CONSTRUCTION OF ECO-FRIENDLY FLEXIBLE CONCRETE REINFORCED WITH BANANA AND PINEAPPLE LEAF FIBER

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ABSTRACT

Concrete is the most widely used construction material today. One of its widely known limitations is brittleness. This can be improved by reinforcing it with natural fibers. The utilization of natural fibers in concrete has garnered significant attention due to their potential to enhance mechanical properties and sustainability. Natural fiber is an ecofriendly and abundant source that can be used as reinforcement. When mixed with natural fiber, we get something called flexible concrete, which has improved strength, ductility and is resistant to cracks. Use of natural fiber as reinforcement also helps in recycling biomass and reduces emission. This paper presents the experimental studies on how properties improve when Pineapple Leaf Fiber (PALF) and banana fibers are mixed with concrete in different ratios. Fibers were cut at a length of 30 mm. We have taken 0%, 1.5%, and 2% fibers by weight with respect to concrete. The ratio of banana fiber and PALF was 1:1 in all the cases. The water-to-cement ratio was 0.5. The concrete was cured for 7 days. We have followed ASTM C39/C39M for the compressive strength test and ASTM C78/C78M for the three-point bending test. For both compressive and bending tests, the strength continued to increase with the increase of fiber content. This shows that a novel natural fiber-reinforced concrete composite material can be made by incorporating the mixture of banana fiber and PALF.

Keywords: *Flexible concrete, Mechanical Properties, Natural Fibers, Eco-friendly, Sustainability*

1. INTRODUCTION

Concrete is defined as material made-up of embedded filler in hard matrix concrete materials placed in between aggregate particles and glued them together. It essential for the binding embedded particles of concrete or fragments of the coarse aggregates. Concrete productions are made from several methods such as batching, mixing, consolidation, finishing and curing. Concrete is one among the foremost widely used artifact. It is composed of three main elements such as fillers, sand and cement, being the bonding factor and forms concrete. It has compressive strength and low tensile strength. To compensate for weak tensile strength, they are reinforced with fibers.

Pineapple leaf fiber and banana fibers are used within the concrete to increase its tensile strength. This composite has a suitable property to reduce the cracking of the surface [1]. Fiber has high energy absorption rate under impacts, so it's not easily torn apart. Adding fiber to the concrete to improve its properties is a practice started in the early 60s during this past six decades a lot of advancement has been seen in addition of fiber to the concrete to obtain various desired quantities [2]. The reason this practice was started to avoid the weak tensile strength of a raw concrete. Pineapple is a very common fruit and available all over the world. Its leave can be used to fibers which then can be added to the concrete. This provides an alternate was for using synthetic fibers and also using a biowaste to a good use [3].

In present, constructions are using various of additives to form various mixtures to achieve various properties which are better than a lot of conventional properties of concrete. Nowadays, fibers are used as a reinforcing material in place of steel in concrete [4]. These natural fibers such as pineapple leaf fiber available at a very low cost could prevent cracking and improve the tensile strength of concrete and also makes transforms it and homogeneous and isotropic it from a brittle to a more ductile material [5] Linto Mathew et al. (2017) carried out an experimental investigate the mechanical properties of PALF fiber subjected to various test under high temperature. The study which determines on the structural properties of PALF is added concrete at normal temperature. In this study, PALF of specific ratio are randomly dispersed in concrete for the preparation of test specimens are used for various experimental tests [6]. From the test conducted, control mix compressive strength was obtained as 22.81MPa for 7 days normal curing and 34.29MPa for 28 days normal of curing. The compressive strength for various percentage addition of PALF had obtained [7]. The peak 7th day compressive strength which obtained for concrete mix ratio containing 0.10 fine adding of PALF as 27.31 MPa and it had been found to be 20% more than the control mix. And peak 28th day compressive strength has obtained for concrete mix ratio containing 0.10 fine adding of PALF as 40.53 MPa and it had been found to be 18% more than the control mix [8]. From this it is clear that by adding 0.1% pineapple fiber to M25 concrete we are able to replace M30 Concrete [6]. Vinod et al. (2014) carried out a study on influence of fiber length on tribological behaviour of short PALF reinforced Bisphenol-A Composite Studied wear and frictional properties unreinforced resin material and composite with different fiber length at varying load PALF of 8 mm show less specific wear rate & coefficient of friction [9].

This project aims to enhance the mechanical proprieties of the reinforced concrete using banana fiber and pineapple leaf fiber. To achieve this aim, several laboratory tests have been performed to find out the ability of the fibers for improving the properties of concrete. Through this work, the most critical factors affecting the performance of flexure behaviour of reinforced concrete and its ability to yield compression beams using banana fiber and pineapple leaf fiber are investigated.

2. METHODOLOGY

2.1 Materials Required

The following materials were used in the construction of eco-friendly flexible concrete reinforced with banana and pineapple fibers:

2.1.1 Cement

Ordinary Portland Cement (OPC) conforming to ASTM standards was used as the primary binder in the concrete mix.

2.1.2 Sand

Fine aggregate with a particle size conforming to standard grading was used. The sand was clean and free from impurities.**2.1.3 Granular Crushed Stone**

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Coarse aggregate used to provide strength and stability to the concrete.

2.1.4 Banana Fiber

Naturally extracted banana fibers, dried and cut into lengths of approximately 20-30 mm.

2.1.5 Pineapple Leaf Fiber

Naturally extracted pineapple leaf fibers, dried and cut into lengths of approximately 20-30 mm.

2.1.6 Water

Clean potable water was used for mixing and curing the specimens.

2.1.7 Wooden Mold

A wooden mold of 500mm x 150 mm x 150 mm dimension was needed to make beam specimen for testing flexural strength.

2.1.8 Cylindrical Mold

A cylindrical mold of steel of 300mm x 150mm dimension was used to make specimen for tensing compression strength.

2.2 Information About Components

2.2.1 Cement: Provides the binding property to the concrete, ensuring cohesion of the mix.

2.2.2 Sand: Acts as a fine aggregate, improving the strength and workability of the concrete.

2.2.3 Granular Crushed Stone: Enhances the compressive strength and durability of the concrete mix.

2.2.4 Banana Fiber and Pineapple Leaf Fiber: These fibers improve the ductility and flexibility of the concrete. The combined addition of these fibers was varied at three levels: 0%, 1.5%, and 3% by weight of cement. Fibers were cut at 25 to 30 mm length.

2.2.5 Water: Ensures proper hydration and aids in achieving the desired workability

2.3 Design of the Experiment

2.3.1 Mix Proportions:

A constant cement-to-sand-to-granular-crushed-stone ratio of 1:2:3 was maintained for all samples.

The water-to-cement ratio was fixed at 0.5 for proper workability.

2.3.2 Specimen Preparation:

A total of six specimens were prepared: Three specimens for the compression test (cylinder dimensions: 300 mm height x 150 mm diameter). The **ASTM standard** for testing the compressive strength of concrete is **ASTM C39/C39M**. Three specimens for the flexural test (beam dimensions: 500 mm x 150 mm x 150 mm). The **ASTM standard** for testing the flexural strength of concrete is **ASTM C78/C78M.** Fibers were added in varying proportions of 0%, 1.5%, and 3% by weight of cement, combined for both banana and pineapple leaf fibers.

2.3.3 Mixing Procedure:

Cement, sand, and granular crushed stone were dry-mixed thoroughly. The fibers were cut at required length and a constant length was maintained. The required amount of fibers was added to the dry mix and evenly distributed. Water was gradually added to the mixture to achieve the desired workability. The mixing was done with a shovel and proper mixing was done. The mix was poured into molds and compacted to eliminate air voids.

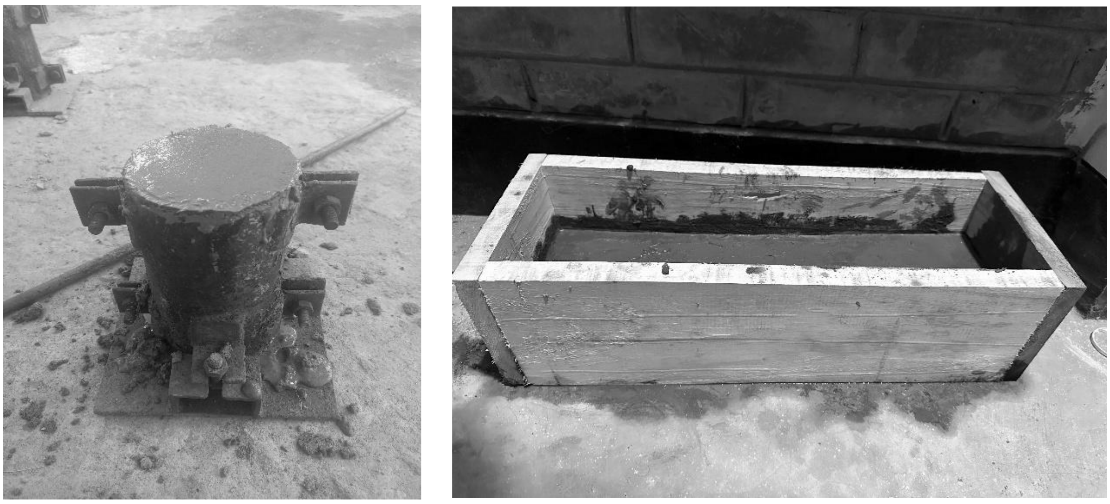

Figure 2.3.3: Preparation of specimen by molding

2.3.4 Curing:

The specimens were cured for **3 days** to ensure proper hydration of the cement.

2.3.5 Testing:

The specimens were dried properly in ambient temperature. Compression tests were conducted using a **Universal Testing Machine (UTM)** to determine the compressive strength. Flexural tests were conducted on beam specimens using a UTM to measure the flexural strength.

2.4 Experimental Setup

The specimens were tested on a **Universal Testing Machine (UTM).** The compression test was performed on cylindrical specimens by applying a uniform load until failure. **T**he flexural test was conducted as a three-point bending test on beam specimens to determine the load at failure and calculate flexural strength.

Fig 2.4.1: Conduction of Compression test and Flexural test using UTM

3. ILLUSTRATIONS

3.1 Figures and Graphs

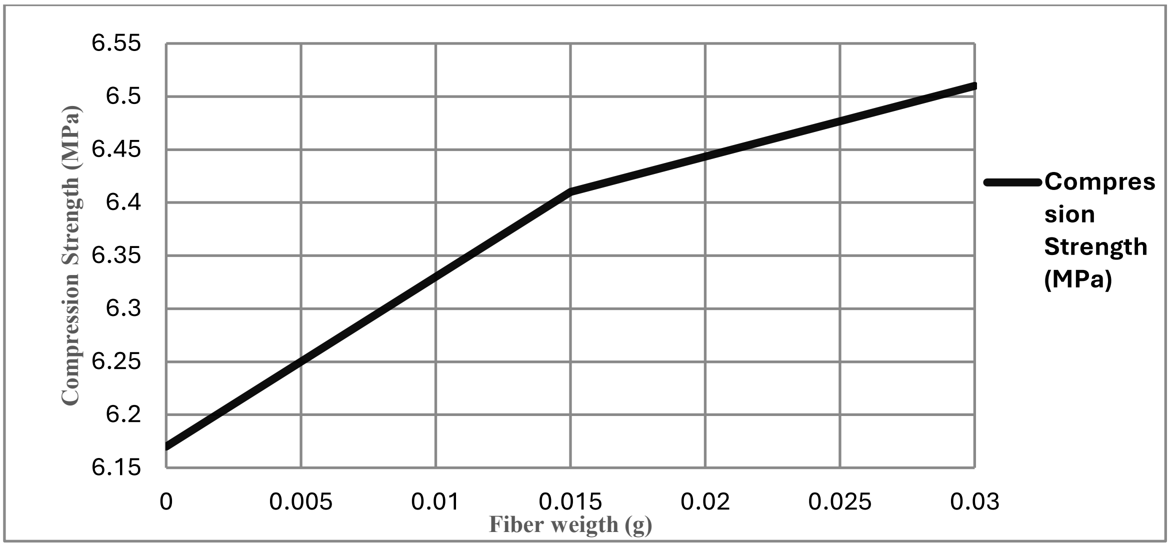

Figure 3.1.1: Compression Strength (MPa) for different amount of fiber addition

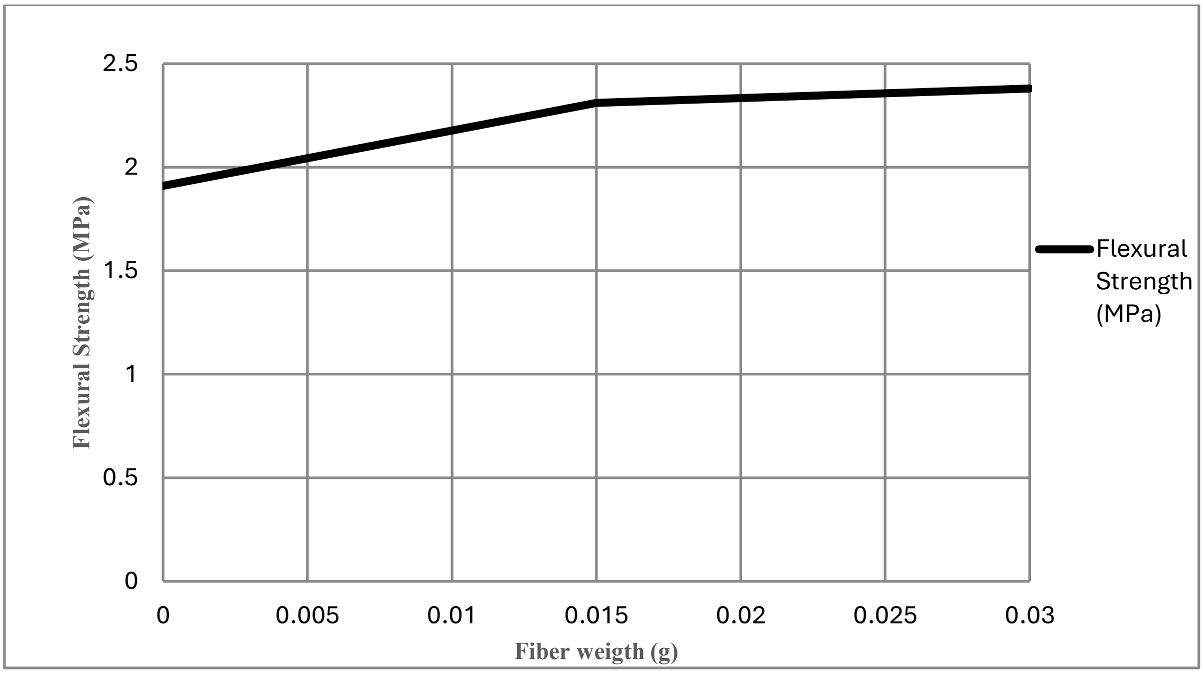

Figure 3.1.2: Flexural Strength (MPa) for different amount of fiber addition

3.2 Tables

Table 1: Compression Test Results:

Specimen	Fiber weight	Cement (Kg)	Banana Fiber (g)	PALF (g)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Compression Strength (MPa)
C1	0%		0	0			5.82
C2	1.50%	0.53	4	4	0.106	1.59	6.41
C3	3%		8	8			6.51

Table 2: Flexural Test Results:

Specimen	Fiber weight	Cement (Kg)	Banana Fiber (g)	PALF (g)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Flexural Strength (MPa)
F1	0%		0	0			1.91
F2	1.50%	1.94	14.5	14.5	3.88	5.82	2.31
F3	3%		29	29			2.38

4. CONCLUSIONS

The use of natural fibers like banana & pineapple fiber is the prime focus of this paper. With varying proportions (0%,1.5%, and 3%), the following conclusions can be drawn:

1. Material Efficiency:

The mixture of cement, sand, granular crusted stone & natural fibers symbolize a sustainable & eco-friendly concrete mix. The addition of banana & pineapple leaf fibers promotes flexibility and ductility to the concrete, compromising its structural integrity. Without compromising its structural integrity.

2. Mechanical strengths:

•The compressive strength increased with the addition of fibers, with the maximum strength at 5% fiber content (11.24MPa) was noticed, which is a 13.9% improvement over the control sample.

•The flexural strength also increased significantly in 3% fiber content about 5 MPa. Which is also a 25% improvement over the control Sample.

3. Sustainability: The use of agricultural waste fibers represents sustainable construction. This reduces the dependency on non-renewable resources and helps to utilize waste.

4. Optimal fiber content: 3% fiber content is the optimal fiber content as this proportion maximizes compressive & flexural strength. If also balances strength enhancement & material cost.

5. Practical Application: The fields where eco-friendly flexible concrete is very much required, this concrete could be a good option such as pavements, lightweight structures & precast elements.

This study highlights the feasibility of natural fibers' incorporation into concrete for sustainable construction. The inclusion of two fibers with random orientation can improve mechanical properties in a work done by according to Shah et el. The study shows that the addition of fiber increases its mechanical properties. But what would be the optimum value of fiber addition, its long-term durability, water absorption properties and scaling up for factory use could be the topic of further studies.

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