

STUDY ON RESULT OF IMPLEMENTATION OF SISAL FIBRE IN REINFORCED CEMENT CONCRETE

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ABSTRACT: This paper widely explains the results obtained by implementation of sisal fibre in various mix proportions. The main target of this paper is to understanding the strength properties and workability of sisal fibre in reinforced cement concrete. The material is chosen to get the improvement in various strength properties of the structure sustainability and better quality. The vegetable fibre having a physical property of no deterioration in concrete medium. The fibre material is chemically treated and studied for its properties. Then the fibrous material is mixed with concrete in addition of 1%, 2% and 3% in M60 mix design and casted in cubes and cylinders. The casted specimens were subjected to tests to find the compressive, tensile and flexural strength. And the results of 7, 14 and 28th day specimens are compared to find the optimum percentage of sisal fibre implementation. The methodology and the process with its results are explained in this paper in detail.

1. INTRODUCTION

In the beginning of the civilization, Fibres have been used to toughen bricks and pottery. Initially, it was suggested that the cracking strain of brittle matrices, such as cement paste mortar and concrete, could be significantly increased by using closely spaced fibres. The experimental studies showed that the stress at which a brittle matrix will crack can be slightly increased by using high modulus fibres but, in general, the cracking strain of the matrix remains unaltered. The fibres bridge across the cracks and so provide post-cracking ductility. A wide variety of fibres have thus been used with cement-based matrices. They include metallic fibres, polymeric fibres, mineral fibres and vegetable fibres. The cement matrices can consist of paste, mortar or concrete. Most of the developments with fibre reinforced concrete involve the use of ordinary Portland cement. However, high alumina cement, cement with additives such as fly ash, slag, silica fume, etc. have also been used generally to improve the durability of the composite or to minimize chemical interactions between the fibres and matrix.

Fibres can be added to cement-based matrices as primary or secondary reinforcement. Fibres work as primary reinforcement in thin products in which conventional reinforcing bars cannot be used. In these applications, the fibres act to increase both the strength and the toughness of the composite. In components such as slabs and pavements, fibres are added to control cracking induced by humidity or temperature variations and in these applications, they work as secondary reinforcement.

Vegetable fibres, including sisal, coconut, jute, bamboo and wood fibres, are prospective reinforcing materials and their use until now has been more empirical than technical. They have been tried as reinforcement for Cement matrices in developing countries mainly to produce low-cost thin elements for use in housing schemes.



Fig. 1.1- sisal fibre

2. PROPERTIES AND TREATMENT OF SISAL FIBRE

Sisal is the plant of the family Asparagaceae and its fibre, the most important of the leaf fibre group. The plant is native to Central America. The length of sisal fibre is between 1.0 and 1.5 m and the diameter are about 100-300 μ m. The fibre is actually a bundle of hollow sub-fibres. Their cell walls are reinforced with spirally oriented cellulose in a hemi-cellulose and lignin matrix. So, the cell wall is a composite structure of lignocellulosic material reinforced by helical microfibrillar bands of cellulose. The composition of the external surface of the cell wall is a layer of lignaceous material and waxy substances which bond the cell to its adjacent neighbours. Hence, this surface will not form a strong bond with a polymer matrix. Also, cellulose is a hydrophilic glucan polymer consisting of a linear chain of 1, 4-b-bonded anhydroglucose units and this large amount of hydroxyl groups will give sisal fibre hydrophilic properties. This will lead to a very poor interface between sisal fibre and the hydrophobic matrix and very poor moisture absorption resistance.

2.1 CHEMICAL TREATMENT

The purpose of this chemical treatment is to give optimum tensile strength with an increase of 76 percent compare to raw fibre. This treatment improves the thermal resistance of fibre due to the removal of the waxy layers and other impurities from the surface.

2.1.1 ALKALINE TREATMENT

Alkaline treatment or mercerization is one of the most used chemical treatment of natural fibres when used to reinforce thermoplastics and thermosets. This treatment removes a certain amount of lignin, wax and oil covering the external surface of the fibre cell wall, depolymerizes cellulose and exposes the short length crystallites. It increases the thermal resistance of the fibre due to the removal of wax content from the fibre.

2.1.2 SILANE TREATMENT

Silane is a chemical compound with chemical formula SiH_4 . Silanes are used as coupling agents to let glass fibres adhere to a polymer matrix, stabilizing the composite material. Silane coupling agents may reduce the number of cellulose hydroxyl groups in the fibre-matrix interface.

2.1.3 ACETYLATION OF NATURAL FIBRES

Acetylation of natural fibres is a well-known esterification method causing plasticization of cellulosic fibres. The reaction involves the generation of acetic acid (CH_3COOH) as by-product which must be removed from the lignocellulosic material before the fibre is used.

2.1.4 BENZOYLATION TREATMENT

Benzoylation is an important transformation in organic synthesis. Benzoyl chloride is most often used in fibre treatment. Benzoyl chloride includes benzoyl ($\text{C}_6\text{H}_5\text{C}=\text{O}$) which is attributed to the decreased hydrophilic nature of the treated fibre and improved interaction with the hydrophobic PS matrix.

2.1.5 ACRYLATION

Acrylation reaction is initiated by free radicals of the cellulose molecule. Cellulose can be treated with high energy radiation to generate radicals together with chain scission.

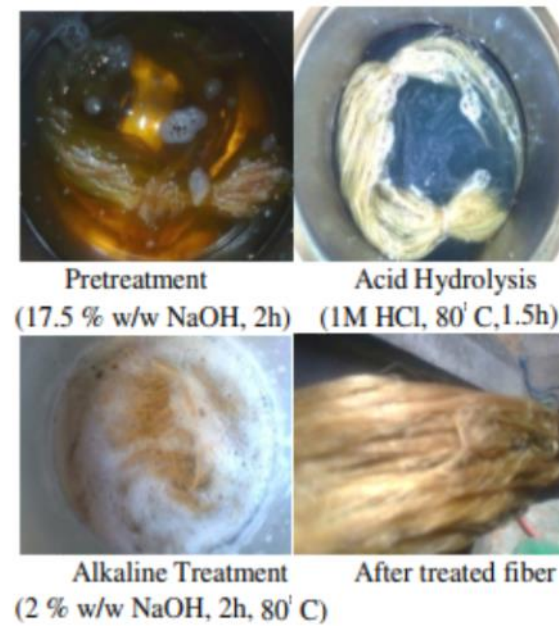


Fig. 2.1- chemical treatment of sisal fibre

3. PROPORTIONING OF CONCRETE

Proportioning

- a). Grade Designation = M60
- b). Type of Cement = OPC 53 Grade
- c). Maximum nominal size of aggregate = 10mm
- d). Minimum cement content = 320 kg/m³
- e). Maximum cement content = 450 kg/m³
- f). Maximum water-cement ratio = 0.30
- g). Workability = 100mm (Slump)
- h). Exposure Condition = Severe
- i). Method of concrete placing = Pumpable concrete
- j). Degree of supervision = Good
- k). Type of Aggregate = Angular
- l). Chemical Admixture type = Super plasticizer (0.8)
- m) Type of mineral admixture = Fly ash (20% of cement)

4. MECHANICAL BEHAVIOUR OF CONCRETE

4.1 SLUMP CONE TEST

The slump cone test measures the consistency of the fresh concrete. It is performed to check the workability of freshly made concrete, and therefore ease with which concrete flows.

Water cement ratio: 1:1.46:2.03:0.3:0.8



Fig 4.1- slump cone test

Table 4.1- slump cone test

Sl.no	Replacement detail	Slump value (mm)
1	Nominal concrete	95
2	1% sisal fibre	85
3	2% sisal fibre	70
4	3% sisal fibre	60

The slump cone test result shows that the replacement of more amount sisal fibre in the concrete affect the slump value. In which it reduces the workability.

4.2 AVERAGE TEST RESULT

4.2.1 AVERAGE COMPRESSIVE STRENGTH

Table 4.21- average compressive strength

Sl.no	Replacement Details	Average compressive strength (N/mm ²)		
		7 th day	14 th day	28 th day
1	Nominal mix	43.9	55	66.9
2	Sisal fibre (1%)	44.4	57.6	69.8
3	Sisal fibre (2%)	38.1	49.2	61.3
4	Sisal fibre (3%)	29.6	41.4	52.1

4.2.2 AVERAGE SPLIT TENSILE STRENGTH

Table 4.22- average split tensile strength

Sl.no	Replacement Details	Average flexural strength(N/mm ²)		
		7 th day	14 th day	28 th day
1	Nominal mix	4.76	6.02	6.91
2	Sisal fibre (1%)	4.98	6.44	7.26
3	Sisal fibre (2%)	5.30	6.67	7.61
4	Sisal fibre (3%)	5.13	6.52	7.42

4.23 AVERAGE FLEXURAL STRENGTH

Table 4.23- average flexural strength

Sl.no	Replacement Details	Average split tensile strength(N/mm ²)		
		7 th day	14 th day	28 th day
1	Nominal mix	3.98	4.99	5.76
2	Sisal fibre (1%)	4.52	5.69	6.11
3	Sisal fibre (2%)	4.81	5.91	6.52
4	Sisal fibre (3%)	4.53	5.74	6.23

5. COMPARISON AND DISCUSSION:

From this test results the compressive strength increases for the replacement of 1% sisal fibre. More than 1% sisal fibre in concrete affects the compressive strength. The compressive strength decreased gradually when increasing the amount of sisal fibre. Where as in flexural and tensile strength test, the strength is maximum at 2% and gradually decreased when adding sisal fibre more than 2 % in concrete. And also, in slump cone test the slump value is gradually reduced with respect to the amount of sisal fibre. 1% sisal fibre does not show greater variation. Because it ranges between 75 -100. It possesses good workability. But replacing more than 1% affects the workability and compaction.

6. CONCLUSIONS

From the results, 1% of sisal fibre gives good compressive, tensile and flexural strength. Replacing 1% cement with sisal fibre in the concrete increases the compressive strength about 5 – 20%. And 2% of sisal fibre increases tensile and compressive strength by 10-30%. But replacing more than 1% of cement reduces the compressive strength considerably. Because more amount of sisal fibres reduces the workability and compaction of fresh concrete.

Replacing of 1% of cement with sisal fibre show good performance in hardened concrete. So optimum percentage of sisal fibre for maximum strengths was found to be 1% for M60 grade of concrete.

Addition of sisal fibre not only increases the tensile strength but also increases the bonding strength and decreases the permeability. This sisal fibres concrete provides thermal resistance to concrete structures. Use of fibres also alters the behaviour of fibre matrix composites after it has cracked, thereby improving its toughness.

By adding sisal fibre, it has been found that there is an increase in properties of both fresh and hardened concrete. The energy ductility is higher for 2% of sisal fibre of volume of cement specimen.

7. REFERENCES

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