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Effects of Coconut and Nylon Fiber on Concrete Strength

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Abstract:
In this paper, we studied and compared conventional concrete with fiber reinforced concrete. Also, to understand the effectiveness of different fibers in strength enhancement, we had performed Compressive strength test and Tensile strength to compare the fiber reinforced concrete made with the utility of Coconut and Nylon fibers respectively.

Keywords: Compression, Coconut Fiber, Fiber Reinforced Concrete (FRC), Nylon Fiber, Split Tensile

I. INTRODUCTION

Fiber-reinforced concrete (FRC) is a concrete containing fibrous material which increases its structural integrity. It is a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers – each of which lend varying properties to the concrete. In addition, the character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities.

Fiber reinforcement can be used in normal concrete for on-ground floors and pavements but can also be used for broad range of construction parts i.e. beams, piers, foundations etc either alone or with hand-tied rebars.

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, so it cannot replace moment resisting or structural steel reinforcement. Some fibers reduce the strength of concrete. The amount of fiber added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed volume fraction (V_f). V_f typically ranges from 0.1 to 3% . Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio.

If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material.

Increase in the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers which are too long tend to "ball" in the mix and create workability problems. Some recent research indicated that using fibers in concrete has limited effect on the impact resistance of concrete materials. [1]-[2] This finding is very important since traditionally people think the ductility increases when concrete reinforced with fibers. The results also pointed out that the micro fibers are better in impact resistance compared with the longer fibers. [1]

Necessity of Fiber Reinforced Concrete:
Fiber reinforced concrete is much better and useful as compared to conventional concrete as:

- FRC not only increases the tensile strength but also the durability of the concrete.
- Reinforced concrete is a composite material, where the reinforcement itself acts as the strengthening fiber and the concrete as the matrix.
- Also, small addition of closely spaced and uniformly dispersed fiber to concrete would act as crack arrester and would substantially improve its static and dynamic properties. [3]

II. FACTORS WHICH AFFECT PROPERTIES OF FIBER REINFORCED CONCRETE

Fiber reinforced concrete is the composite material containing fibers in the cement matrix in an orderly manner or randomly distributed manner. Its properties depend on the efficient transfer of stress between matrix and the fibers. The factors are briefly discussed below:

1. **Relative Fiber Matrix Stiffness**: The modulus of elasticity of matrix must be much lower than that of fiber for efficient stress transfer. Low modulus fibers like nylon give unlikely strength to the concrete, but at the same time absorb a large amount of energy and hence add to up to greater energy and resistance. On the other hand, fibers such as steel, carbon, etc have high modulus of elasticity and hence provide strength to the FRC.[3]

Volume of Fibers: The strength of the composite largely depends on the quantity of fiber used in it. Fig 1 and 2 show the effect of volume on the toughness and strength. It can see from Fig 1 that the increase in the volume of fibers, increase approximately linearly, the tensile strength and toughness of the composite. Use of higher percentage of fiber is likely to cause segregation and harshness of concrete and mortar.[3]

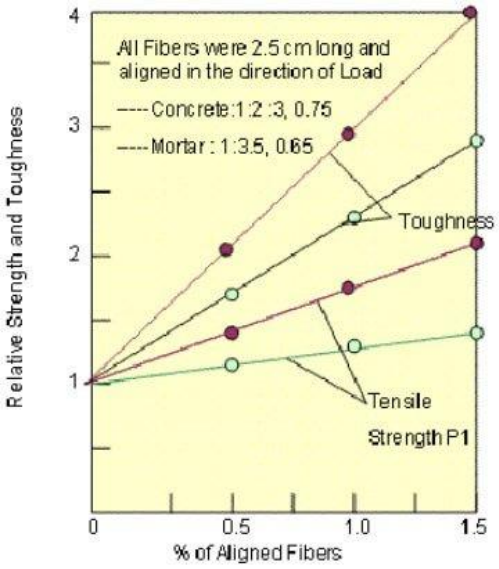


FIGURE 1: EFFECT OF VOLUME OF FIBERS IN FLEXURE [3]

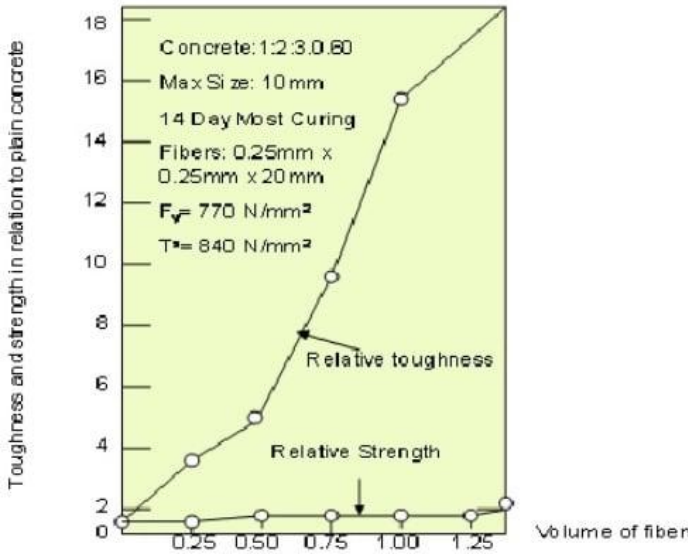


FIGURE 2: EFFECT OF VOLUME OF FIBERS IN TENSION [3]

2. **Aspect Ratio of the Fiber**: Another important factor which influences the properties and behavior of the composite is the aspect ratio of the fiber. It has been reported that up to aspect ratio of 75, increase on the aspect ratio increases the ultimate concrete linearly. Beyond 75, relative strength and toughness is reduced. Table-I shows the effect of aspect ratio on strength and toughness. [3]

TYPE OF CONCRETE	ASPECT RATIO	RELATIVE STRENGTH	RELATIVE TOUGHNESS
PLAIN CONCRETE	0	1	1
WITH	25	1.5	2.0
RANDOMLY	50	1.6	8.0
DISPERSED FIBERS	75	1.7	10.5
	100	1.5	8.5

TABLE 1: ASPECT RATIO OF THE FIBER [3]

3. **Workability and Compaction of Concrete:** Poor workability leads to non-uniform distribution of the fibers. Generally, the workability and compaction standard of mix is improved through increased water/cement ratio or by the use of some kind of water reducing admixtures. [3]

4. **Mixing**: Mixing of fiber reinforced concrete needs careful conditions to avoid balling of fibers, segregation and in general the difficulty of mixing the materials uniformly. Increase in the aspect ratio, volume percentage, size and quantity of coarse aggregate intensify the difficulties and balling tendency. It is important that the fibers are dispersed uniformly throughout the mix; this can be done by the addition of the fibers before the water is added. [3]

III. MATERIAL TESTING

For the testing of materials we added 1%, 2% and 3% of fibers i.e. coconut and nylon fiber respectively by volume to concrete of M20 grade, fine and coarse aggregate. Cubes and cylinders with dimensions of 150mm x 150mm x 150mm and 150mm x300mm were casted for different proportions of fiber. Tests were performed on the specimen after 14 days of curing.

FIGURE 3: CONCRETE CUBES

FIGURE 4: CONCRETE CYLINDERS

COMPRESSIVE STRENGTH TEST:

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material and quality control during production of concrete etc. Test for compressive strength is usually carried

out either on cube or cylinder. We used concrete cubes of dimensions 150mm x 150mm x150mm. Compression test machines are universal testing machines specially configured to evaluate static compressive strength characteristics of materials, products, and components. Compression test machine can also be equipped to perform other applications such as tensile, cyclic, shear, flexure, bend, peel, tear by adding appropriate fixtures. We used the Compression Testing Machine which had the following specifications:
Capacity of machine: 200Kn
Rate of Loading: 14N/mm^2 /min
Least Count: 5kN

FIGURE 5: COMPRESSION TESTING MACHINE

Load was applied using compression testing machine without shock at the rate of 140kg/cm^2/min until the specimen failed
.
Compressive strength can be found using the formula:

Strength = Load (force) / Cross- section Area [4]

SPLIT TENSILE STRENGTH TEST:

The concrete cylinder cured at room temperature were tested to find the tensile strength of the concrete using compressive testing machine (CTM).Cylindrical concrete of dimensions 150mm x 300mm are used along with compression testing machine. Load was applied continuously after making arrangements of the cylinder alignment on the machine at a constant rate within the range of 689 to 1380 kPa/min splitting tensile stress until failure of the specimen.

The tensile strength can be measured by:

$$f_{ck} = 2p / \pi dl \quad [5]$$

Where, p = applied load
d = diameter of the specimen
l = length of specimen

IV. RESULT AND ANALYSIS

Compressive strength test was performed on cubes with dimensions 150mm x 150mm x 150mm. And area of specimen being 22500mm^2 (225cm^2) with an applied load of 200kN (max).
The tables (Table-II & Table-III) show compression test results for nylon fiber and coconut fiber respectively, for different proportions of fiber mixed with concrete **by weight.**

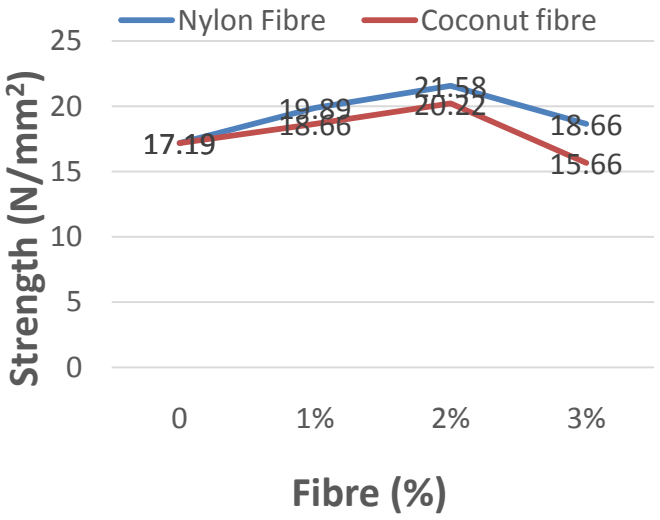
S.NO.	Percentage of Nylon Fiber Added to Concrete (by weight)	Strength (N/mm^2)
1.	0%	17.19
2.	1 %	19.89
3.	2%	21.58
4.	3%	18.66

TABLE II
COMPRESSION TEST RESULTS FOR NYLON FIBER

S.NO.	Percentage of Coconut Fiber Added to Concrete (by weight)	Strength (N/mm^2)
1.	0%	17.19
2.	1 %	18.66
3.	2%	20.22
4.	3%	15.66

TABLE III
COMPRESSION TEST RESULTS FOR COCONUT FIBER

Also, Plot 1 compares the results of compression test for Nylon and Coconut fiber based on the results obtained from Table-II and Table-III.



PLOT 1
COMPARISON OF RESULTS OF COMPRESSION STRENGTH TEST COMPRESSION TEST RESULTS FOR NYLON AND COCONUT FIBER

From the above plot i.e. Plot 1 it can be analyzed that on adding nylon and coconut fiber to the concrete and performing the compression test, the compressive strength of the FRC is greater. Which means fiber addition to the conventional concrete increases compressive strength of the concrete.

Split tensile strength test was performed on cylinders with dimensions 150mm x 300mm and applied load of 14N/mm^2 /min.

The tables (Table-IV & Table -V) show split tensile strength test results for nylon fiber and coconut fiber respectively, for different proportions of fiber mixed with concrete.

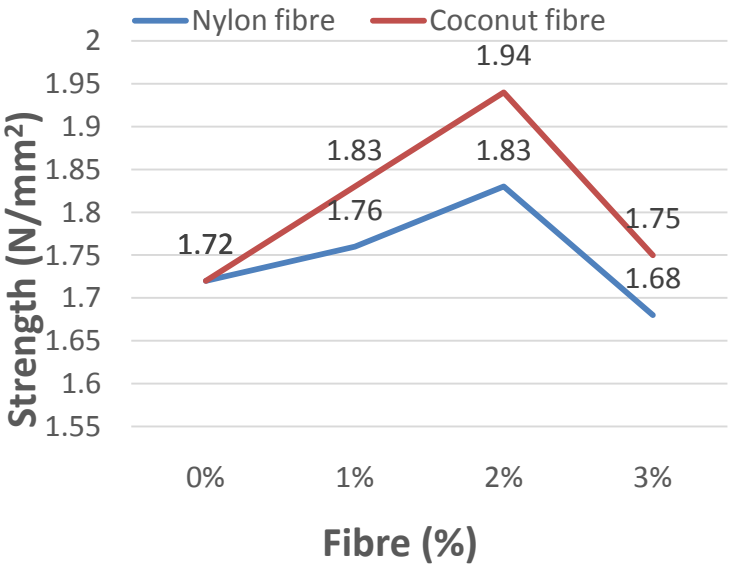
S.NO.	Percentage of Nylon Fiber Added to Concrete (by weight)	Strength (N/mm^2)
1.	0%	1.72
2.	1%	1.76
3.	2%	1.83
4.	3%	1.68

TABLE IV: SPLIT TENSILE STRENGTH TEST RESULTS FOR NYLON FIBER

S.NO.	Percentage of Coconut Fiber Added to Concrete (by weight)	Strength (N/mm^2)
1.	**0%**	**1.72**
2.	**1%**	**1.83**
3.	**2%**	**1.94**
4.	**3%**	**1.75**

TABLE V: SPLIT TENSILE STRENGTH TEST RESULTS FOR COCONUT FIBER

Plot 2 compares the results of split tensile strength test for Nylon and Coconut fiber.



PLOT 2: COMPARISON OF RESULTS OF SPLIT TENSILE STRENGTH TEST COMPRESSION TEST RESULTS FOR NYLON AND COCONUT FIBER

Like Plot 1, from Plot 2 also we can say that on adding fiber to concrete, we can increase the tensile strength of the concrete.

V. CONCLUSION

From the tables (Table-II, Table-III, Table-IV, Table-V) and plots (Plot 1 and Plot 2) for concrete mixed with nylon and coconut fiber respectively, we concluded that:

- The compressive strength of the concrete increases up to **17%** by weight when we add **coconut fiber** and **25%** by weight when we use **nylon fiber** then gradually decreases with increase in both the fibers.
- The split tensile strength of the concrete increases up to **13%** by weight when we add **coconut fiber** and **7%** by weight when we use **nylon fiber** then gradually decreases with increase in both the fibers.

Thus, concrete can be strengthened by adding fibers to it in definite proportions and is better that conventional concrete.

VI. REFERNCES

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VII. ADDITIONAL RESOURCES

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