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Effect of Sisal Fibre Reinforced Concrete on Tensile and Flexure Strength

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ABSTRACT

Fibre is reinforcing material possessing characteristic properties when used in concrete. They are discontinuous and distributed randomly throughout the concrete. Mainly they are in two types, natural fibre and artificial fibre. Jute, flax, kneaf, sisal, henequen, coir, bamboo, reeds, sugarcane are the natural fibre. Artificial fibre such assteel, glass, carbon, polypropylene, nylon, polyester, polyethylene etc. Fibre can improved the tensile strength as well as flexure strength of concrete. The composition of sisal fibre is of cellulose, lignin and hemicelluloses. The failure strength and modulus of elasticity depend on amount of cellulose and the orientation of micro fibre. This research work is done to study the properties of concrete by using sisal fibre. Micrometer gauge is used to measure the diameter of fibre and it was found to be as 0.5mm. Typical aspect ratio ranges from 30 to 150. Adopted fibre in constant percentage i.e.1% with different aspect ratio of 60, 100 and 140. The M30 grade of concrete is used and material is mixed manually and Fibres are extracted also manually by using natural method. Casted specimens are tested to check tensile strength as well as flexure strength. Flexural strength is carried out under the two point loading. The increase in tensile strength by 73.71% and flexure strength by 54.55%.

Keywords – Fibre reinforced concrete (FRC), Natural fibre, Sisal fibre, tensile strength, flexure strength.

1. INTRODUCTION

Concrete is the composite material or mixture of cement, fine aggregate, course aggregate and water. It has high compressive strength but lower tensile strength. For increase the tensile strength it is reinforced with steel material. The cracks are developed in all concrete structure after some period, due to shrinkage and tension. At high stress level cracks are developed and in case of low stress level elasticity of concrete remains constant and it decreases as stress level increases. Fibre reinforced concrete is the composite mixture of cement mortar or concrete and fibre. Fibre can be continuous or discontinuous, are distributed randomly in mixture. Mechanical properties of concrete such as toughness, ductility, and tensile as well as flexural strength can be increase by using the fibre. Fibres can also resist the propagation of crack. In plain concrete, structural cracks develop before loading due to drying shrinkage and other causes. At the time of loading internal crack propagates and opens up due to stress and additional cracks are formed. These cracks are developed due to inelastic deformation in concrete.

Plants named as Agave sisalana, from the leave of this plant sisal fibre are obtained. In Maharashtra state the local name of Agave sisalana is “Kektad”. The Agave sisalana plant grows well in hot climate; mostly they are cultivated in dry areas which are not suitable for other crops. Sisal fibre is reinforcement material because of it is easy available in low cost, it can renewable and has high specific strength. Sisal fibres are used for

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making ropes, baler and binders twine. Ropes and twines are widely used in agriculture field and for general industrial uses.

The aim of this study to work out influence of various length of sisal fibre i.e. aspect ratio on the strength of concrete (split tensile strength & Flexural strength)

Figure 1: Sisal plant

2. OBJECTIVE OF THE WORK

The following are the objective of project work

1) To find the significant of strength due to a variation of sisal fibre length.
2) To find out the value of tensile and flexure of the specimen with different length of sisal fibre.
3) To compare the results with and without sisal fibre.
4) To choose the optimum length of sisal fibre contents in concrete structure respects to its tensile and flexure strength.

3. SCOPE OF THE WORK

The scope of our work is as follows:

In order to achieve the objective of this study, a split tensile test and flexure test was implemented which was accordance to the universal testing machine (UTM) for cylinder and beam with appropriate loading bearers. The flexure test carried out under two point loading condition. The concrete grade M30 was used during the preparation of the concrete mixture for the usage of normal concrete as well as FRC.

Total 24 cylinders and beam of concrete were prepared for this study. The proposed size for the cylinder is diameter of 150mm and height of 300mm. The size of beam is 150mm x 150mm x 700mm. For the both specimen, test for 7 days and 28 days is conducted.

4. MATERIALS USED

A) Cement

53 grade Ordinary Portland cement is used for the study program. The properties of this cement have been tested and given below:

Specific gravity of Cement = 3.15

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Initial Setting Time = 30 minutes

Final setting time = 600 minutes

B) Fine Aggregate

River sand was used in preparing the concrete mix. The properties of this fine aggregate have been tested and given below:

Specific gravity of fine aggregate = 2.6

Water absorption = 2.32%

C) Coarse Aggregate

The course aggregate was obtained from local crushing plant. The properties of this coarse aggregate have been tested and given below:

Specific gravity CA = 2.66

Bulk density of coarse aggregate = 1487.6 Kg/m3

Water absorption = 1.5%

D) Water

Potable water is used for the mixing and curing, which is free from impurities like oils, acids, alkalis, sugar, salts and organic materials or other substances that may be deleterious to concrete or steel and confirming to IS: 456-2000.

E) Sisal fibre

Sisal fibre is soft and shiny obtain from the leave of sisal plant. Plant is look like a pineapple fruit where leaf of sisal plant much larger than pineapple fruit. The extraction process of sisal fibre is quite simple where in process leafs are kept in wet condition by deep in water for 10 days and then water is use to wash away the scatter parts of the leaf. The fibre is then dried out. For the comparative study fibre is cuts in various lengths such as 3mm, 5mm, 7mm and randomly distributed in concrete mix to obtained sisal fibre reinforced concrete.

Figure 2: Sisal fibre

Table 1: Properties of sisal fibres (Mukherjee & Satyanarayana, 1984)

Diameter (µm)	Density (g c^{-2})	Cellulose (%)	Lignin (%)	1/d ratio*	Cell wall thickness(µm)	Microfibrillar Angle (deg)
100-300	1.450	70	12	100	12.5	20-25

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5. MIX PROPORTION

Mix design is the process of selecting the ingredients of concrete and determining their relative proportions. Following table shows the mix proportion obtained by referring IS 10260:2009

Table 2: Mix proportion

Sr. No.	Cement (Kg)	FA (Kg)	CA (Kg)	Water (Kg)	Fibre (Kg)
1	85.05	115.48	214.33	35.15	0.85

6. CASTING AND TESTING OF SPECIMEN

Based on the design four batches were prepare by using M30 grade of concrete; One for normal mix and three for different length of fibres i.e. for 3mm, 5mm and 7mm. For the four mixes cylinders and beams are casted. For taking an average three specimen were casted for every mix for each test. Mixing is done by hand and well compaction is done by compacting rod. The test was conducted on 7 days and 28 days after casting and curing of specimen.

Table 3: Number of moulds for Testing

Aspect ratio	60	100	140	Normal mix	Total quantity
Length of fibre	3cm	5cm	7cm		
Cylinder	6	6	6	6	24
Beam	6	6	6	6	24

7. RESULT AND DISCUSSIONS

7.1. Test on fresh concrete

7.1.1 Workability of concrete

Figure 3: Slump cone test

Workability of concrete was checked by slump cone test and it was true slump that indicates concrete having good workability. 1% sisal fibre does not affect the workability.

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7.2. Test on hardened concrete

There are in 3 different length of fibre dosage. At the time of mixing, the fibres are randomly distributed in the fresh concrete.

7.2.1 Split tensile strength of concrete cylinder (d=150mm, h=300mm)

Figure 4: Split tensile test

Table 4: Tensile strength results

Specimen	Normal concrete		FRC with 3cm fibre		FRC with 5cm fibre		FRC with 7cm fibre	
	7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
Cylinder no. 1	1.994	2.342	2.156	2.376	2.352	2.765	2.634	3.098
Cylinder no. 2	1.783	2.094	2.092	2.354	2.406	2.830	2.593	3.050
Cylinder no. 3	2.095	2.454	2.214	2.472	2.485	2.901	2.705	3.201
Average	1.957	2.297	2.327	2.401	2.414	2.832	2.644	3.116

It has been seen that from the above results the tensile strength is increase by introducing 1% sisal fibre. The obtained results also show that as length of fibre increases the tensile strength is also increases. In case of normal concrete cracks are developed in early stage of loading because there is no resistance to crack propagation. The presence of micro-crack at the mortar-aggregate interface can be reason for tensile failure of concrete. The maximum tensile strength was observed by the length of 7cm fibre (Aspect ratio of 140). Tensile strength of 5cm length of fibre is slightly less than strength obtained by 7cm length of fibre. When fibre is added to concrete it obstructs to propagation of crack.

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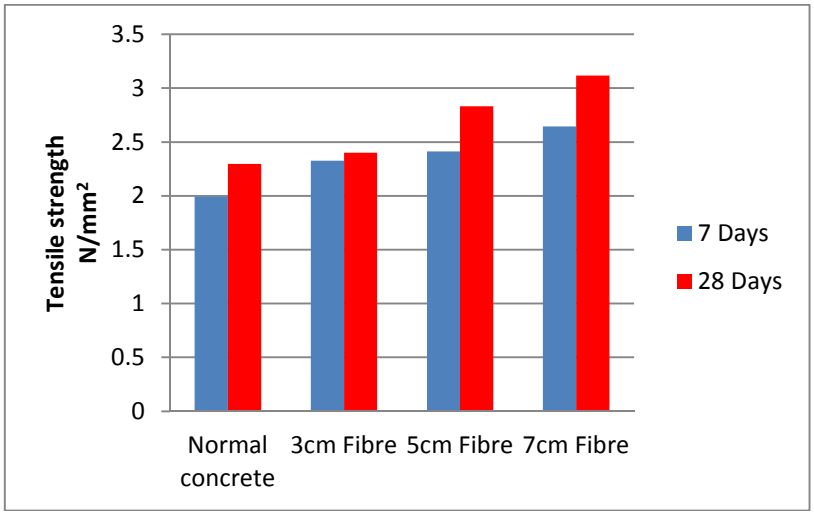

Chart 1: Graphical representation split tensile strength

7.2.2 Flexure strength of concrete beam (150mm x 150mm x 700mm)

Figure 5: Flexure test

Table 5: Flexure strength results

Specimen	Normal concrete		FRC with 3cm fibre		FRC with 5cm fibre		FRC with 7cm fibre	
	7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
Beam no. 1	2.68	3.43	2.96	3.81	4.40	5.64	5.67	7.26
Beam no. 2	3.08	3.95	3.25	4.17	3.94	5.05	4.74	6.08
Beam no. 3	2.38	3.05	2.89	3.71	3.56	4.56	4.36	5.79
Average	2.71	3.48	3.03	3.89	3.96	5.08	4.92	6.38

From the results it was observed that by adding 1% sisal fibre flexure strength is improved. The results show that there is not very much difference between strength obtained by normal concrete and 3cm length of fibre reinforced concrete. In case of 5cm length of fibre there is significantly improved the flexure strength. The maximum flexure strength was observed by 7cm length of sisal fibre reinforced concrete and it was twice the normal concrete.

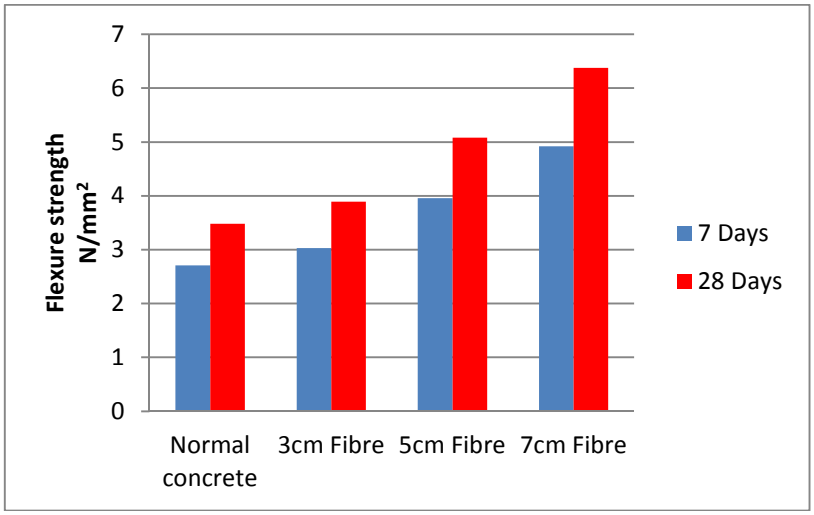

Chart 2: Graphical representation flexure strength

8. CONCLUSIONS

According to this comparative study it was observed that by 1 % additional of sisal fibre can improved the tensile strength as well as flexure strength of concrete without affecting the workability. As length of fibre increases the flexure strength as well as tensile strength increases. The maximum length of fibre (Aspect ratio of 140) can gives the maximum strength. At aspect ratio of 60, the flexure strength of sisal fibre reinforced concrete is quietly similar to normal concrete.

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