Comparative study of banana fibre concrete with metakaolin

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***Abstract*—This study investigates the combined effect of deploying Metakaolin and banana fibers (BF) on mechanical properties of hardened concrete of grade M25. Banana has been used as the partial replacement of cement by 0, 5, 10, 15, 20,25 and 30% by weight and BF has used as volume substitution by 0, 1, 2, 3, 4, 5 and 6%. In our present investigation, banana fibers having 35mm length were used.**

Compressive strength and splitting tensile strength are determined by using various combinations of Metakaolin and BF. A notable improvement is being noticed in the strength properties of concrete when Metakaolin is used. The addition of Metakaolin to the concrete improved the properties of strength as well as durability to a great extent. On the other hand, the addition of banana fibers to the concrete results in the reduction of permeability and the improvement in the crack resistance eventually.

***Index Terms*—Banana fiber, Compressive strength, Crack resistance, Durability, Metakaolin, Split tensile strength.**

I. INTRODUCTION

Now-a-days, Construction Technology has advanced through several investigations and experiments to enhance the durability and strength of concrete. Fibers used in concrete are mainly categorized into natural and artificial fibres. The sources of natural fibers are vegetables, animal and mineral sources. On the other hand, artificial fibers are produced from synthetic materials, steel and natural polymers. Fibres exist in various forms such as Cocosnucifera (coconut) fiber, Musacuminate(banana) fiber, steel fiber, AR glass fiber, natural fibre, Jute fibre, synthetic fiber, etc. Banana fiber offers the resistance to suddenly applied loads, limits the shrinkage cracking, decreases the permeability and hence ultimately decreases the bleeding of water.

A lot of researchers have shown a remarkable interest in determining the behaviour of concrete using Metakaolin and its effect on the strength properties. Metakaolin has an amazing characteristic of acting as a cementitious Puzzolanic additive.

In this investigation, the strength properties of concrete are investigated and determined experimentally by deploying various combinations of metakaolin and banana fibers in concrete to attain the concrete with high characteristics compared with conventional concrete.

II. PROBLEM STATEMENT

The aim is to investigate and analyze the structural and mechanical properties of these materials to determine their suitability for various construction applications. By examining factors such as strength, durability, and environmental impact, this study seeks to provide valuable insights into the potential advantages and limitations of using banana fiber concrete and metakaolin as alternatives to conventional concrete.

III. OBJECTIVES

The objective of this study is:

- To evaluate the compressive strength, split tensile strength of concrete by using Musa acuminates (banana fiber).
- To utilize banana fiber waste optimally and increase the tensile capacity of concrete and metakaolin increased resistance to chemical attack.

IV. MATERIALS AND METHODOLOGY

In the investigation, the following materials were used.

- Ordinary Portland cement of 53 Grade.
- Fine aggregate

- Coarse aggregate
- Metakaolin
- Banana fibres

Cement: Locally available 53 Grade Ordinary Portland cement is used for the experimental work. The physical properties of cement tested in the laboratory in Table 1

Table -1: Physical Properties of cement

SL NO	Properties	Values
1.	Normal consistency	32%
2.	Initial setting time	55 min
3.	Final setting time	360 min
4.	Fineness test	4.5
5.	Specific gravity	3.15

Fine aggregate: The nearby available river sand is used for the experimental investigation. The physical properties are presented in Table 2.

Table -2: Physical Properties of fine aggregate

SL NO	Properties	Values
1.	Specific gravity	2.53
2.	Sieve analysis	3.1
3.	Water absorption test	1%

Coarse aggregate: The tested physical properties of the coarse aggregates are tabulated in Table 3.

Table -3: Physical Properties of coarse aggregate

SL NO	Properties	Values
1.	Specific gravity	2.64
2.	Sieve analysis	5.63
3.	Water absorption test	1%

Water: Potable water from the laboratory was used for mixing the concrete and also for curing the specimens.

Banana fiber: Banana fiber is a very good replacement for synthetic fiber. The banana used for this work is collected from the local village, Arkalagud. The fibers are made into uniform length of 35mm by using cutting machine. Salient physical and mechanical properties of Banana were determined in their natural form. The physical properties of banana fiber tested in the laboratory in Table 4.

Table -4: Physical Properties of banana fiber

SL NO	Fiber parameter	Values
1.	Stiffness (mm)	56.8
2.	Linear mass density (g/m)	1953
3.	Diameter (μm)	102.82
4.	Breaking strength(gf)	142.17
5.	Breaking elongation (%)	3.22
6.	Tensile strength (MPa)	167.89

Fig: -1: Banana fiber

CHEMICAL TREATMENT WITH NAOH

The fibers were treated with 6% of NaOH for 1hr to increase the wet ability. The fibers are then washed thoroughly with distilled water. Fibers are then dried in oven for 2hrs at 100℃ to remove the moisture present in it.

EXTRACTION PROCESS OF BANANA FIBER

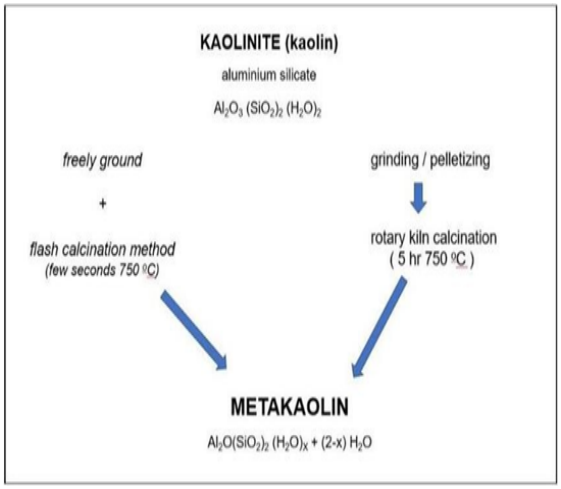
The extraction of natural fiber from the plant required certain care to avoid damage. In the present experiments initially the banana plant sections were cut from the main stem of plant and then rolled lightly to remove the excess moisture. Impurities in the rolled fibers such as pigments, broken fibers, coating of cellulose etc. Banana fibers, which are concentrated near the outer surface are extracted by manual method (hand scraping). Banana stem is cut into small pieces about 1mm in size and dried under sunlight for 24 hrs. Then the banana fiber treated with NaOH solution

Metakaolin: Metakaolin is an admixture used as a partial replacement of cement in HSC (High Strength Concrete). Some concrete is said to be high strength concrete if its compressive strength is more than 35MPa. Metakaolin is prepared by calcinations of kaolin (clay mineral) at a temperature of 650-800°C. It has Pozzolanic properties, and its chemical formula is $Al_2O_3.2SiO_2.2H_2O$. It reacts with $Ca(OH)_2$ one of the by-products of hydration reaction of cements and results in additional C-S-H gel which results in increased strength. Metakaolin in concrete reduces the size of pores in cement paste by transforming finer particles into discontinuous pores. It increases compressive, flexural strength and reduces efflorescence in concrete.

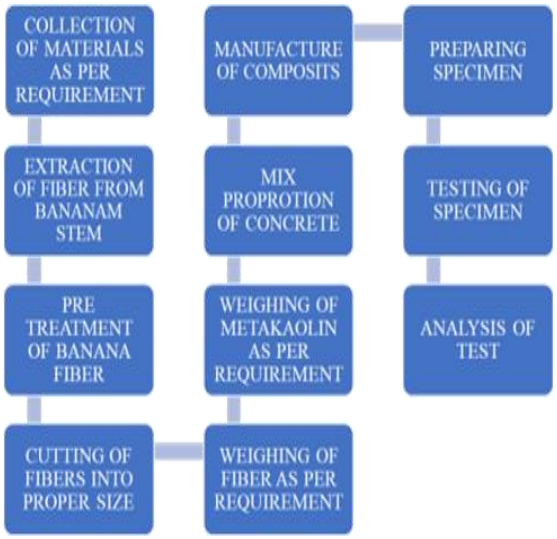
Table -5: Physical Properties of metakaolin.

SL NO	Chemical Composition	Metakaolin %
1.	Silica (SiO_2)	54.3
2.	Alumina Al_2O_3	38.3
3.	Calcium oxide Cao	0.39
4.	rric oxide Calcium oxide (Fe_2O_3)	4.2
5.	agnesium oxide (MgO)	0.08
6.	otassium oxide (K_2O)	0.50
7.	huric anhydride (SO_4)	0.22
8.	Specific gravity	2.5
9.	Physical Form	Powder
10.	Colour	White

MANUFACTURING PROCESS OF METAKAOLIN



V. METHODOLOGY



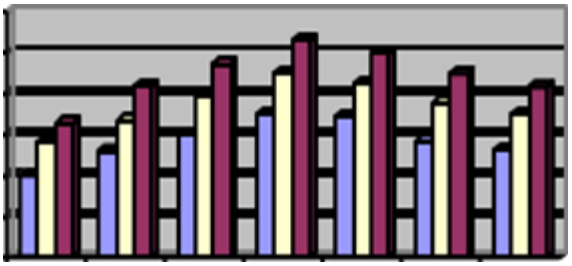
MIX PROPORTIONS: Concrete mix design developed to suit the M-25 grade of concrete. The procedure for designing concrete mix adhered as per 10262:2009.

VI. RESULTS AND DISCUSSIONS

Compressive Strength: The compressive strength of Metakaolin concrete in association with banana fibers has shown increment. The results that are obtained for the compressive strength at 7, 14 and 28 days are presented in Table 6.

TABLE-6: Compressive Strength Test Results (M25)

Sample	% of metakaolin	% of metakaolin	Compressive strength at 7 days (N/mm²)	Compressive strength at 14 days (N/mm²)	Compressive strength at 28 days (N/mm²)
CO	0	0	19.90	28.2	32.76
T1	5	1	25.84	33.32	41.97
T2	10	2	29.92	39.19	47.09
T3	15	3	35.05	45.06	53.14
T4	20	4	34.43	42.52	49.96
T5	25	5	28.41	37.65	44.84
T6	30	6	26.14	34.86	41.7

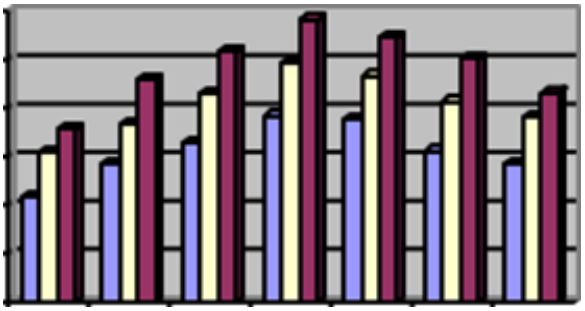


Graph -1: Graphical representation of compression test results

Split Tensile Strength: The addition of banana fibers to the Metakaolin concrete increases the split tensile strength appropriately. The results that are obtained for the split tensile strength at 7, 14 and 28 days are presented in Table 7.

TABLE-7: Split Tensile Strength Test Results (M25)

Sample	% of metakaolin added	% of metakaolin added	Split tensile strength at 7 days	Split tensile strength at 14 days (N\mm²)	Split tensile strength at 28 days (N\mm²)
CO	0	0	2.18	3.10	3.60
T1	5	1	2.84	3.66	4.61
T2	10	2	3.29	4.31	5.17
T3	15	3	3.85	4.95	5.84
T4	20	4	3.78	4.67	5.47
T5	25	5	3.12	4.14	5.01
T6	30	6	2.87	3.83	4.33



Graph -2: Graphical representation of compression test results

VII. CONCLUSIONS

The research investigation on the addition of banana fiber and metakolin for strengthening reinforced concrete established some general facts related to composite strengthening.

1. The experimental tests revealed that the strength properties of concrete improved with the addition of banana fibres to the metakaolin concrete.
2. The addition of banana fibers considerably increased the strength characteristics of

metakaolin concrete, mainly compressive strength and tensile strength.

3. The cracking resistance of the concrete has also improved to a greater extent.
4. When compared to normal concrete, the compressive strength of banana fiber reinforced metakaolin concrete of M25 grade has improved.
5. The maximum increment of compressive strength i.e.at 15+3% is 44.92 for 7 days,43.43% for 14 days &41.54% for 28 days.

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