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Effect of Banana Fiber on the Strength Characteristics of Concrete Pavement Using Partially Replaced Natural Aggregate by Recycled Aggregate

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ABSTRACT: The use of recycled concrete aggregate in concrete as partial replacements of natural coarse aggregate is growing interest in the construction industry, as it reduces the demand for virgin aggregate. In addition, the use of recycled concrete aggregate leads to a possible solution to the environmental problem caused by concrete waste and reduces the negative environmental impact of the aggregate extraction from natural resources.
This paper will present a comprehensive review on the effect of banana fiber on the strength characteristics of recycled concrete aggregate. The design integration of the M25 series was modified in this work. From most of the researches recycled aggregate upto 30% shows good characteristics of concrete. In this experiment 30% natural aggregate was replaced by recycled aggregate. Also, banana fiber was used in different mixes with different quantity from 0-6% with an increment of 1.5% in each mix. Different mixes were then tested after 7days, 14 days and 28 days for strength characteristics and according to the studies the strength characteristics of the concrete were enhanced.

KEYWORDS: Recycled Aggregate Concrete, Banana Fiber, Natural Aggregate

I. INTRODUCTION

Demolition of old constructed structures and construction of new structures is a frequent phenomenon due to change of purpose, design, style, structural deterioration, expansion of roads and natural and manmade disasters and has increased over the last few years. Globally a vast amount of concrete waste is derived from the demolition of old constructed structures. This waste concrete derived from the demolition process of the old structures is disposed to landfills which causes environmental load, health hazards and shortage of land. The increasing charges for landfill make this environmental problem worse. The reuse and recycling of this waste material is necessary. Therefore, the utilization of concrete waste in construction may overcome these problems. Aggregates form the backbone of concrete. The aggregates usually occupy about 70% of the total volume of the concrete and a major part of aggregates are coarse aggregates. Therefore, its demand in the construction sector is enormous. This increasing demand of the coarse aggregates leads to the increased extraction of the aggregates from the natural resources which create an ecological imbalance in the environment. Therefore, one of the means to achieve the use of alternative coarse aggregates is to use the recycled aggregates obtained from the demolished structures. The use of such an alternative of coarse aggregates reduces the need of natural coarse aggregate in the construction sector which in turn reduces the negative impact on the environment due to extraction of natural aggregates. Banana fiber is also known as musa fiber. It is one of the world's strongest natural fibers. The banana fiber is made from the stem of the banana fiber and is incredibly durable. This banana fiber consists of thick-walled cell tissues that are bonded together by natural gums. It is mainly composed of cellulose, hemicelluloses and lignin. This fiber is similar to the natural bamboo fiber but its fineness, spin ability and tensile strength are said to be better than bamboo fiber.
Also, the characteristics of the concrete using recycled aggregate are generally less than the concrete which is made from natural aggregates. As the banana fiber has high spin ability, fineness and tensile strength therefore its effect will also influence the properties and characteristics of the concrete.

II. RESEARCH OBJECTIVES

The purpose of this study is to determine the characteristic strength of the concrete using 30% recycled aggregate and 0-6% banana fiber with an increment of 1.5% in each mix. Following are the objectives of the study:

- To investigate the effect of the banana fiber on concrete using partially replaced natural aggregate with recycled aggregate in order to determine the compressive strength, split tensile strength and flexural strength of the concrete.
- To investigate the effect on the workability of recycled concrete aggregate.
- To differentiate the properties of altered concrete and customary concrete.
- To look after the natural assets by using the demolition waste and hence reducing the cost.

III. LITERATURE REVIEW

A. *Literature Review about Recycled Concrete*

Rahman et al. [1] studied the influence of recycled aggregate concrete was used as a virgin coarse aggregate and concluded that the use of recycled aggregates in place of virgin or natural aggregates reduces the strength characteristics of the concrete.

Uche [2] studied the basic properties of both fine and coarse recycled aggregates and compared to the properties of the natural fine and coarse aggregate. This study concluded that the recycled aggregate concrete has better resistance to carbonation than the natural aggregate concrete.

Jitendra Sharma [3] studied the recycled aggregate concrete were examined. They found that if the water cement ratio in the recycled concrete aggregate is reduced, the tensile strength and the modulus of elasticity of concrete are improved.

Prabhat Kumar [4] concluded that the natural aggregates and recycled aggregates can be used in the ratios of 80:20 and 70:30. The increase in the ratio of recycled aggregate leads to the decrease in the properties and characteristics of the concrete.

Narayanan et al. [5] investigation revealed the suitability of banana fiber as an effective reinforcement in epoxy matrix

Sapuan [6] shows the importance of this product and allows many researchers to develop an adequate system for producing a good quality of woven banana fibre composite which maybe used for household utilities.

Safiuddin et al. [7] presents a comprehensive review on the use of RCA in concrete based on the experimental data available in the published research. The most important physical, mechanical, and chemical properties of RCA.

Kumar et al. [8] established and validate a design methodology that, when applied to the most important characteristics of friction courses as a component of a pavement structure, works in concert.

B. *Literature review about Banana Fiber:-*

N. Venkateshwaran: Studied the physical and mechanical properties of the banana fiber and concluded that due to the low density, high tensile strength and low elongation at break of banana fibers these fibers have good potential use in various construction and machinery sectors.

S. M. Sapuan: Studied the mechanical properties of the woven banana fiber and experiments of tensile and flexural strength tests were carried out. In this study only tensile and flexural stress in x and y direction were find out.

V. S. Srinivasan: Studies on evaluation of mechanical and thermal properties of the banana fiber and concluded that hybrid composite has very good properties than single fiber under impact and flexural load.

IV. MATERIALS AND METHODOLOGY

A. *Materials used:*

Coarse Aggregate: Aggregates which has a size bigger than 4.75mm or which are retained on the 4.75mm IS sieve is known as coarse aggregates as shown in Figure 1. These are stones that are broken into small sizes and irregular in shape. These are the essential components of the concrete and occupy large volumes in the concrete mix. These acquire 60-65% volume of concrete. Table 1 shows the properties of coarse aggregate.

Table 1: Properties of Coarse Aggregate

Physical properties	Values as per IS 2386-1963
Specific gravity	2.78
Bulk density Kg/M^3	1830
Water absorption %	1.50
Free moisture content %	Nil
Fineness modulus	7.50

Figure 1: Coarse Aggregate

Recycled Aggregate: The recycled aggregate as shown in Figure 2 is the debris that is generated from the demolition of the old structures. It is the composed material that consists of cement, sand, aggregates and bricks. In this research the recycled aggregate were taken from the demolished concrete and broken into small pieces accordingly the size of the aggregate that is used in the preparation of the concrete and washed with clean water. From most of the researches recycled aggregate upto 30% shows good characteristics of concrete. In this experiment natural aggregate was replaced by recycled aggregate by 30%. Properties of recycled aggregate are shown in Table 2.

Table 2: Properties of Recycled Aggregate

Physical properties	Values as per IS 2386-1963
Specific gravity	2.40
Bulk density Kg/M^3	1570
Water absorption %	2
Aggregate crushing value %	27.50
Aggregate impact value %	32

Figure 2: Recycled Aggregate

Fine Aggregate: The aggregates less than 4.75mm in size are called fine aggregates as shown in Figure 3. The most commonly used fine aggregate in concrete is sand. Using the largest size will give more dense concrete but a mixture of all sizes is more desirable and more economical. Table 3 shows the properties of fine aggregate.

Table 3: Properties of Fine Aggregate

Physical properties	**Values**
Specific gravity	2.41
Bulk Density Kg/M^3	1514
Moisture content %	3.62
Fineness modulus	2.40
Water absorption %	0.97
zone	Nil

Figure 3: Fine Aggregate

***Banana Fiber*:** Banana fiber is also known as Musa fiber and is one of the world's strongest natural fibers. It is made from the stem of the banana tree and is incredibly durable. Banana fiber consists of thick-walled cell tissues that are bonded together by natural gums. It is mainly composed of cellulose, hemicelluloses and lignin. Its spin ability, fineness and tensile strength are said to be better. In this experiment banana fiber was used in different mixes with different quantity from 0-6% with an increment of 1.5% in each mix. Table 4 shows the properties of banana fiber.

Table 4: Properties of Banana Fiber

Properties	**Values**
Density Kg/M^3	1350
Moisture content %	11
Fineness	17.15
Tensile strength MPa	56

Water: Table 5 shows the parameters of water. Water is the most important and least expensive ingredient of the concrete. It plays an important role in mixing, laying and compaction, setting and hardening of the concrete. Also, the strength of the concrete depends on the quality and quantity of water used for mixing the concrete. In this experiment I preferred tap water for the preparation of the concrete.

Table 5: Parameters of Water

Parameter	**Value**
Specific gravity	1
P^H value	6.7
Colour	Colourless
Odour	Odourless

V. TEST METHODS

- Slump test
- Compressive strength test
- Split tensile strength test
- Flexural test

VI. RESULTS AND DISCUSSION

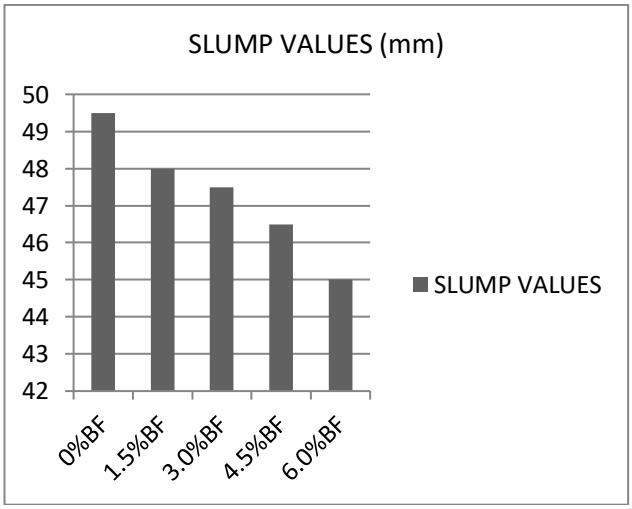

Figure 4: Slump Values of All Mixes

The represents the effect of banana fiber on the concrete using partially replaced natural aggregate (70%) by recycled aggregate (30%). The variation as shown in Figure 4 due to the increase in the banana fiber in slump decreases continuously resulting in dry mixes.

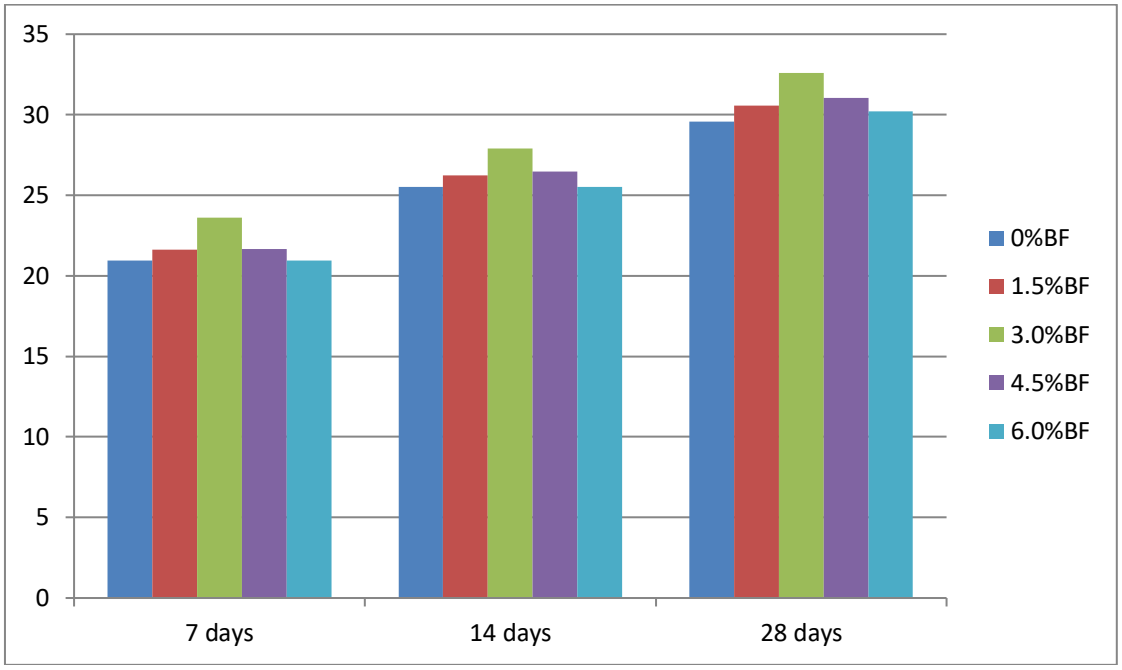

Figure 5: Combined graphical representation of the test samples for compressive strength

Results obtained for the compressive strength at 7, 14 and 28 days are shown in Figure 5. The mix containing 3% banana fiber shows good compressive strength after the curing period of 7, 14 and 28 days and increase in its percentage lead to decrease in strength.

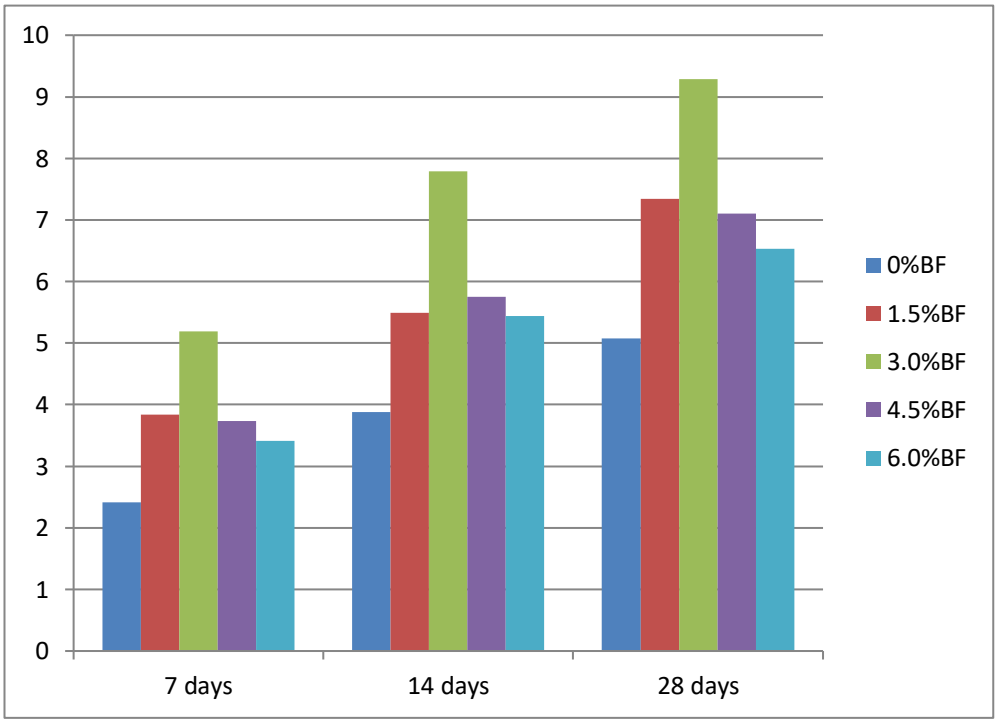

Figure 6: Combined Graphical representations of all test samples for split tensile strength

The results obtained for the tensile strength at 7, 14 and 28 days are shown in Figure 6. The mix containing 3% banana fiber shows good tensile strength after the curing period of 7, 14 and 28 days and increase in its percentage lead to decrease in strength.

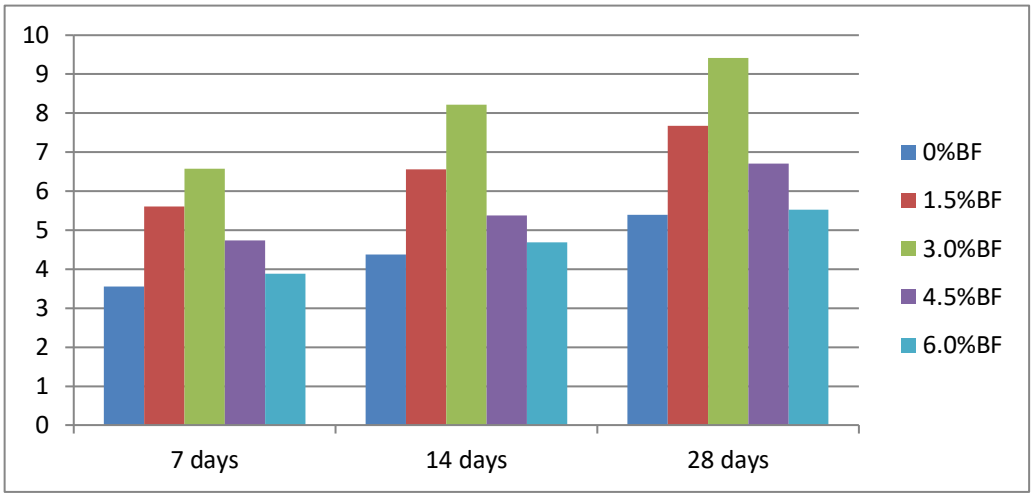

Figure 7: Combined graphical representation of test samples for flexural strength

The results obtained for the flexural strength at 7, 14 and 28 days are shown in Figure 7. The mix containing 3% banana fiber shows good flexural strength after the curing period of 7, 14 and 28 days and increase in its percentage lead to decrease in strength.

VII. CONCLUSION

Various experiments conclude that reusing concrete or replacing natural aggregate with recycled aggregate could be the best arrangement and greatly diminish land filling. The whole process was carried out to know the effect of banana fiber on concrete using recycled aggregate. This experimentation was done to know the effects on the workability, compressive strength, tensile strength and flexural strength. The results obtained from all the tests were compared to the recycled aggregate concrete without the addition of banana fiber.

Following are the points that were concluded from the whole experiment:-

- The experimental tests revealed that the strength characteristics of the concrete improved with the addition of the banana fiber to the concrete.
- Due to the addition of banana fiber to the recycled concrete aggregate the strength characteristics mainly the compressive strength and the tensile strength increased.
- There was a continuous decrease in the workability of the concrete using banana fiber.
- The compressive strength has increased upto 3% of the addition of banana fiber in the recycled concrete, beyond which it decreases with the increase in the percentage of banana fiber.
- The tensile strength has increased gradually with the addition of 3% banana fiber and then decreases gradually beyond that percentage.
- Also, the flexural strength of the concrete has increased with the addition upto 3% of banana fiber and beyond that percentage there was gradual decrement in the flexural strength.

VIII. FUTURE SCOPE

Following is some of recommendations for the future work:

- Effect of banana fiber with varying ratios can be a promising work as there is always a need to overcome the concrete brittleness problem.
- Precast concrete members using recycled aggregate is recommended to be studied.
- Proper utilization of recycled concrete and other materials from demolished structures need to be studied.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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