Experimental Study on Properties of Concrete by Partial Replacement of Cement with Banana Leaves Ash

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Abstract **- The research work is determination of the effect of the use of 'Banana Leaves Ash' as a replacement of cement to assess the pozzolanic nature of banana leaves ash when mixed in concrete. Concrete is one of the mostly used building construction materials in the construction industry. This material is widely used because it has many advantages such as durability, energy saving, low maintenance cost, economy, fire resistance, excellent heat quality and variety of activities. The world is now focusing on alternative sources of environmentally friendly, biodegradable natural ingredients. Banana wood Agricultural waste that can replace cement as a building material. Banana leaf ash contains a pozzolana reaction that often occurs in Portland. After harvesting the fruit, need to learn how to use banana leaves, rather than cut it down enough to eat. The goal of this project was to determine the durability when using banana ash to make concrete and make a good binder. The source of BLA is obtained from banana plant and they are readily available, environmentally friendly, and cheap. Banana leaf ash has great potential to improve the concrete performance. Banana leaf material Created by placing dried banana leaves and collecting residues. BLA is used in cement and replaces about 0%, 10%, 20% and 30% respectively. Strength and mechanical properties (such as compressive strength, tensile strength, and flexural strength) are determined by castings, columns, and beams, respectively. Compared to other cements, the mechanical properties of banana concrete are increased by 10%. Compare the results with the control mix.**

Index Terms **- Banana leave ash, Concrete Compressive strength, Cement replacement, Cost reduction.**

I.INTRODUCTION

1.1 General

Concrete is the most widely used material by humans, and it is irreplaceable for large-scale infrastructure development. On the one hand, the success of concrete comes from the wide availability and low cost of its components, and on the other hand from its ease of preparation. Every person in the world produces more than 1 cubic meter of concrete each year, of which Portland cement is the key ingredient, but the burden on the environment is the greatest. At present, the world consumes about 3 billion tons of Portland cement, and every 600 kg of cement produced will release about 400 kg of carbon dioxide, which accounts for about 5% to 8% of the total carbon dioxide produced by humans. Concrete is the most widely used as a building material due to its good compressive strength. This material is used in construction projects more than any other man-made material on earth. The main factor that determines the strength of concrete is the ratio of water in the mix and the amount of cement used. Ordinary concrete must provide moisture for at least 28 days to maintain good hydration, which requires a suitable atmosphere. Depending on the type of cement work, good mixing, mixed water, and water mixed in certain quantities to produce concrete. Empty concrete requires proper ventilation by providing a minimum of 28 days for moisture to get the best hydration. We know that hydration treatment is necessary for concrete. Any untreated will adversely affect the strength and durability of the concrete. The use of alternative materials in construction is increasing day by day. The project deals with a comparative study of the properties of concrete using banana leaf ash as a binder in concrete mixes.

This project works on research comparing concrete structures using Banana Leaves Ash as cementations material in the mix. Ash produced from various types of agricultural waste can be used effectively as a substitute for cement. Some researchers have

examined the existence of pozzolanic activity in the ashes from Banana Leaves.

After cutting the bananas, the rest of the tree, namely the stems and leaves, are thrown away or burned after drying. It can be used as a substitute material for partial replacement of cement. Bananas contain about 80% of liquid substances, and their weight is reduced to about 80% after drying. After burning the dried leaves, their dry weight is 20%. This means that if we dry 500 kg of fresh leaves and banana stems, we will get 100 kg of dried leaves and 20 kg of leaf ash. Banana leaves are mainly from various banana production farms (the largest production is in the Jalgoan area). These leaves were dried in the sun for 30 days and then burned in the open air. The residue left after burning is collected and is called banana leaf ash. If necessary, use a ball mill to refine this ash for 30 minutes. The final product obtained is fine enough to be mixed with cement.

The BLA will be used for cement to replace 0%, 10%, 20% & 30% respectively. Concrete obtained after this will be re-evaluated with standard concrete by performing various tests such as Compressive Strength, Split Tensile strength & Flexural Strength after 7 days and 28 days of treatment. This is likely to result in economic growth, strength, and resilience in concrete. OPC 53 grade cement was used. In this current article an attempt has been made to identify the various physical properties of the building materials as well as the mechanical and durable properties of the concrete sample. In this process the Banana leaves the ash to pass through a 90-micron sieves.

1.2 Problem Statement

Agricultural waste is usually treated by backfilling or open burning, which results in pollution. This material is often used to improve the standard and properties of concrete by partially replacing cement or concrete admixture. It offers good resistance and durability. Economic performance is also an important factor for the use of agricultural waste.

This study is conducted to overcome the problem of agricultural waste disposal (BLA).

1.3 Objective of the Project

The aim of this study is to analyze the possibility of a BLA as an alternative to cement.

1. To investigate the use of BLA in concrete mixes to improve concrete structure performance.
2. To determine the optimal BLA ratio in the concrete mix.
3. To meet the scarcity of cement in future by using BLA.
4. To reduce the effect of pollutant in the environment.
5. To compare the strength & density of BLA concrete with normal concrete.
6. To study the influence of partial replacement of banana leaves ash in concrete.
7. To evaluation of the effectiveness of concrete and BLA compared to conventional concrete mix.
8. To compare the strength, flexural and split strength of 0%, 15% and 25% BLA cement.
9. To compare the concrete mixing economy using BLA and standard concrete.
10. To determine the compressive strength and split tensile strength of the concrete by using banana leaves ash in various proportion at the age of 7 and 28 days.

II. MATERIAL USED

2.1 Collection of Materials: For BLA ash concrete, materials are collected and their physical properties.

These are the following materials are used for preparing of BLA ash cement concrete.

1. Cement
2. Fine Aggregate
3. Coarse Aggregate
4. Banana Leaves Ash
5. Water

1. CEMENT:

Ordinary Portland cement of 53 grade from one batch was used for the whole work. The cement procured was tested for physical necessities in accordance with IS: 12269-1987 and for chemical necessities in accordance with IS: 4032-1977.

Fig: Cement

Table 1: Physical Properties of Cement

Sr.no	Description of Test	Result
1	Fineness	2.48%
2	Specific gravity	3.12
3	Standard consistency	32%
4	Setting time of cement: (IS 12269-1987)	
	a) Initial setting time	36 min
	b) Final setting time	490 min
5	Soundness of cement	2 mm

Table 2: Chemical properties of Cement

Oxide	Percent content
Lime (CaO)	60–67
Silica (SiO_2)	17–25
Alumina (Al_2O_3)	3.0–8.0
Ferrous Oxide (Fe_2O_3)	0.5–6.0
Magnesium Oxide (MgO)	0.1–4.0
Alkalies (K_2Na_2O)	0.4–1.3
Sulphur di-Oxide (SO_2)	1.3–3.0

2. FINE AGGREGATE (Sand):

The river sand, passing through 4.75 mm sieve and retained on 600µ sieve, conforming to Zone II as per IS 383-1970 was used as fine aggregate in the present study. The sand is free from clay, silt, and organic impurities. Generally, the naturally occurring mineral aggregate is usually strong enough to make conventional strength concrete. Local sand, from "BOTHALI RIVER", is used as a fine aggregate.

The aggregate was tested for its physical requirements such as silt content, fineness modulus, specific gravity, and bulk modulus in accordance with IS: 2386-1963.

Fig: Sand

Table - 3: Properties of Fine aggregate

Sr. No.	Description of Test	Result
1	Fineness Modules	2.66
2	Silt content	8%
3	Specific Gravity	2.65
4	Water absorption	3%

3. COARSE AGGREGATE:

The maximum nominal size of the coarse aggregate should be as large as possible within the specified range, but in any case, its maximum thickness should not exceed a one fourth of the minimum thickness of the member, provided that the concrete can be laid without difficulty around all the reinforcement thoroughly and fill the corners of the form. A crushed stone is used in an area of various sizes ranging from 12.5mm to 20mm aggregates.

The aggregate was tested for its physical requirements such as specific gravity and bulk density etc.in accordance with IS: 2386-1963 and IS: 383-1970.

Fig: Coarse aggregate

Table 4: Properties of Coarse Aggregate

Sr.No.	Description of Test	Result
1.	Fineness Modules	4.28
2.	Specific Gravity	2.78
3.	Water absorption	2.02%

4. BANANA LEAVES ASH:

Banana leaves or banana leaves with stems, used for research or obtain from local banana farms in Bothali, bhandara district. The leaves that can be used for this process are dried for 25 days, then the dried banana leaves are burned in a controlled environment and the residual ash of stem and leaves is collected. The ash is passed through a 90-micron sieve to obtain a fine powder of banana leaf ash. The chemical properties of banana leaf ash are given in Table 5.

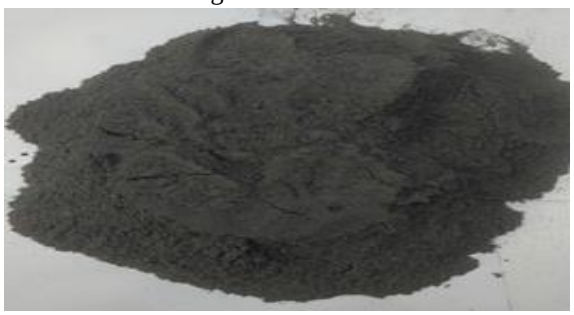


Fig: - Banana Leaves Ash

Table 5: Chemical Properties of BLA

Parameters	Composition of banana leaf ash (%)
Silicon Dioxide (SiO_2)	47.8
Iron Oxide (Fe_2O_3)	1.4
Aluminum Oxide (Al_2O_3)	2.6
Sodium Oxide (Na_2O)	0.21
Loss if ignition	5.06

4. WATER:

Water is a very important ingredient in the preparation of concrete, as it actively participates in the chemical reaction with the cement during the mixing of concrete. Use portable fresh water that does not contain organic substances or oils to mix concrete. Measure the amount of water needed through a measuring cup and add it to the concrete. The pH value should not be less than 6.

The Impurities in water may affect the initial and final setting time, strength, and shrinkage of concrete. It should be free from adverse amount of soils, solids, alkalis, salts, organic materials and inorganic impurities.

2.2 MIX DESIGN (IS 10262:2009)

Mix design can be defined as the process of selecting suitable ingredients of concrete and finding out their relative proportions with the object of producing concrete of certain minimum strength and durability.

Stipulations for proportioning	
Grade designation	M30
Type of cement	OPC 53 Grade
Type of mineral Admixture.	Banana leaves ash
Maximum nominal size of aggregates	20 mm
Minimum cement content	320 kg/m3
Maximum Water cement ratio.	0.45
Slump workability	100
Exposure condition.	Severe
Degree of supervision	Good
Type of aggregate	Crushed angular aggregate
Maximum cement content	450 kg/m3
Method of concrete placing.	Placing and Casting

BLA %	W/C ratio	Water (Kg/m^3)	Cement (Kg/m^3)	BLA(Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)
0	0.45	197	438	0.00	650.07	1161.17
10	0.45	197	394.2	43.8	650.07	1161.17
20	0.45	197	350.4	87.6	650.07	1161.17
30	0.45	197	306.6	131.4	650.07	1161.17

Mix Proportions for M30 Grade Concrete (for per cubic meter)

III. EXPERIMENTAL PROGRAMME

TEST SETUP AND TESTING PROCEDURE:

3.1 Mixing of Concrete:

There are many components of mixing that need to be considered in order to ensure that a uniform concrete mixing can be achieved. Location, shape and angle of the mixing blades, shape of the mixing chamber, speed of rotation, and horsepower must all be taken into account.

The internal surface of mould is thoroughly cleaned. Also, it is ensured that the mould is free from moisture and adherence of any old set concrete. With the help of spanner all the screws are made tight and to be oiled.

3.2 Molding Process:

Concrete cubes specimens (150 mm x 150 mm x150 mm) were casted for computing compressive strength. The cylindrical specimens (diameter- 150 mm and length- 300 mm) were casted to determine spilt tensile strength of concrete. Totally, 6 specimens were molded, in which 3 specimens tested after 7 days and rest 3 specimens tested after 28 days. Concrete is mixed by hand and thoroughly mixed, and the concrete placed in cubes with the minimum delay. It was well compacted by rodding. Temping and vibrating to remove all air voids after placing.

3.3 Placing Concrete:

Concrete is placed in the moulds using a trowel in three layers of approximately equal depth and is remixed in the mixing pan with a shovel to prevent segregation during the moulding of specimens. The mixed concrete should be placed in the mould within 30 minutes of its preparation.

3.4 Compaction of Concrete:

Compaction is the removal of air from fresh concrete. Proper compaction results in concrete with an increased density which is stronger and more durable. Concrete is placed in the mould, in three layers of approximately equal volume. 25 strokes will be done in compaction.

3.5 Removing of Mold:

After 24 hours molds were removed. After. Demolding, each cube was marked with a legible identification on the top or bottom using a waterproof marker.

3.6 Curing Process:

Concrete cubes were cured normally in fresh water for 7 to 28 days at room temperature. Curing plays an important role in gaining of strength of concrete. If concrete cube not properly cured then it will not gain enough strength and on other hand if concrete cubes cured for more time then also its strength decrease. Curing process in concrete increases strength and decrease permeability.

3.7 Testing Process:

After removing of mould, concrete specimens are tested in laboratory. The compression and split tension tests were carried in compression testing machine of capacity 2000 KN.

1. TESTS ON FRESH CONCRETE:

- WORKABILITY TEST

Tests on fresh concrete were carried out to determine the workability of normal concrete as well as BLA concrete as per IS: 1199-1959.

2. TESTS ON HARDENED CONCRETE:

- COMPRESSIVE STRENGTH TEST
- SPLIT TENSILE STRENGTH TEST

Specimen Tested	Properties Test	Type and replacement	Specimens
Cube	7 & 28 days compressive strength	Conventional	3
		10%	3
		20%	3
		30%	3
Cylinder	7 & 28 days split tensile strength	Conventional	3
		10%	3
		20%	3
		30%	3

1. COMPRESSIVE STRENGTH TEST:

Testing hardened concrete plays an important role in controlling and conforming the quality or cement concrete work. The main factor in favour of the use of concrete in structures is its compressive strength. One the important properties of the hardened concrete is its strength which represents its ability to resist forces. The compressive strength of the concrete is considered to be the most important and is often taken as an index of the overall quality of concrete. The compressive strength of concrete is defined as the load which causes the failure of specimen per unit cross section on compression under given rate of loading.

The compression strength test is carried out on the cubes at 7 & 28 Days curing to determine compressive strength. Concrete cube is of size 150 x150 x 150mm. The specimens are gradually loaded in Compression Testing Machine till specimen fails.

Fig: - Compressive Strength Test

2. SPLIT TENSILE STRENGTH TEST:

Concrete is not usual y expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength is necessary to determine the load at which the concrete members may crack. The cracking is a form of tensile fail.

The Split Tensile strength test is carried out on the cylinders at 7 & 28 Days curing to determine tensile strength. Concrete cylinder is of size 300 height x

150mm diameter. The specimens are gradually loaded in Compression Testing Machine till specimen fails.

Fig: - Split Tensile Strength Test

IV. TEST RESULTS

General: Testing of concrete plays an important role in controlling and confirming the quality of cement concrete. Concrete specimens viz., Cubes, Cylinders are casted by partially replacing the weight of cement with Banana leaves ash at different percentages (at 10%, at 20%, at 30%). Concrete specimens are tested at 7 days, 28 days to calculate the mechanical properties viz., Compressive strength of cubes, Split - Tensile strength of cylinders.

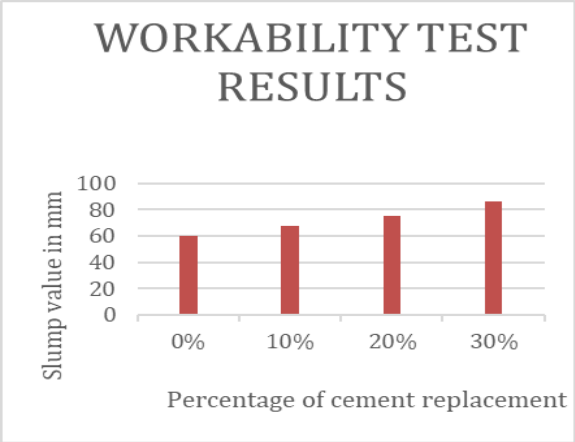
4.1 Tests on Fresh concrete:

1. Workability Test Result:

The slump values of all the mixtures are listed in Table 4.1. The slump increased with the increase in banana leaves ash content. Banana leaves ash particles absorbed less water as compared to cement and thus increasing the workability of concrete mix. The variation of slump with banana leaves ash content is shown in Fig.

Table 4.1. Workability Test

Sr. No.	W/C ratio	Percentage of cement replaced (%)	Height of mould H_1 (mm)	Height of subsided concrete H_2 (mm)	Slump H_1-H_2 (in mm)
1.	0.45	0	300	240	60
2.	0.45	10	300	232	68
3.	0.45	20	300	225	75
4.	0.45	30	300	214	86



4.2 Tests on Hard Concrete:

1. Compressive Strength Test Result:

The compressive strength is calculated by using following equations:

Compression strength (Mpa) = $\frac{P}{A}$ (N/mm2)

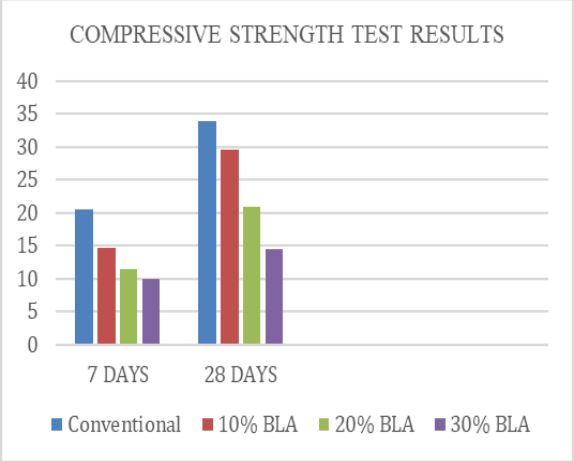
Where, A=loaded area (150mm x150 mm)

P= Ultimate Load (N)

Compressive Strength of the concrete cubes at 7 & 28 days is shown in table.

Table - 4.2.1-Compression Test

Sr. No.	Type of Specimen	Compressive Strength N/mm2	
		7 Days	28 Days
I	Conventional	20.41	33.89
2	10% BLA	14.67	29.58
3	20% BLA	11.41	20.93
4	30% BLA	9.93	14.38



2. Split Tensile Strength Test

The split tensile strength is calculated by using following equations.

Split tensile strength (MPa) = $\frac{2P}{\pi LD}$ (N/mm2)

Where, P = Ultimate load (N)

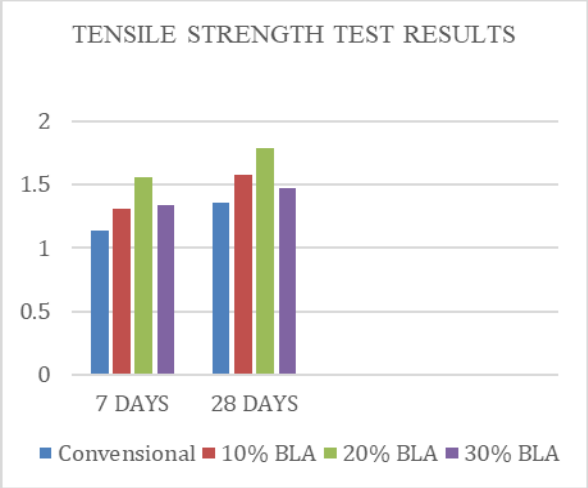
D= Diameter of cylinder (mm) = 150 mm

L = Length of cylinder (mm) = 300 mm

Split Tensile Strength of the concrete cubes at 7 & 28 days is shown in table.

Table - 4.2.2: Tensile Strength Test

S.No	Type of Specimen	Tensile Strength N/mm2	
		7 Days	28 Days
I	Conventional	1.14	1.36
2	10% BLA	1.31	1.58
3	20% BLA	1.56	1.79
4	30% BLA	1.34	1.47



V. CONCLUSIONS

Experimental investigation has been carried out to determine utilization of the banana leaves ash as cement replacement materials by making the cement concrete. Based on the results obtained from the experimental work the following conclusions can be drawn:

1. Partial substitute of cement with BLA changes the Compressive & Split tensile strength of concrete.
2. As the proportion of BLA increase in the concrete the compressive strength reduced as compared to normal cement.
3. The compressive strength of concrete was lesser than the conventional concrete for 10% banana leaves ash replacement by the weight of cement at 7 & 28days of curing ages. However further increase in replacement percentages lowers the compressive strength of concrete.
4. The Split Tensile strength increases for 10% and 20% substitute & slightly decrease for 30% replacement.
5. The split tensile strength of concrete in which cement was replaced by 20% was higher than conventional concrete. However further increase in replacement percentages lowers the split tensile strength of concrete.
6. By using above combination of partial replacement we can decrease cost of concrete and increase the strength of concrete.
7. Banana leaves ash can be used as partial replacement for cement in concrete which helps in reduction of construction cost.
8. So, the mixture of the two materials can be used to get good strength properties in low cost.
9. From the on top of the graphs we can conclude that the Split tensile strength increases at 20% replacement of cement with BLA.
10. The optimum replacement of cement by Banana Leaves ash (BLA) is 20%, further increase in the replacement percentages results in reduction of concrete strength.

We will get most positive result i.e. maximum strength at 20% replacement, further increase in banana leaves ash concentration will decrease the strength of concrete.

VI. FUTURE RESEARCH

1. Determine the effect of banana leaves ash on concrete using Banana fibre.
2. Replacement of cement with banana leaves ash in different water cement ratio.
3. In the present study the ordinary Portland cement was used. Further its mechanical properties can be compared by using different cement.
4. Study on replacing cement with banana stem can be carried out.
5. Tests for chemical properties, tensile strength, slump loss, workability & many others can be done.
6. Determine the effect of banana leaves ash on consistency, initial setting, and final setting time of cement.

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