

COMPARATIVE STUDY OF BANANA AND SISAL FIBRE REINFORCED CONCRETE WITH CONVENTIONAL CONCRETE

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Abstract: This research describes experimental studies on the use of sisal and banana fiber to enhance the strength and applications of concrete. These natural fibers have excellent physical and mechanical properties and can be utilized more effectively. They are economical with no chemicals. The addition of sisal fibers and banana fibers significantly improved many of the engineering properties of the concrete notably compressive strength, tensile strength and flexural strength. The ability to resist cracking and spalling were also enhanced. Thus it acts as a natural admixture giving additional properties to the ordinary cement concrete. In this project three different percentages of sisal fibers and banana fibers (0.5%, 1%, 1.5%) having 30mm length to be used. M25 grade of ordinary reinforced cement concrete is casted by using Ordinary Portland cement of grade 53. Compressive strength, splitting tensile strength, flexural strength at different ages of ordinary reinforced cement concrete was tested and the sisal fiber and banana fiber reinforced cement concrete to be tested.

Keywords: Banana fibre, Sisal fibre, Material Properties, Hardened concrete properties.

1. Introduction

Even though the market for fiber reinforced concrete is still small compared to the overall production of concrete, the worldwide yearly consumption of fibers used in concrete is 300,000 tons. Concrete containing hydraulic cement, water, aggregate, and discontinuous discrete fibers is called fiber reinforced concrete. Fibers can be in form of coconut fiber, banana fiber, steel fiber, glass fiber, natural fiber, synthetic fiber, etc. But in our project we have to use banana fiber and sisal fiber. The fibers are used to reduce shrinkage cracking. Main role of fibers is to bridge the cracks that develop in concrete and increase the ductility of concrete elements, improvement on post cracking behavior of concrete. It increase more resistance to Impact load, controls plastic shrinkage cracking and drying shrinkage cracking and lowers the permeability of concrete matrix and thus reduce the bleed.

2. Material Properties

2.1 Cement

Cement is a binding material which possess very good and cohesive properties which make it possible to bond with other materials to form a compact mass. Ordinary Portland cement is the most commonly used cement for general engineering works. The specific gravity of all grades namely 33, 43 and 53 grades. In this project Ordinary Portland Cement of 53 grades is used for experimental work. Initial and final setting time of the cement was 30 minutes and 600 minutes.

Table 1. Physical properties of cement

Sl.NO	Specifications	Results
1	Type	OPC
2	Specific Gravity	3.0
3	Initial setting time	30mins
4	Consistency	30%
5	Fineness	4%

2.2 Fine Aggregates

The fine aggregate used was locally available river sand without any organic impurities and conforming to IS: 383 – 1970. The fine aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density. A concrete can be made from sand consisting of rounded grains as good as form that in which the grains or granular.

Table 2. Properties of fine aggregate

Sl.NO	Specifications	Results
1	Type	River sand
2	Specific Gravity	2.61
3	Water absorption	2.24%
4	Fineness modulus	2.9%

2.3 Coarse Aggregates

Coarse aggregate are the important constituents in concrete. Coarse aggregate are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter.

Table 3. Properties of Coarse Aggregates

SLNO	Specifications	Results
1	Fineness modulus	3.53
2	Specific Gravity	3.16
3	Water absorption	0.38

2.4 Water

Water is an important ingredient of concrete as it activity participates in the chemical reaction with cement .potable water available in laboratory with pH value of not less than 6.5 and not more than 8.5 ,conforming to the requirement of IS 456-2000 were used for mixing concrete and curing the specimen. The water which is fit for drinking should be used for making concrete.

2.5 Banana Fibre

The Banana used for this work is from the local village, Tamil Nadu region. Uniform length of fibers was obtained by using cutting machine. Salient physical and mechanical properties of Banana were determined in their natural form.

Properties of Banana Fibre

- Density (kg/m³) – 1350
- Moisture content (%) - 11
- Tensile strength (M Pa) - 56
- Elongation at Break (%) - 2.6
- Young's modulus (M Pa) – 3.5
- Fineness – 17.15

Characteristics of Banana Fibre

- It is highly strong fiber.
- It has smaller elongation.
- It is light weight.
- Its average fineness is 2400Nm

Chemical Composition

- Cellulose (%) – 63 to 64
- Hemicellulose
- Lignin (%) – 19

BANANA FIBER:



Figure 1. Banana Fibre

2.6 Sisal Fibre

Sisal fiber is a species of Agava. It is botanically known as Agave sisalana. The material is chosen to improve the various strength properties of the structure to obtain sustainability and better quality structure.

Properties of Sisal Fiber

- It is exceptionally durable & low maintenance
- It is recyclable.
- It exhibits good sound & impact absorption properties.

Chemical Composition

- Cellulose - 65%
- Hemicellulose - 12%
- Lignin - 9.9%



Figure 2. Sisal Fibre

3. Literature Survey

Banana fibers are widely available worldwide as agricultural waste from Banana cultivation. Banana fibers are environmentally friendly and present important attributes, such as low density, light weight, low cost, high tensile strength, as well as being water and fire resistant. The demand for low cost sustainable building materials is growing as social, economic, and environmental issues evolve in today's society. The study focuses on the compressive strength, split tensile strength, flexural strength performance of the blended concrete containing sisal fiber.

The influence of sisal fibers on the development of plastic shrinkage in the pre-hardened state, on tensile, compressive and bending strength in the hardened state of mortar mixes is discussed. Creep and drying shrinkage of the composite and the durability of natural fibers in cement based matrices are of particular interest and are also highlighted. The mechanical properties of a natural-reinforced composite depend on many parameters such as fibre strength, modulus, fibre length etc. Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability.

They are low cost, biodegradability, flexibility, minimal health hazards, high tensile strength and flexural modulus. As per IS 10262: 2009 the mix proportion of concrete was done. To achieve specified characteristics at specific age, workability of fresh concrete and durability requirements are carried out.

4. Experimental Investigation

4.1 Casting of Concrete

A. Preparation of Mould

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.



Figure 3. Moulds for casting the concrete

B. Mixing of concrete

There are many components of mixing that need to be considered in order to ensure that a uniform concrete mixture 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.



Figure 4. Mixing of fibre in dry sand



Figure 5. Mixing of fibre in concrete

C. Placing of 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 molding of specimens. The mixed concrete should be placed in the mould within 30 minutes of its preparation.

D. 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 mold, in three layers of approximately equal volume. 25 strokes will be done in compaction.

E. Curing of Specimen

Cubes must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after demoulding in the curing tank or mist room. The curing temperature of the water in the curing tank should be maintained at 27-30°C.

4.2 Test on Fresh Concrete

A. Workability

The workability of a concrete mix is the relative ease with which concrete can be placed, compacted and finished without separation or segregation of the individual materials.

B. Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. The slump of the concrete is measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.

4.3 Test on Hardened Concrete

A. Compressive Strength Test

The cube specimen is of the size 15 x 15 x 15 cm. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm² per minute till the Specimens fails. Compressive strength of the specimen is calculated by

$$F_{ck} = P/A \text{ (N/mm}^2\text{)}$$

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

P = ultimate load (N)



Figure 6. Compressive strength test

B. Split Tensile Strength Test

Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension.

$$2P/\pi DL \text{ (N/mm}^2\text{)}$$

Where, P = ultimate load (N)

D = diameter of cylinder (mm)

L = length of cylinder (mm)



Figure 7. Split tensile strength test

C. Flexural Strength Test

The flexural strength of the specimen is expressed as modulus of rupture, f_b and is calculated by

$$F_b = 3PL/2bd^2 \text{ (N/mm}^2\text{)}$$

Where, P = ultimate load (N)

L = Centre to Centre distance between supports (400mm)

b = breadth of the specimen (100mm)

d = depth of the specimen (100mm)



Figure 8. Flexural strength test

5. Test Results

5.1 Test on Fresh Concrete

Slump Cone Test

Slump cone value = $300 - 75 = 225\text{mm}$

5.2 Test on Hardened Concrete

Compressive Strength Test

Table 4. Compressive strength test of concrete

No of days	Compressive strength of concrete (N/mm ²)
7	30.88
14	32.40
28	39.77

Split Tensile Strength Test

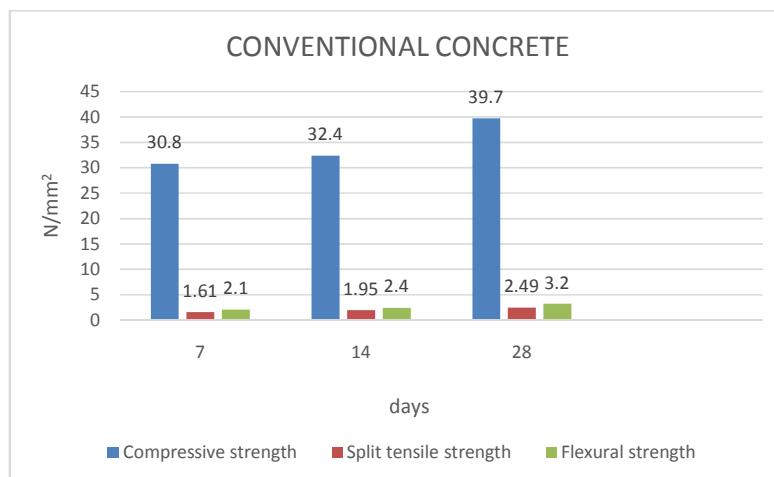
Table 5. Tensile strength of concrete

No of days	Tensile strength of concrete (N/mm ²)
7	1.61
14	1.95
28	2.49

Flexural Strength Test

Table 6. Flexural strength of concrete

No of days	Flexural strength of concrete (N/mm ²)
7	2.1
14	2.4
28	3.2



For 0.5% of addition of sisal fiber

Compressive Strength Test

Table 7. Compressive strength of concrete

No of days	Compressive strength of concrete (N/mm ²)
7	30.9
14	33.1
28	39.8

Split Tensile Strength Test

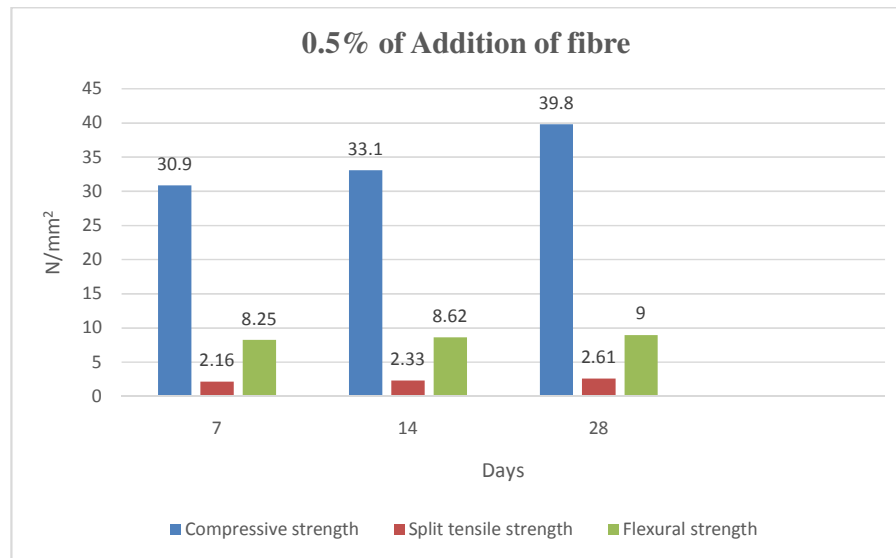
Table 8. Split Tensile Strength of Concrete (Banana and Sisal fibre)

No of days	Split tensile strength of concrete (N/mm ²)
7	2.16
14	2.33
28	2.61

Flexural Strength Test

Table 9. Flexural strength of concrete (Banana and Sisal fibre)

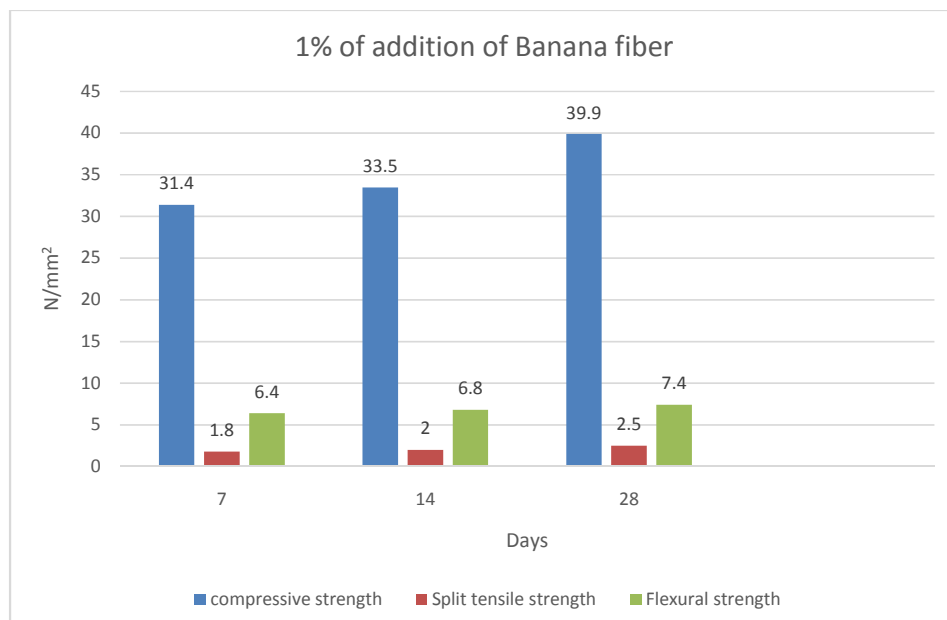
No of days	Flexural strength of concrete (N/mm ²)
7	8.25
14	8.62
28	9.00



For 1% of addition of Banana fibre

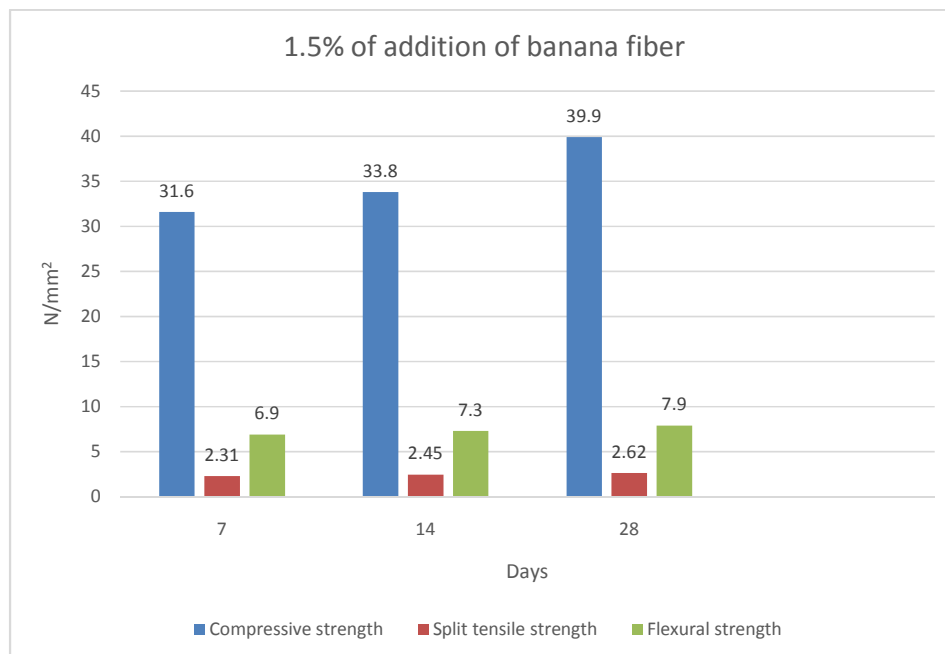
Table 10. Compressive strength, Split tensile strength, Flexural strength of concrete

No of days	Compressive strength of concrete(N/mm ²)	Split tensile strength of concrete (N/mm ²)	Flexural strength of concrete (N/mm ²)
7	31.4	1.80	6.4
14	33.5	2.00	6.8
28	39.9	2.50	7.4



For 1.5% of addition of Banana fibre**Table 11.** Compressive strength, Split tensile strength, Flexural strength of concrete

No of days	Compressive strength of concrete(N/mm ²)	Split tensile strength of concrete (N/mm ²)	Flexural strength of concrete (N/mm ²)
7	31.6	2.31	6.9
14	33.8	2.45	7.3
28	39.9	2.62	7.9

**6. Result and Discussion**

- For M25 grade of mix design, obtained mix ratio is 1:1.2:2.4 as per IS 10262:2009.
- The compaction factor show the workability of the concrete is poor.
- The compressive strength of cube at 7days of curing were calculated. Practically the strength of cube at 7 days should be 70% of the cube at 28 days of curing. There was slight difference in our obtained results.
- The split tensile strength of cylinder at 7 and 28 days were calculated. Based on IS 456:200 the split tensile strength value should be $0.35\sqrt{f_{ck}}$ N/mm² of average characteristics cube compressive strength of concrete. There was slight difference in our obtained results.
- The flexural strength of prism at 7 and 28 days were calculated based IS 456:200 the flexural strength value should be $0.7\sqrt{f_{ck}}$ N/mm² of average characteristics cube compressive strength of concrete. There was slight difference in our obtained results.

- For Conventional Concrete:
Maximum Compressive Strength is 39.7 N/mm²
Maximum Split Tensile Strength is 2.49 N/mm²
Maximum Flexural Strength is 3.2 N/mm²
- For 0.5 % of Banana and sisal Fiber:
Maximum Compressive Strength is 39.8 N/mm²
Maximum Split Tensile Strength is 2.61 N/mm²
Maximum Flexural Strength is 9 N/mm²
- For 1.0 % of Banana Fiber:
Maximum Compressive Strength is 39.9 N/mm²
Maximum Split Tensile Strength is 2.50 N/mm²
Maximum Flexural Strength is 7.4 N/mm²
- For 1.5 % of Banana Fiber:
Maximum Compressive Strength is 39.9 N/mm²
Maximum Split Tensile Strength is 2.62 N/mm²
Maximum Flexural Strength is 7.9 N/mm²
- For the comparison between different mix proportions 1, 1.5 % addition of fiber in concrete 1.5% of fiber reinforced concrete gives higher strength.
- But we compared 0.5% addition of both banana and sisal fiber in concrete with above mixes, 0.5% mix gives higher strength. Due to addition of sisal fibre

gives more strength when compared to single fibre added in concrete.

7. Conclusion

- The Natural fiber reinforced Concrete is effective when compared to conventional concrete on the basis of mechanical properties.
- Compressive strength of 1.5 % natural fiber reinforced concrete is 0.5% more than conventional M25 grade of concrete
- Split tensile strength of 1.5 % natural fiber reinforced concrete is 5.2% more than conventional M25 grade of concrete
- Flexural strength of 1.5 % natural fiber reinforced concrete is 2.5times more than conventional M25 grade of concrete
- Due to variation in strength of single fiber concrete we decided to add one more fiber in banana fiber reinforced concrete. It gives higher Flexural strength when compared to 1%, 1.5% of banana fiber reinforced concrete. But compressive strength more or less equal both type of concrete.
- We conclude that, addition of natural fiber in concrete gives higher flexural strength. Due to this strength increment, we can reduce the depth of section and design a reinforced concrete member with high load carrying capacity.

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