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RESEARCH ARTICLE OPEN ACCESS

Partial Replacement of Cement with Banana Fibre in Concrete

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Abstract:

The effect of glass fibre on flexural strength, split-tensile strength and compressive strength was studied for different fibre content Banana trunk is cut layer by layer and bum in furnace with four different percentage compositions of banana fiber and fly ash. A total of 12 cubes with 150 mm x 150 mm x 150mm were used to determine the strength of concrete using banana fiber ash. All this specimens is cure for 7, 28 and 90 days using water curing method. 0.5% to 2% of banana fiber ash is added with fly ash 0-20% by weight. The materials use in my study is banana fiber ash, sand, cement, coarse aggregate, and water. The result analysis shows, the mix with 10% replacement of cement with fly ash achieved the maximum value of splitting tensile strength of 2.4 and 3.2 N/mm2 corresponding to 28 and 90 days of curing periods respectively. It was also concluded that specimen containing 10% replacement of cement with fly ash recorded increase in compressive strength of 27 N/mm^2& 29 N/mm^2 over the control specimen at 28 and 90 days of curing respectively. Specimens with 10% and 20% replacement of cement with fly ash achieved higher flexural strength than the plain concrete.

Introduction

Fibers are broadly classified into man-made and natural fibers. Man-made fibers are made from synthetic materials like steel and natural polymers while natural fibers originate from vegetable, animal and mineral sources. Presently, the use of natural fibers in composites is preferred over manmade fibers due to their numerous advantages, which include light weight, high strength to weight ratio, corrosion resistance and other advantages such as biodegradability, low cost and wide spread availability.

According to Rawi & khafagy many investigations have already been carried out on various mechanical properties and physical performance of concrete materials using natural fibers from coconut husk, sisal, hemp, sugar cane biogases, bamboo, jute, wood and other vegetable fibers and these investigations showed encouraging commercial prospects of these new materials for application in low cost housing construction.

It is interesting to note that natural fibers such as jute, coir, banana, sisal, etc are abundantly available in developing countries like India, Sri Lanka, and some of the African countries but are not optimally utilized. At present these fibers are used in a conventional manner for the production of yarns, ropes, mats, and matting as well as in making articles like wall hangings, table mats, handbags, and purses.

1.3 Objective

The general objective of this study is to investigate the compressive strength of concrete banana fiber as cementitious to produce high strength concrete with different temperature. The specific objectives of this study were:

To measure the compressive strength of concrete using banana fiber ash as waste agriculture with various temperature.

To measure the chemical properties of banana fiber ash burning with different temperatures as cement replacement.

To reduce cement consumption replace a portion of a Portland cement, a High energy product material, with fly ash, a by-product of power plants, to reduce the environmental impact of cement production.

Utilize agricultural waste a incorporate banana fiber, an abundant agricultural waste product, into concrete to minimize waste disposal issues.

1.4 Scope of Work

This study is conducted to investigate the optimum temperature and measure the strength of concrete using banana fiber ash. In addition, natural fiber, ash is an excellent potential to improve the performance of concrete. The scope of work mainly focuses on:

In this research, compressive strength test was conducted to determine the strength of concrete with three different temperatures.

Banana trunk was cut layer by layer and burnt in furnace with three different temperatures that is 400°C, *500°C,* and 600°C.

A total number of 12 cubes with (150 mm X 150 mm X 150mm) were used to determine the compressive test as shows in Table 1.1 below.

All this mixture is cured for 7 days, 14 days and 28 days which will be performed at the concrete laboratory of Civil Engineering using water curing method.

0.5 to 2% of banana fiber ash was use to replaced the cement by weight.

The materials use in this study is banana fiber ash, sand, cement, coarse aggregate, and water.

Table 1.1: Number of Samples and Test.

Composition of banana fiber	0.5%	1%	2%
Fly ash	0 %	10%	20%

ring	7	14	28	7	14	28	7	14	28
Total simples	12								

Literature Review:

The purpose of this chapter is to study and analyze the previous study that has been done earlier through journals, articles, research papers and also thesis. This chapter will review more detail regarding banana fiber ash, its advantages and analyze more valuable information.

2.5 Properties Of Banana Fiber Ash

According to ***Rodrigo C.K et al.*, (2014),** banana fiber ash can be use to produce concrete and mortar which can be classified to have cementitious properties. He used banana leaf as part of component material instead of using banana trunk. Almost *95* million tons of banana waste was produce since 2012. Banana fiber ash can be classified as pozzolanic material in civil engineering construction with several benefits such as lower cost and give equivalent reduction to environmental impact. The banana leaf ash has been proved to increase the strength of concrete and demonstrate pozzolanic activity by replacing 10% of banana leaf ash into the concrete Rodrigo C.K et al., (2014). The process to produce banana fiber ash is by burning the banana leaves with 900°C for 24 hour in air. Then, the material was ground in Marconi ball mill with capacity of *351* rpm for 30 minutes and was sent to laboratory to determine the physical and chemical properties of banana fiber ash. Table 2.1 below show the chemical compositions found in banana leaves ash.

Table 2.1: Chemical Compositions in Banana Leaves Ash

Parameter Composition	Symbol	Banana Leaves Ash (%)
Silicon Dioxide	$Si0_2$	48.7
Iron Oxide	Fe_20_3	1.4
Aluminum Oxide	Al_20_3	2.6
Sodium Oxide	Na_2O	0.21
Loss of Ignition	LOI	*5.06*

From Table 2.1 above, the chemical composition that can be found inside banana fiber ash are Silicon Dioxide ($Si0_2$), Iron Oxide (Fe_20_3), Aluminium Oxide (Al_20_3), Sodium Oxide (Na_2O), and also Loss of Ignition (LOI). The highest chemical composition that can be found in banana fiber ash is SiO2 which has 48.7% composition. The Silicon Dioxide (SiO_2) is very important chemical composition that must have in every pozzolanic material because it will react with calcium hydroxide at an ordinary temperature to form compound that has cementitious properties. This reaction will produce calcium silicate hydrate gel and it is used to fill the void inside the concrete as well as increase the strength of concrete. The lowest composition that can be found in banana fiber ash is Sodium Oxide (Na_2O) which is 0.21%.

Gram performed tensile tests on fibers subjected to a concentrated solution of calcium hydroxide and found that the tensile strength was substantially reduced. He also found that in carbonated concrete with a pH of less than 9, fibres preserved their flexibility and strength, but in non-carbonated zones, the fibers were fragile. The work recommended the reduction of water-cement ratio and the use of high content of silica fume as a solution. Silica fume was observed to be highly reactive and reduces alkalinity of the cement paste down to a pH of 9-10.

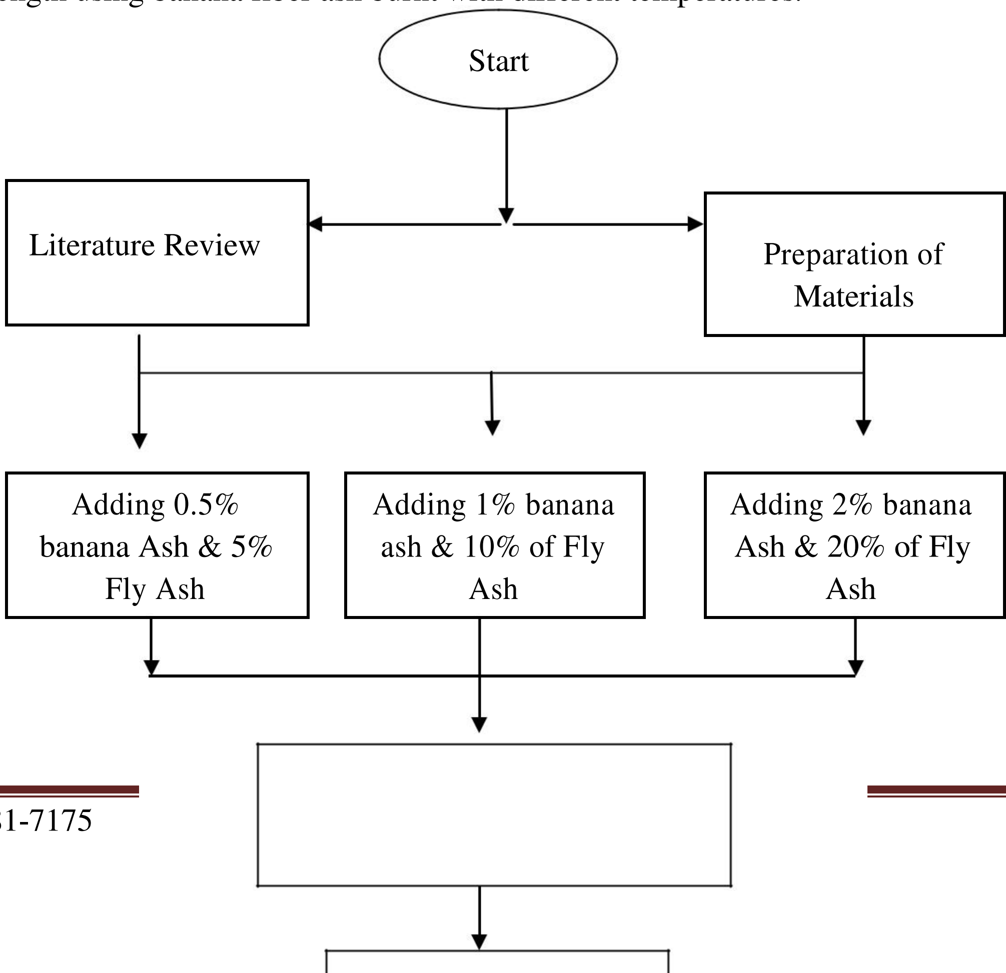
However, ***Juarez, Duran, Valdez and Fajardo*** observed that silica fume is expensive and the reduced alkalinity can pose a corrosion problem for the steel reinforcement. As a result of the observed deficiency of silica fume, obtaining a denser matrix by reducing the water cementious ratio and adding fly ash (pozzolanas) which is cheaper and less reactive compared with silica fume was recommended. The addition of fly ash to cementitious composite results in a denser matrix while maintaining its alkalinity. Fly ash also reduces the cement requirement for the same concrete strength thereby saving the raw materials such as limestone and coal required for cement manufacture. Less requirement of cement means less emission of carbon dioxide as a result of cement manufacture and reduction in green house gas emission. It results also to saving in the cost of concrete.

Fly ash is presently available in Nigeria as waste product of electricity generation plant in Oji River, Enugu State, Nigeria. This material could be utilized in natural fiber reinforced concrete to improve the durability of the composite and also reduce the cost of concrete and in turn housing production. This study therefore investigates the mechanical properties of banana fiber reinforced concrete when cement is partially replaced with fly ash.

RESEARCH METHODOLOGY

3.1 General

The experimental procedures, material use, preparation of materials, and apparatus, Regarding my research will be discussed further in this chapter. This research was focused on Compressive strength using banana fiber ash burnt with different temperatures.



Tests after 7 days, 28
days& 90 days

Results

Research Methodology

3.2 Material Used

Water:

Water is transparent fluid and also a major constituent of fluid of the livingthing. In mixing process, water must be clean from injurious of substances such as oil, acid, alkalis or other organic material. Portable water, such as water in wells is accepted to be mix in mortar. The other characteristic of water that can be used is water that containing pH value less than 6.Seawater containing up to 35,000 parts per million 11 (ppm) of dissolved salts is generally suitable mixing water for unreinforced concrete.

3.2.6 Banana Fiber:

Banana fiber is a characteristics fiber. The natural banana fibredisplays some of the important advantages like low thickness, stiffness and mechanical properties and high sustainability and disposal. The different tests conducted on Banana fiber and the results obtained are tabulated in table 3.4.

Fig. 3.6: Banana Fiber

Table 3.4: Mechanical Property of Banana Fiber

S. No	Test conducted	Result
1	Fineness	17.15
2	Moisture regain	13%
3	Tenacity	. 29.98 g/denier
4	. Elongation	6.54

3.3 Preparation of Materials

In this research, Ordinary Portland Cement (OPC), water, fine aggregate, course aggregate and also banana fiber ash were used in experimental work.

Cement is widely use in our country and it is use to hold concrete together. Ordinary Portland Cement (OPC) was manufactured in four types of processes that is,

Quarrying process.

Raw material preparation

Clinkering and

Cement milling.

In quarrying process, limestone and cement rock are use. These materials contain Lime (CaCO3), Silica (SiO2), Alumina (Al203) and Ferrous Oxide (Fe203). In clinkering process, the raw materials were heated in kiln at very high temperature to produce Tricalcium Silicate (3CaOSiO2), Dicalcium Silicate (2CaOSiO2), Tricalcium Aluminate (3CaOAL203), and also Tetracalcium Alumino-Ferrate (4CaOAL203Fe2O2). In cement milling process, the clinker will be crush to a fine powder to form cement.

Table 3.5 shows the percentage of chemical composition for Portland cement. He highest percentage of chemical composition for Portland cement is Calcium Oxide (CaO) which is 60-67% followed by Silica (SiO_3), 18-25% and Alumina (AL_2O_3), 3-8% The lowest percentage of chemical composition for Portland cement was Sodium (Na_2O) which is 0.13%, followed by Potassium Oxide 0.72% and Sulphur Trioxide (SO_3), 2.4%.

Table 3.5: Percentage of chemical composition of Portland cement.

Chemical Composition	Percentage

CaO	60-67%
SiO_2	18-25%
Al_2O_3	3-8%
Fe_2O_2	0.5-6%
MgO	0.1-4%
SO_3	2.4%
Na_2O	0.13%

3.2.1 Cement: For this experimental investigation OPC 43 grade cement has been used and the cement is tested as per IS 4031- 1988. The different tests conducted on cement and the results obtained are tabulated in table 3.1,

Table 3.1: Physical property of cement

S. No	Test conducted	Results	Requirements as per IS:8112-1989
1	Initial setting time	38 minutes	Shall not be less than 30 minutes
2	Final setting time	605 minutes	Shall not be less than 600minutes
3	Normal consistency	32%	26%-33%
4	Specific gravity	3.12	3.15
5	Bulk density	1440	Not specified

Fig. 3.2: Ordinary Portland cement grade 43.

Results and Discussions

4.1 General

Banana fibers used in this study were extracted from the stems of harvested banana plants. The specie of banana used in this study was musa acuminate (Modern banana). The fibers were extracted by water retting method. Mature banana pseudo-stem obtained from farm were cut to lengths of about 500mm and were totally submerged in clean water fit for drinking for a period of six weeks, after which the stems were removed from the water, loosened and washed in a tank of clean water. The fibers were subsequently sun dried and further loosened by manual combing. This process allows for biodegradation of the banana pseudo-stems that separates the fibers from the pith. The extracted fibers were later chopped to lengths of 30mm ready for the experiments. The properties of banana fiber used in this study were determined and presented in Table 4.3. Fly ash concrete of grade 25 was designed according to the specifications mix design method (British method). Fly ash was used to replace cement at various levels of 0%, 10%, 15% & 20% by mass of binder. Banana fibres of 30mm length and volume fraction of 0.5%, 1%, 1.5% & 2% were used in all mixes being the optimum values obtained by Anowai and Job for grade 25 concrete.

Batching, mixing and casting were done adopting a careful procedure. The fine aggregates and coarse aggregates were accurately weighed first. The required volume fractions of the banana fibres were computed and weighed out ready for mixing. The concrete mixing was done by hand mixing on a water tight platform. The coarse and fine aggregates were firstly mixed thoroughly, to this mixture, the required quantity of cement and fibers were added. These were then mixed to a uniform color. For mixture in which Portland cement was partially replaced with fly ash, the fly ash and cement were mixed dry to uniform color separately.

The required amount of water were weighed and added carefully so that no water was lost during mixing. The required dosage of super plasticizers was added in steps, and then the whole constituents mixed for proper time until uniform dispersion of fibers was achieved. The moulds were oiled and filled with the mixtures. Mechanical vibration using table vibrator was adopted. The top of surface of the specimen were leveled and finished. After setting for 24 hours, the specimens were remolded and were transferred to the curing tank where in they were allowed to cure for 7days, 28 days and 90 days.

Properties of Banana Fiber Ash

According to Rodrigo C.K et al., (2014), banana fiber ash can be use to produce concrete and mortar which can be classified to have cementitious properties. His used banana leaf as part of component material instead of using banana trunk. Almost *95* million tons of banana waste was produce since 2012. Banana fiber ash can be classified as pozzolanic material in civil engineering construction with several benefits such as lower cost and give equivalent reduction to environmental impact. The banana leaf ash has been proved to increase the strength of concrete and demonstrate pozzolanic activity by replacing 10% of banana leaf ash into the concrete Rodrigo C.K et al., (2014).

The banana fibres were extracted from the stems of harvested banana plants sourced from farms in Tayu, Sanga Local Government area of Kaduna State Nigeria. "Dangote" brand of 43 grade ordinary Portland cement conforming to used. Standard consistency, initial and final setting time, bulk density and specific gravity were carried out to determine the physical properties of this cement and the results tabulated in Table 4.1. The fly ash used was sourced from the waste dump. The physical properties and chemical composition of the fly ash were determined & shown in table 4.2. The chemical analysis of the sample was carried out at National Metrological Development Centre (NMDC) using Energy Dispersive X-ray Fluorescence Spectrometer (EDXRF). The apparent specific gravity of the fly ash was 2.24, which was less than that obtained for cement. The loose bulk density and co compacted bulk density of the fly ash were 1300 and 1418kg/m^3 respectively. The chemical composition of the fly ash is presented in Table 4.2. The result shows that the combined SiO_2, Al_2O_3 and $Fe_2O_3$was 90.24% greater than the minimum of 70.00% as such it could be classified as pozzolana.

The sand used was clean river sand sourced from Gumo in Toro Local Government area of Bauchi State Nigeria. The sieve analysis result shows that the sand fall under zone II as stipulated. The fineness modulus, specific gravity and water absorption of the fine aggregate were 4.87, 2.62 and 0.72 respectively. The coarse aggregate was sourced from a Satzen Quarry Mista Ali, Jos Plateau State, Nigeria. The nominal size of coarse aggregate used in this study was 10mm. The properties of the coarse aggregate were determined by conducting tests in accordance with the provisions of [14]. The specific gravity and water absorption of the coarse aggregate were 2.54 and 0.65 respectively. Clean tap water conforming to recommendation of [15] was used. Conplast SP430 (G), superplasticizer that complies with [16] was used for the study. Banana fibres used in this study were extracted from the stems of harvested banana Plants sourced from farms. The specie of banana used in this study was musa acuminate (Modern banana).

The fibers were extracted by water retting method. Mature banana pseudo-stem obtained from farm were cut to lengths of about 600mm and were totally submerged in clean water fit for drinking for a period of six weeks, after which the stems were removed from the water, loosened and washed in a tank of clean water. The fibers were subsequently sun dried and further loosened by manual combing. This process allows for biodegradation of the banana pseudo-stems that separates the fibers from the pith. The extracted fibers were later chopped to lengths of 30mm ready for the experiments. The properties of banana fiber used in this study were determined and presented in Table 4.3.

Fly ash concrete of grade 24 was designed according to the specifications of [17] mix design method (British method). Fly ash was used to replace cement at various levels of 0%, 10%, 15% & 20%, by mass of binder. Banana fibers of 30mm length and volume fraction of 0.5%, 1%, 1.5% & 2% were used in all mixes being the optimum values obtained by Anowai and Job [18] for grade 24 concrete. The mix proportions of different mixes of banana fiber reinforced fly ash concrete are presented in Table 4.4.

Batching, mixing and casting were done adopting a careful procedure. The fine aggregates and coarse aggregates were accurately weighed first. The required volume fractions of the banana fibers were computed and weighed out ready for mixing. The concrete mixing was done by hand mixing on a watertight platform. The coarse and fine aggregates were firstly mixed thoroughly, to this mixture, the required quantity of cement and fibers were added. These were then mixed to a uniform color. For mixture in which Portland cement was partially replaced with fly ash, the fly ash and cement were mixed dry to uniform color separately. The required amount of water were weighed and added carefully so that no water was lost during mixing.

Effect of Fly Ash on the Ph of Banana Fiber Reinforced Concrete

The results of pH of Banana fiber reinforced fly ash concrete specimens are presented in Table 5. The results showed that the partial replacement of cement with fly ash by weight resulted to a reduction in the concentration of OH- ions, which subsequently led to significant reduction of the pH of the concrete specimens tested. 0%, 10%, 15% & 20% partial replacement of cement with fly ash resulted to concretes with pH of 12.20, 11.50, 11.20, and 11.50 respectively after curing for 90 days.

It is expected that further reduction in pH will be recorded with increase in curing age. These results follow the same trend as that obtained by [4], which showed that partial replacement of cement with bauxite (pozzolana) at various percentages of replacement of 10%, 15% & 20% resulted to significant reduction of pH values of the concrete. Gram also found that the alkalinity of cement matrices are reduced by partially replacing ordinary Portland cement (OPC) with silica fume, fly ash or completely replacing OPC by high alumina cement.

5.1 Conclusions

Based on the experimental results obtained, the following conclusions were drawn:

Partial replacement of cement with fly ash by weight resulted to a reduction in the concentration of OH- ions and led to significant reduction of the pH of the concrete specimens tested 0%, 10%, 15%, & 20% partial replacement of cement with fly ash resulted to concretes with pH of 12.20, 11.50, 11.20, 11.50 respectively after curing for 90 days.

Partial replacement of cement with fly ash has a beneficial effect in banana fiber reinforced concrete with respect to water absorption. Partial replacement of cement with 10% fly ash produced the best result in terms of water absorption of banana fiber reinforced concrete.
It can also be used in mass concrete works or we can say that it may be used the places where high strength is not necessary.

Flyash actually lowers the early strength but fluctuates the lateral strength.

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