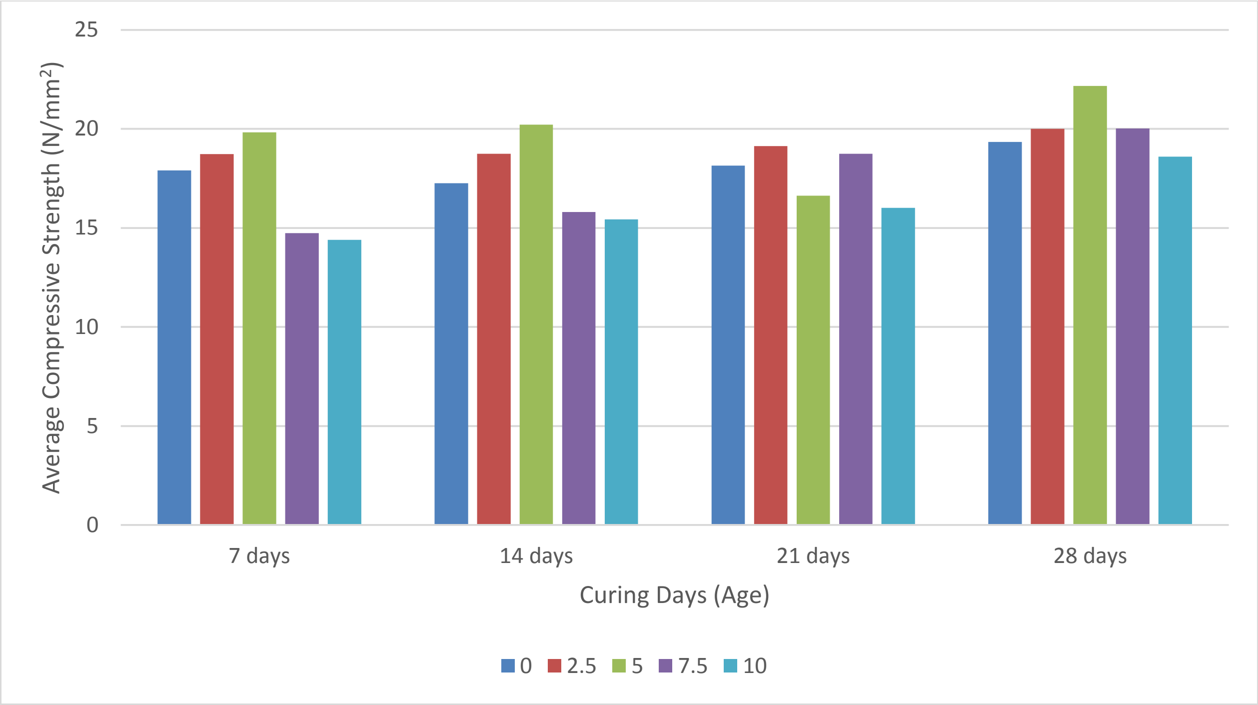

Figure 4.7 Average Compressive Strength (N/mm^2) Vs. Curing Days (Age)

4.6 Effect of Bamboo Leaf Ash (BLA) and Coconut Fibre Ash (CFA) as a Substitute for Cement on Compressive Strength

The compressive strength decreases with increase in the percentage substitution of bamboo leaf ash (BLA) and coconut fibre ash (CFA) for all the curing time as shown in figure 4.4 and figure 4.6.

From the table 4.5, For 7 days curing period, compressive strength decreased from 16.85 N/mm^2 at 0% to 13.44 N/mm^2 at 10% substitute of bamboo leaf ash (BLA), and 17.90 N/mm^2 at 0% to 14.74 N/mm^2 at 7.5% substitute of coconut fibre ash (CFA) from table 4.6.

At 14 days curing period, compressive strength decreased from16.49 N/mm^2 at 0% substitute to 15.17 N/mm^2 at 10% substitute of bamboo leaf ash. While 17.25 N/mm^2 at 0% substitute to 15.80 N/mm^2 at 7.5% substitute of coconut fibre ash (CFA).

Also at 21 days curing period, compressive strength decreased from 17.37 N/mm^2 at 0% to 16.82 N/mm^2 at 10% substitute of bamboo leaf ash (BLA) and 18.15 N/mm^2 at 0% to 16.0 N/mm^2 at 10% substitute of coconut fibre ash (CFA).

Finally, at 28 days curing period compressive strength decreased from 20.04 N/mm^2 at 0% substitute of bamboo leaf ash to 16.77 N/mm^2 at 10% substitute of bamboo leaf ash. and 19.34N/mm^2 to 18.60N/mm^2 substitute of coconut fibre ash.

It can therefore be said conclusively that compressive strength decreases with increase in the percentage of substitution of bamboo leaf (BLA) and coconut fibre ash (CFA).

4.7 Effect of Curing Time on Compressive Strength

The compressive strength increases at all percentage substitution with curing time as seen in the figure 4.4 and figure 4.6.

At 0% substitution of bamboo leaf ash (BLA) compressive strength increased gradually from 16.85 N/mm^2 at 7 days to 20.04 N/mm^2 at 28 days. For 2.5% substitution of coconut fibre ash also, compressive strength increased from 18.72 N/mm^2 at 7 days curing time to 20.01 N/mm^2, and 17.57 N/mm^2 at 7days to 20.25N/mm^2 at 28 days' bamboo leaf ash substitution.

At 5% substitution of coconut fiber ash, compressive strength increased from 19.83 N/mm^2 at 7 days to 22.17 N/mm^2 at 28 days while 17.45 N/mm^2 to 19.66 N/mm^2 for bamboo leaf ash substitution.

At 7.5% substitution of CFA, Compressive strength increased from 14.74% N/mm^2 at 7 days to 20.02 N/mm^2 at 28 days while 14.85 N/mm^2 at 7 days to 17.79 N/mm^2 at 28 days bamboo leaf ash (BLA) substitution.

Finally, it was observed that at 10% substitution of coconut fibre ash compressive strength increased from 14.40 N/mm^2 at 7 days curing to 18.60 N/mm^2 at 28 days curing period while 13.44N/mm^2 at 7 days to 16.77 N/mm^2 at 28 days substitution of bamboo leaf ash.

It can therefore be said conclusively that giving more time for curing concrete cubes the compressive strength increases.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

The effectiveness of coconut fibre ash (CFA) and bamboo leaf ash (BLA) in enhancing the performance of concrete was compared with normal concrete. All the plain and ash mixed concrete were designed with a fixed proportion (1:2:4) and also with the same type and size of materials. The only variable parameter is in the CFA and BLA content which was done by the substitution of 2.5% - 10% by weight of Portland cement to the concrete mix. Results obtained in the test were the effect of substitute of Portland cement with CFA and BLA on compression test and workability (slump test).

5.0.1 Workability

The workability of coconut fibre ash and bamboo leaf ash mixed with concrete decreases with the increase in ash content of the concrete mix. This is due to the water absorption characteristics of CFA and BLA during the mixing process and thus gave low slump during the slump test. The tests also show that with high ash content, the mixture got stiffer, causing a reduction in the consistency of the mixture. Consistency is a function of workability.

5.0.2 Compressive Strength

The study on CFA and BLA-Portland cement substituted concrete cubes under compression test shows that, substituting 7.5% of Portland cement with CFA and BLA to the concrete mix decreases the strength of the composite. The result shows that the composite had high early strength and low final strength at 7.5% CFA and BLA when compared to the control. And also the strength from 7.5% - 10% is found to decrease. This may be due to segregation and voids that exist in the composite due to excess addition of coconut fibre ash (CFA) and bamboo leaf ash (BLA).

5.1 Recommendations

This study has its own limitations and the following recommendations are made for further studies to improve the current work on coconut fibre ash (CFA) and bamboo leaf ash substituting Portland cement.

1. The study was conducted using 2.5% - 10% of CFA and BLA to substitute Portland cement. It is recommended to use different percentages in other to get the optimum percentage of finely crushed CFA and BLA that substitute’s fine aggregate.
2. It is recommend that future studies should be done for a longer period of time asides the 28 days used in this project in order to observe the maximum effects of CFA and BLA because when used for construction, it is essential that the material used are long lasting.
3. It is recommended that more tests be done to find out the effects of CFA and BLA concrete on other properties of concrete.
4. This study was also done using a fixed proportion of mix. I recommend that different mix ratios should be used in further investigations in order to maximize the optimum CFA and BLA.
5. It is recommended that future studies should be done to determine the characteristics of CFA and BLA during hydration process as the hydration process plays the most important role in strength development.

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APPENDICES

APPENDIX I

Table 4.2: Sieve analysis results

SIEVE SIZE (mm)	WEIGHT OF SAMPLE RETAINED (g)	% OF WEIGHT RETAINED (%)	CUMMULATIVE (%) RETAINED	% PASSING
4.750	4.700	0.940	0.940	99.060
2.000	8.840	1.768	2.708	97.292
1.800	16.260	3.252	5.960	94.040
0.850	20.430	4.086	10.046	89.954
0.600	49.570	9.914	19.960	80.040
0.425	92.570	18.412	38.372	61.628
0.300	154.13	30.826	69.198	30.802
0.100	143.01	28.602	97.800	2.200
0.075	8.050	1.610	99.410	0.590
PLATE	1.300	0.260	99.670	0.330
TOTAL	499.98	99.670		0

Initial weight of sample used = 500g

APPENDIX II

COMPRESSIVE STRENGHT RESULTS OF CONCRETE

Table 4.5 Compressive strength of hardened concrete for Bamboo Leaf Ash (BLA)

SPECIMEN		WEIGHT AFTER CURING (KG)		AVERAGE WEIGHT (KG)	CROSS SECTIONAL AREA(mm^2)	COMPRESSIVE STRENGTH (N/MM^2)		AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
0% OF BLA	TIME	C1	C2		(150 X 150)	C1	C2	
	7 days	8.4	8.2	8.3	22500	15.70	18.00	16.85
	14 days	8.2	8.3	8.25	22500	17.42	15.56	16.49
	21 days	8.5	8.1	8.3	22500	18.74	16.00	17.37
	28 days	8.3	8.4	8.35	22500	21.48	18.60	20.04
2.5% OF BLA	7 days	8.4	8.1	8.25	22500	18.78	16.35	17.57
	14 days	8.2	8.0	8.1	22500	16.40	19.80	18.10
	21 days	8.1	8.3	8.2	22500	19.00	19.50	19.25
	28 days	8.0	8.1	8.05	22500	20.60	19.90	20.25
5 % OF BLA	7 days	8.0	8.6	8.3	22500	18.40	16.50	17.45
	14 days	8.5	8.3	8.4	22500	19.43	17.65	18.54
	21 days	8.1	8.4	8.25	22500	14.60	20.70	17.65
	28 days	8.2	8.0	8.1	22500	21.76	17.56	19.66
7.5% OF BLA	7 days	8.1	8.3	8.2	22500	15.50	14.20	14.85
	14 days	8.4	8.2	8.3	22500	17.90	18.00	17.95
	21 days	8.2	8.1	8.15	22500	21.76	19.80	20.78
	28 days	8.6	8.2	8.4	22500	16.87	18.70	17.79
10% OF BLA	7 days	8.3	8.4	8.35	22500	11.89	14.99	13.44
	14 days	8.2	8.1	8.15	22500	13.65	16.69	15.17
	21 days	8.0	8.3	8.15	22500	15.58	18.05	16.82
	28 days	8.4	8.5	8.45	22500	15.89	17.65	16.77

Table 4.7 Compressive strength of hardened concrete for Coconut Fibre Ash (CFA)

SPECIMEN		WEIGHT AFTER CURING (KG)		AVERAGE WEIGHT (KG)	CROSS SECTIONAL AREA(mm^2)	COMPRESSIVE STRENGTH (N/MM^2)		AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
0% OF CFA	TIME	C1	C2		(150 X 150)	C1	C2	
	7 days	8.2	8.1	8.15	22500	16.80	19.00	17.90
	14 days	8.3	8.4	8.35	22500	18.26	16.23	17.25
	21 days	8.5	8.1	8.3	22500	19.29	17.00	18.15
	28 days	8.3	8.0	8.15	22500	19.89	18.79	19.34
2.5% OF CFA	7 days	8.2	8.4	8.3	22500	17.86	19.58	18.72
	14 days	8.1	8.3	8.2	22500	17.96	19.52	18.74
	21 days	8.2	8.4	8.3	22500	15.28	22.98	19.13
	28 days	8.2	7.3	7.75	22500	18.59	21.43	20.01
5 % OF CFA	7 days	8.5	8.0	8.25	22500	18.97	20.69	19.83
	14 days	7.9	8.1	8.00	22500	19.66	20.76	20.21
	21 days	8.3	8.1	8.20	22500	14.98	18.26	16.62
	28 days	8.4	8.3	8.35	22500	24.58	19.76	22.17
7.5% OF CFA	7 days	8.3	8.3	8.30	22500	13.98	15.50	14.74
	14 days	8.1	8.3	8.20	22500	15.57	16.02	15.80
	21 days	8.4	8.1	8.25	22500	19.27	18.23	18.75
	28 days	8.2	8.4	8.30	22500	20.32	19.71	20.02
10% OF CFA	7 days	8.1	8.3	8.20	22500	15.74	13.06	14.40
	14 days	8.9	8.0	8.45	22500	16.23	14.62	15.43
	21 days	8.1	8.4	8.25	22500	17.52	14.50	16.01
	28 days	8.3	8.4	8.35	22500	18.7	18.5	18.60

AVERAGE COMPRESSIVE STRENGHT RESULTS OF CONCRETE WITH BLA

Two cubes per crush

7 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% BLA	2.5% BLA	5% BLA	7.5% BLA	10% BLA
C1	15.70	18.78	18.40	15.50	11.89
C2	18.00	16.35	16.50	14.20	14.99
Average	16.85	17.57	17.45	14.85	13.44

14 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% BLA	2.5% BLA	5% BLA	7.5% BLA	10% BLA
C1	17.42	16.40	19.43	17.90	13.65
C2	15.56	19.80	17.65	18.00	16.69
Average	16.49	18.10	18.54	17.95	15.17

21 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% BLA	2.5% BLA	5% BLA	7.5% BLA	10% BLA
C1	18.74	19.00	14.60	21.76	15.58
C2	16.00	19.50	20.70	19.80	18.05
Average	17.37	19.25	17.65	20.78	16.82

28 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% BLA	2.5% BLA	5% BLA	7.5% BLA	10% BLA
C1	21.48	20.60	21.76	16.87	15.89
C2	18.60	19.90	17.56	18.70	17.65
Average	20.04	20.25	19.66	17.79	16.77

AVERAGE COMPRESSIVE STRENGHT RESULTS OF CONCRETE WITH CFA

Two cubes per crush

7 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% CFA	2.5% CFA	5% CFA	7.5% CFA	10% CFA
C1	16.80	17.86	18.97	13.98	15.74
C2	19.00	19.58	20.69	15.50	13.06
Average	17.90	18.72	19.83	14.74	14.40

14 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% CFA	2.5% CFA	5% CFA	7.5% CFA	10% CFA
C1	18.26	17.96	19.66	15.57	16.23
C2	16.23	19.52	20.76	16.02	14.62
Average	17.25	18.74	20.21	15.80	15.43

21 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% CFA	2.5% CFA	5% CFA	7.5% CFA	10% CFA
C1	19.29	15.28	14.98	19.27	17.52
C2	17.00	22.98	18.26	18.23	14.50
Average	18.15	19.13	16.62	18.75	16.01

28 Days curing

COMPRESSIVE STRENGTH (N/mm^2)	0% CFA	2.5% CFA	5% CFA	7.5% CFA	10% CFA
C1	19.89	18.59	24.58	20.32	18.70
C2	18.79	21.43	19.76	19.71	18.50
Average	19.34	20.01	22.17	20.02	18.60