Effect of Natural Fibre on the Strength Properties of Concrete

Helen Jai Sneha Swathy.J[1], Dr Manju.R[2]

[1]PG scholar, Department of Civil Engineering, Kumaraguru College of Technology, Coimbatore - 641049, Tamilnadu, India
[2] Associate Professor, Department of Civil Engineering, Kumaraguru College of Technology, Coimbatore-641049, Tamilnadu, India

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Abstract - *Sustainability is a widely accepted concept in the modern construction scenario. Even though the construction industry is revolutionizing in a significant manner in terms of both equipment and materials used, the cost of construction has soared along with the ecological imbalance. This has paved way for the adoption of a more balanced approach with the environment as its hub to create a better world to live in. This has also led to the utilization of natural fibres like coir and kenaf for the strength enhancement in concrete. Kenaf and coir fibres possess highest tensile strength amongst natural fibres. They possess the greatest capability to be used as reinforcement in low-cost concrete structures. For this purpose, the mechanical properties of Coir Fibre Reinforced Concrete (CFRC) and Kenaf Fibre Reinforced Concrete (KFRC) members need to be well understood. Kenaf fibre possesses greater tensile property. Kenaf fibre also aids in the absorption of Carbon di oxide from the atmosphere. On the other hand incorporation of coir fibre in the concrete enhances its mechanical properties. This experimental investigation involved studying the strength properties of six coir mixes with 0.1%,0.2%,0.3%,0.4%,0.5%,0.6% fibre volume fraction of concrete, four kenaf mixes with 0.25%,0.5%,0.75%,1% fibre volume fraction of concrete and four hybrid fibre mixes. It has been found that concrete specimen with 0.4% of coir and 0.75% of kenaf has shown excellent mechanical properties than the control specimens of mix M20. The hybrid mix with 0.3% coir and 0.4% kenaf has exhibited flexural strength of 9.4 MPa at 7 days which is 86 % greater than the control mix. This report emphasizes the effect of natural fibre on strength properties of concrete.*

***Key Words*: *Coir fibre, Kenaf fibre, Mechanical properties, Natural fibre, Tensile strength*.**

1. INTRODUCTION

The development of high-performance engineering products made from natural resources is increasing worldwide, due to renewable and environmental issues. Among the many different types of natural resources, kenaf plants and coconut trees have been extensively exploited over the past few years. The use of natural fibres as building materials is benefit to achieve a sustainable construction. In order to optimize the cost of construction, engineers have always been in quest for efficient and light roofing which requires minimum maintenance and labor to install. Kenaf fibre as shown in fig.1 is a natural fibre obtained from the bast of the Kenaf plant. Kenaf plant (Hibiscus cannabinus) belongs to the family Malvaceae which grows extensively in Southern Asia. Coir fibres as shown in fig.2 are extracted between the hard, internal shell and the outer coat of a coconut. The hollow fibre cells consist of thick walls made of cellulose. They are pale when immature, but later become hardened and yellowed as a layer of lignin is deposited on their walls.

Fig -1: Kenaf fibre

Fig -2: Coir fibre

In this modern era, utilization of natural fibre in the concrete sector promotes the eco friendly approach. Inclusion of natural fibre such as kenaf and coir fibre in the concrete is a promising solution for the low cost housing projects.

2. LITERATURE REVIEW

It has been reported that the optimum dosage of coir fibre is 0.25% by weight of fine aggregate (Gupta and Kumar, 2019)and the optimal proportion of kenaf fibre in concrete is 0.75 % of the concrete mix with fibre length of 50 mm.The flexural strength and split tensile strength of kenaf fibre reinforced concrete is directly proportional to its fibre content and fibre length but its compressive strength is inversely proportional to its fibre content.(Tian Fook Lam et al 2015) The Water/Cement ratio of 0.58 can be maintained to obtain the required slump value as fibres are hydrophilic in nature(Syed Mohsin et al 2018).The research indicates that the kenaf fibre possesses higher toughness and it exhibits more ductile behavior in addition to its greater energy absorption property. Besides these addition of kenaf fibre in concrete aided in the propagation of cracks thereby leading the structural elements casted to sustain the load for a long time rather than allowing the concrete specimen for a catastrophic failure(Elsaid et al., 2011).It has also been observed that the incorporation of coir fibre in the concrete has shown improved resistance to compressive stress.

3. MATERIALS AND MIX PROPORTIONS

M20 mix with the water cement ratio of 0.48 was adopted as the control mix.The fibre proportioning in the mixes are summarized in the Table 2.Further,the l/d ratio adopted for kenaf mix and coir mix was 143 and 105 respectively.

Table -1: Material Properties

S.No	Materials	Properties	Values
1	Ordinary Portland Cement	Specific gravity	3.13
		Standard consistency	29.5%
		Fineness	6%
		Initial Setting Time	70 minutes
		Final Setting Time	600 minutes
2	M-Sand	Specific gravity	2.61
		Grading	Zone II
3	Coarse aggregate	Specific gravity	2.67
		Water absorption	0.4%
4	Kenaf fibre	Diameter	0.35 mm
		Unit weight	1000 Kg/m^3
		Water absorption	411.82%
		Tensile strength	1166 MPa
5	Coir fibre	Diameter	0.38 mm
		Unit weight	1250 Kg/m^3
		Water absorption	68.6%
		Tensile strength	1000 MPa

Table -2: Mix Proportions

4. EXPERIMENTAL INVESTIGATION

For each mix three cubes of dimension 150X150X150 mm, three cylinders of diameter 150 mm and height 300 mm, three prisms of 100X100X500 mm were casted.The specimens were in the moulds undisturbed at room temperature for about 24 hours after casting. The specimens after removing from the moulds were immediately transferred to curing ponds containing clean and portable water.The mechanical properties of the fibre reinforced concrete specimen such as compressive strength, split tensile was conducted as specified in test method of IS 516:1959.

5. RESULTS AND DISCUSSION

Mix description	Mix ID	Fibre volume fraction of concrete (%)	
Control mix	M20	---	
Kenaf mix	25K	0.25	
	50K	0.5	
	75K	0.75	
	100K	1	
Coir Mix	1C	0.1	
	2C	0.2	
	3C	0.3	
	4C	0.4	
	5C	0.5	
	6C	0.6	
		Kenaf fibre	Coir fibre
Hybrid mix	H1	0.5	0.25
	H2	0.45	0.3
	H3	0.4	0.35
	H4	0.35	0.4

The mechanical properties of the concrete with kenaf, coir and hybrid mix tested at 28 days has been shown in Chart - 1,Chart - 2,Chart -3 respectively.

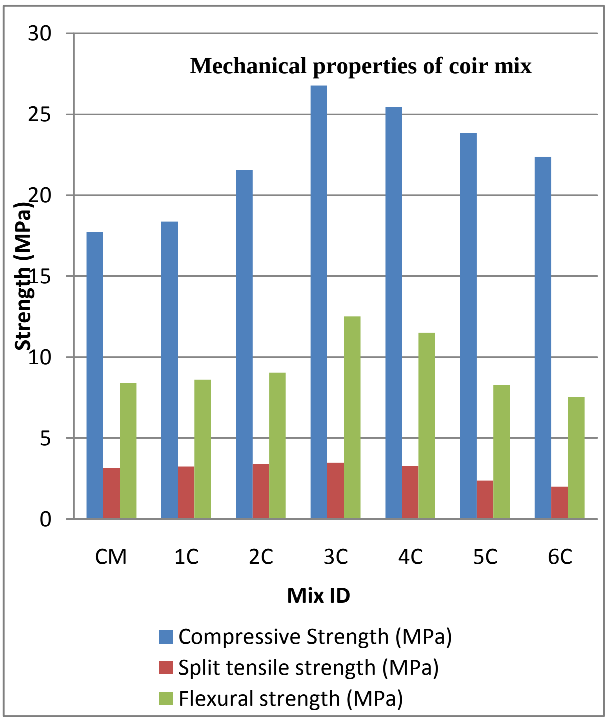

Chart -1: Graph showing the test results of coir mix

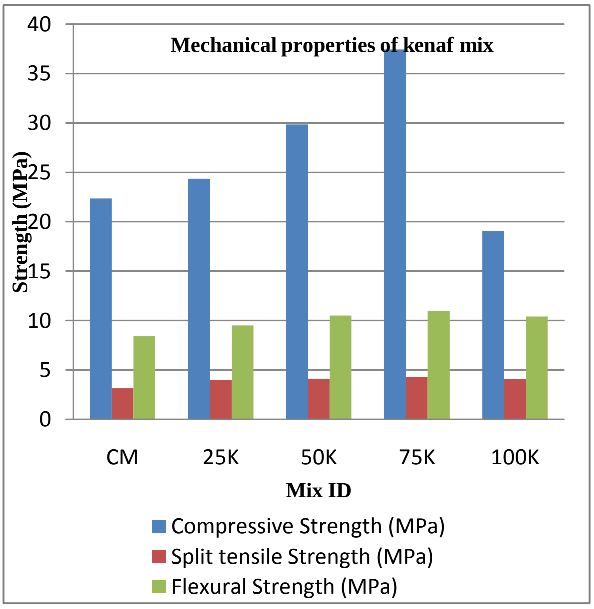

Chart -2: Graph showing the test results of kenaf mix

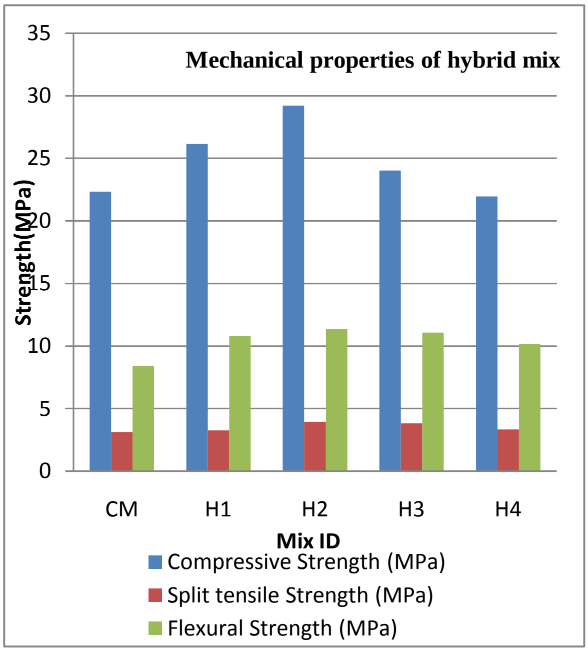

Chart -3: Graph showing the test results of hybrid mix

Chart -1 indicates that at 0.3% addition of coir fibre in concrete with a Water/Cement ratio of 0.48,higher compressive strength value of 38.12 MPa was observed. When the fibre content is increased there is an increase in split tensile strength with a maximum at 0.3%. However when the fibre content is increased beyond this value a reduction in tensile strength is observed.

Chart - 2 indicates that 0.75% addition of kenaf fibre in concrete the specimens have shown excellent mechanical properties. Besides these kenaf fibre has predominantly increased the split tensile strength value of the concrete specimen to 4.25MPa.

Even at lower mix design of M20, the hybrid fibre H2 mix (0.45% kenaf fibre and 0.3% coir fibre) have shown about 36 % increase in flexural strength,27 % increase in split tensile strength and 30 % increase in compressive strength than the control specimen as shown in Chart - 3.

6. CONCLUSIONS

From the results and discussion the conclusions are summarized as follows,

1. Maximum compressive strength of 38.12 MPa which is 71 % greater than the control specimen was observed at 0.3% of coir fibre addition by fibre volume fraction. On further addition of fibres compressive strength values way below that of conventional concrete are obtained.
2. Besides these coir fibres hinder better packing of the constituents of concrete creating weak zone around the coir fibres thereby making the entire concrete specimen weak.
3. It has also been observed that the split tensile strength and flexural strength of the concrete specimen has been increased about 11.18% and 67% than the control specimen. However when the fibre content is increased beyond this value decreasing trend is observed.
4. It can be found that Kenaf Fibre Reinforced Concrete specimens with 0.75% kenaf fibre exhibited higher compressive strength of 37.46 MPa, split tensile strength of 4.25 MPa and flexural strength of 11 MPa .
5. It can be concluded that the optimal proportion of the kenaf fibre is 0.75% and kenaf fibre content should not be used beyond 1%.
6. When a crack is formed in the Kenaf Fibre Reinforced Concrete prisms, the presence of the kenaffibres helped to bridge the crack and the crack is smaller, which led to a more ductile failure mode.Thus the concrete specimens with 0.3% coir fibre and 0.75% kenaf fibre has shown excellent mechanical properties .
7. Based on the findings, it was observed that kenaf fibre reduced the cracking propagation of the concrete specimen.
8. From the hybrid mix results, it has been observed that the H2 (0.3 % coir fibre and 0.45 % kenaf fibre) mix has exhibited higher compressive strength of 29.23 MPa which is 30 % greater than the control specimen.

9. The split tensile strength results indicates that the higher tensile strength of 3.97 MPa can be achieved by H2 mix (0.3 % coir fibre and 0.45 % kenaf fibre).
10. From the flexural strength results shown in Chart - 3, both H2 mix (0.3% coir fibre and 0.45% kenaf fibre) and H3 mix (0.35 % coir fibre and 0.4 % kenaf fibre) has exhibited greater flexural strength value of 11.4 and 11.1 MPa respectively which is 36% greater than the control specimen.
11. When compared with the individual properties of kenaf and coir fibre reinforced concrete specimens the combined hybrid concrete specimens have exhibited excellent mechanical properties.

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