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Experimental Study and Investigations of Nylon Fiber Induced Natural Fiber (Coir) Reinforced Concrete

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Abstract. *Worldwide, a great deal of research is currently being conducted concerning the use of fibers in increasing the workability and strengthening of reinforced cement concrete and plain cement concrete members. Use of fibers is a very effective way to increase the compressive strength of concrete. When two different fibers are added to concrete to make the composite structure and it gives maximum strength to concrete that type of concrete is hybrid fiber reinforced concrete (HFRC). In the current study, two different fibers are used namely crimped* coir *fiber and* nylon *fiber.* Coir *and* nylon *fibers have different properties and these properties will increases the tensile, flexural, impact strength of concrete. In present experimental work for M*20 *grade of concrete can be designed according to is 10262:2009. The proportion of* coir *fiber and* nylon *fiber are* replaced by by the weight of coarse aggregate 0.50% *each with* 0.25 %. *For strength parameters compressive, tensile, flexural, impact strength specimens are casted and cured for 28 days and tested for hardened concrete. To evaluate the strength parameters different tests are conducted and results are tabulated.*

Keywords*:* ***Composite Structures, Nylon Fiber Reinforced, Coir Fiber Reinforced***

1 Introduction

Concrete made with Portland cement has certain characteristics. It is relatively strong in compression but weak in tension and tends to be brittle. These two weaknesses have limited its use. Another fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly hardened. These cracks are major cause of weakness in concrete particularly in large onsite applications leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers.

Latest developments in concrete technology now include reinforcement in the form of fibers, notably polymeric fibers as well as steel or glass fibers. Fiber-reinforcement is predominantly used for crack control and not structural strengthening. Although the concept of reinforcing brittle materials with fibers is quite old; the recent interest in reinforcing cement-based materials with randomly distributed fibers is based on research starting in the 1960's. Since then, there have been substantial research and development activities throughout the world. It has been established that the addition of randomly distributed nylon fibers reduced the plastic cracking and steel fibers increase their fracture toughness, ductility and impact resistance. Since fibers can be premixed in a conventional manner, the concept of nylon fiber concrete has added an extra dimension to concrete construction.

There is a hardly anyone type of fiber that can improve all the desired properties of fresh and hardened concrete. To improve all properties of concrete the combination of two or more types of fibers is required and the composite is known as “hybrid fiber reinforced concrete”. The basic purpose of using hybrid fibers is to control cracks at different size levels in different zones of concrete, stress levels and to enhance the properties of concrete by combining the benefits that each particular fiber type can impart. In this project experimental study on compressive and flexural behavior of hybrid fiber reinforced concrete will be carried out using the combination of coir and nylon fibers.

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1.1 Role of Fibers

Cracks play an important role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. If these cracks do not exceed a certain width, they are neither harmful to a structure nor to its serviceability. Therefore, it is important to reduce the crack width and this can be achieved by adding nylon fibers to concrete.

Thus addition of fibers in cement concrete matrix bridges these cracks and restrains them from further opening. In order to achieve more deflection in the beam, additional forces and energies are required to pull out or fracture the fibers. This process, apart from preserving the integrity of concrete, improves the load-carrying capacity of structural member beyond cracking. This improvement creates a long post-peak descending portion in the load deflection curve. Reinforcing steel bars in concrete have the same beneficial effect because they act as long continuous fibers. Short discontinuous fibers have the advantage, however, of being uniformly mixed and dispersed throughout the concrete.

Fig.1 Hemp Fiber

Fig.2 Flax Fiber

Fig.3 Steel Fiber

Fig.4 Jute Fiber

1.2.1 Hybrid Fiber Reinforced Concrete

A composite can be termed as hybrid, if two or more types of fibers are rationally combined in a common matrix to produce a composite that drives benefits from each of the individual's fibers and exhibits a synergetic response. Addition of short discontinuous fibers plays an important role in the improvement of mechanical properties of Concrete. It increases elastic modulus; decreases brittleness controls cracks initiation

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and its subsequent growth and propagation. Deboning and pull out of the fiber require more energy absorption, resulting in a substantial increase in the toughness and fracture resistance of the materials to the cyclic and dynamic loads.

Fig.5 a)

Fig.5 b)

Fig.5 c)

Fig. 5 Pictures of Hybrid Fiber Reinforced Concrete

2 Methodology Adopted

To check the Compressive strength of calculated mix proportion of M20 Grade concrete casting of concrete cube specimens is done. Six concrete cubes and four beam specimens were casted of 150 mm X 150 mm X150 mm size, to check their 7 days and 28 days compressive strength. The concrete mix with grade M20 was tried to check workability and so that the strength of concrete can be compared with the cubes having 0.5% of fibers. Trial mix was taken as per the mix design given in IS 10262:2009. The initial mix was tried without any dosage of super- plasticizer to check the workability without any admixtures. The water cement ratio adopted in the both the cases is 0.45. As water cement ratio is inversely proportional to the strength of the concrete. The optimum water content required in the chemical reactions of the concrete is 0.38. so 0.45 water cement ratio was adopted in all the 2 trial mixes. The mix taken for trials are shown in following table 1

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Table 1 Trial mix for different water cement ratio

S.NO.	Materials	Quantity (kg/m3)	
		Mix 1	Mix 2
1	Cement	181	181
2	Water	198	198
3	Fine Aggregates	720	720
4	Coarse Aggregates	1113	1113
5	Fiber	Coir	Nylon+Coir
6	Water-Cement Ratio	0.45	0.45

3 Materials Used for the Study

A) Plain Concrete

Table 2 Characteristic of Plain Concrete

Fiber Type	Dia.	Length	Qty. of Fiber	W/C Ratio	Water	Cement	FA	CA
None	-	-	-	4.5	600gm	5.2kg	4.75 mm pass.	20 mm pass.

B) Fiber Reinforced Concrete

(i) Jute (3 cube samples)

Table 3 Characteristic of Jute

Fiber Type	Dia (mm)	Length (mm)	Qty of Fiber	W/C Ratio	Water	Cement	FA	CA
Natural (Jute)	0.5	50	1%	.45	600gm	5.2kg	4.75mm pass.	20 mm pass.

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(ii) Coir ($1m^3$)

Table 4 Characteristic of Coir

Fiber Type	Dia. (mm)	Length (mm)	Qty. of Fiber	W/C Ratio	Water kg	Cement kg	FA kg	CA kg
Natural (Coir)	0.5	50	0.5% of CA	.45	198	181 (53 Grade)	720 (4.75 mm pass.)	1113 (20 mm pass.)

(iii) Hybrid material (Nylon and Coir ($1m^3$)

Table 5 Characteristic of Hybrid material (Nylon and Coir)

Fiber Type	Dia. (mm)	Length (mm)	Qty. of Fiber	W/C Ratio	Water kg	Cement kg	FA kg	CA kg
Coir & Nylon	0.5	50	0.25% each	.45	198	181 (53 Grade)	720 (4.75 mm pass.)	1113 (20 mm pass.)

4 Results

In present work all 6 cubes and 4 beams were casted in different sets. Result consist of measurement of compressive strength at 7,14 and 28 days and flexural strength tests at 7 and 28 days. The quantities of material have already been specified previously.

A) Compressive Strengths

FIBER	7 DAYS	14 DAYS	28 DAYS
Plain Concrete	13.5N/mm2	18.0N/mm2	20.0N/mm2
Jute FRC	14.35N/mm2	19.8N/mm2	22.0N/mm2
Coir FRC	12.15N/mm2	16.85N/mm2	18.7N/mm2
Hybrid FRC	17.8N/mm2	20.08N/mm2	22.31N/mm2

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B) Flexure Strength

FIBER	7 DAYS	14 DAYS	28 DAYS
Plain Concrete	9.45N/mm2	-	14N/mm2
Jute FRC	8.7N/mm2	-	15.4N/mm2
Coir FRC	2.8N/mm2	-	5.6N/mm2
Hybrid FRC	4.9N/mm2	-	8.2N/mm2

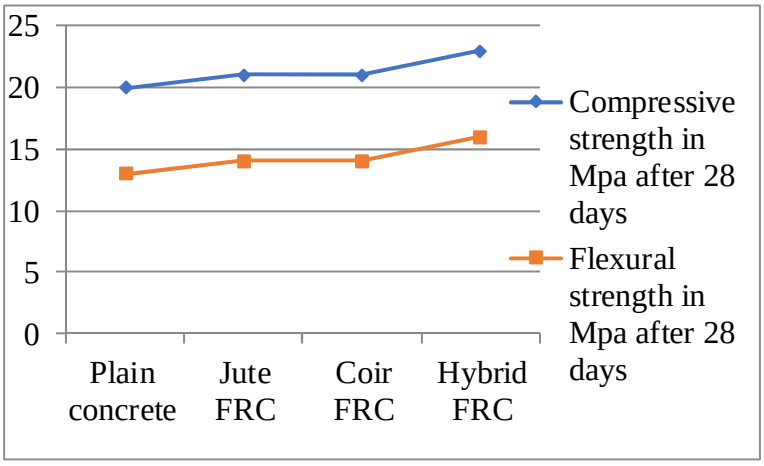

Fig 6 Expected Strength Characteristics

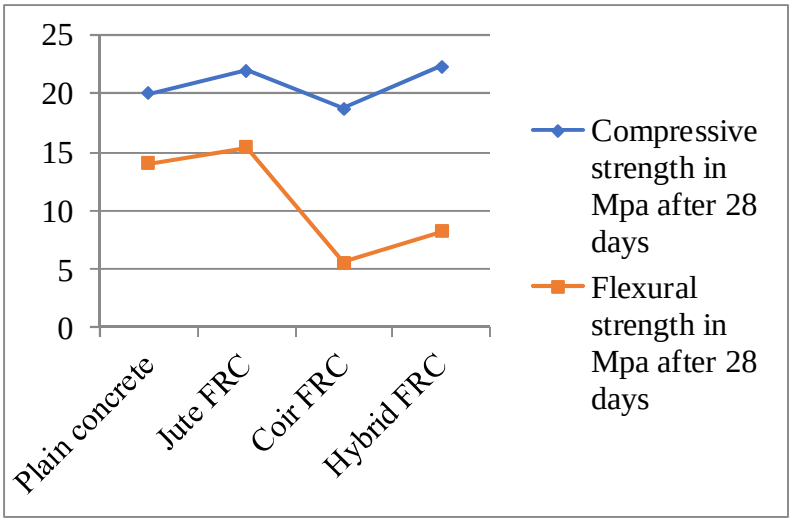

Fig. 7 Obtained Strength Characteristic

5 Conclusions

As the various fibers are used thus varied results are obtained. The compressive strength has shown a considerable increase while the Flexural strength has not shown the expected result. This may be due to low quality control, use of inappropriate material or quantities, unfavourable site conditions and testing in non-conventional and old machineries. It was found that

- The concrete designed is light in weight.
- There is a considerable increase in strength.
- The designed concrete is low density.
- As natural fiber has been used thus a considerable reduction in cost is there.

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