FIBER REINFORCED CONCRETE USIING SISAL FIBER WITH $MgSO_4$

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Abstract - *This research work involves the topic of adding natural fibers to the concrete to study the strength properties and observe whether the propagation of shrinkage problems is reduced. Basically, there are two types of natural fibre. Natural inorganic fibres like asbestos, basalt, etc. as well as natural organic fibres like banana, bamboo, coconut, palm, pine, kenaf, jute, sisal, sugar cane, and so on. Natural fibres are studied as construction materials by different researchers and can be used in cement, mortar or concrete in building materials. This research work may include the characteristics of sisal fibre, its properties and also compatibility of fibre(sisal) and compares its nature of fibre- free concrete and concrete with natural fibre(sisal). But it also to compare and draw the conclusion of the proportion of different fibres cement. This study summarizes the comparison and difference between fiber-free concrete and concrete with natural fiber(sisal).*

Key Words: Sisal fiber, Fiber reinforced concrete, Natural fiber, Artificial fiber, Testing.

1. INTRODUCTION TO SISAL FIBER

Sisal fiber is the most commonly used plant fibers and is very easy to grow. Sisal is a strong fiber obtained from the sisal plants leaves. The plant of sisal fiber is officially called agave-sisalana. The plants having leaves like a sword-shaped rose that begins to have teeth and gradually wears mature teeth over time. All leaves have many straight and long fibers that can be eliminated by means of a method called peeling or decortication. During the peeling process, the leaves are broken to remove the pulp and plant material, left behind the strong fibers. For the production of twine and textile, fibers will be warped into thread, or pulped to make paper make paper products.

1.1 PROPERTIES OF SISAL FIBER

The actual content of the fiber elements is about 4% of the weight of the plant and can be extracted by a method as “decortication”. In their natural life, typical plants generate 200 to 250 fruitfully available leaves. Also, each leaf of sisal plants will produce approximately 1000 fibers.

In order to obtain a superior quality structure and good sustainability, it is preferable to use sisal fibers to develop several strength characteristics of the structure. Different plant fibers of sisal fibers of sisal were tested for its adequacy for the addition in cement concrete. The physical properties of the fibers do not show deterioration of the concrete structure. The leaves are dried out, brushed and bailed to produce fibers from sisal plant.

1.2 CHARACTERISTICS OF SISAL FIBER

Sisal fiber is the hardest cellulose fibers like coconut fiber. It contains cellulose about 70% in the fiber. With cellulose, this fiber also consists of hemicellulose, lignin, pectin and wax etc. the properties of this fiber are greatly affected by its chemical composition. In fibers like sisal and coconut fibers, cellulose is the strongest organic constituent that imparts fiber stability, stiffness and strength, where sisal fibers contain 70% of cellulose only. Hence, we can say that sisal fiber is a one of the strongest fibres. Hemicellulose is a polysaccharide that binds together in a relatively short branch. Lignin is an aromatic hydrocarbon polymer-composite that gives stiffness to the sisal plant.

1.3 NEED OF STUDY

The application of concrete as a strengthening material in structural is somewhat limited by the disadvantage such as poor ductility and durability, fatigue, lower impact resistance, low tensile strength, brittleness. It is also very much restricted to absorb dynamic stresses caused due to shock loading. The brittleness is compensated in the structural member by adding a reinforcing bar or pre- stress in the tensile area. The development of steel bars solves the problem of lower tensile property of concrete. Lower tensile strength and higher strength requirements of the concrete is the main problems of steel and these problems are still existed, and will be improved through different types of reinforcement material. Further concrete also has lower ductility. In concrete, increasing the fiber- content will increase will increase the strength and decrease drying and plastic shrinkage by limiting the crack-expansion.

1.4 SCOPE

The scope pf this study work is to find out the gap in research of the FRC using sisal fiber band improvement in the physical and mechanical properties of SFRC (sisal fiber reinforced concrete). A limited number of additional tests are also performed to determine the tensile and flexure properties, compressive -and durability properties and also to check its suitability by comparing the concrete with sisal fiber and without sisal fiber.

2. MATERILS

The various to be used in this research works to make sisal fiber reinforced are:

1. Sisal fiber
2. Cement
3. Aggregates
    - Fine aggregate
    - Coarse aggregate
4. Water
5. Magnesium Sulphate (To check durability)

2.1 Sisal Fiber:

Sisal fibres are used as reinforcement in the sisal fibre reinforced concrete. Sisal fibre is a natural fibre, one of the strongest fibres. The length of sisal is to be used around 2 to 8 cm; various sizes of sisal fibres are available in market. Short discrete vegetable fibre (sisal) was examined for its suitability before incorporation in a cement concrete.

2.2 Cement:

The Ordinary Portland Cement of 53 grades which is readily available in the market is used in the project. The most commonly used cement in concrete is Ordinary Portland cement of 53 Grade conforming BIS: 12600-1989(2009).

It is an important constituent of concrete, mortar – mix and many plasters. Typical physical requirement for cements is: air content, fineness, expansion, strength, heat of hydration and setting (earlier & final) time. Most of these physical tests are carried out using mortar or paste created from cement.

2.3 Sand:

The sand particles should also pack to give minimum void ratio, higher voids content leads to requirements of more mixing water. In the present study the sand confirms to Zone III as per Indian standards (BIS: 10262, BIS: 383). Sand should not contain any foreign material that affects the strength of concrete.

2.4 Aggregates:

Generally, a concrete-mix includes both fine and coarse aggregate (combined) content about 60 to 70%. Aggregate (coarse and fine) used by the concrete industry are suitable to manufacture fibre reinforced concrete. The many aggregate properties that are very important with respect to concrete strength are particle size distribution, shape of the particles, mechanical properties of the aggregate properties, and different types of chemical reaction between the aggregate and the cement-paste which may have an effect on the bond.

2.5 Water:

Water is requirements can be used for concrete and curing. Water exercised for concrete should be free from all type of impurities. The dirty water exercised for concreting work, then it will create difficulties in initial as well as final setting and also a reason behind early failure of the structure. In order to cover the large surface area of the fibres with a cement- paste, the experience shows that the cement ratio is 0.4-0.6 and the minimum cement content is 320 kg/ m.

2.6 Magnesium Sulphate:

Magnesium sulphate solution was used to find out the resistance to sulphate attack of sisal fiber reinforced concrete. The sulphate resistance was determine based on the change in weight and change in compressive strength of the samples after exposing t magnesium sulphate. The magnesium sulphate procured in the powdered from local supplier was used. The magnesium sulphate used was in 99.97% pure form.

The magnesium sulphate ($MgSO_4$) powder was dissolved in water to prepare on acidic solution. Depending upon the concentration required, the quality of the magnesium sulphate ($MgSO_4$) varies in the solution expressed in terms of percentage by weight.

For instances, a solution of magnesium Sulphate ($MgSO_4$) at a concentration of 5% consists of 5 kg of magnesium sulphate (Mg SO_4) powder consisting of 100 liters of water. Note that water is the main ingredient and the of magnesium sulphate ($MgSO_4$) powder is only a part of the mass of the magnesium sulphate ($MgSO_4$) solution.

3 RESULTS AND DISCUSSIONS

3.1 Fresh Concrete Properties

As part of investigation, determine of fresh concrete properties was necessary to determine the effects of adding sisal fiber concrete on workability of the concrete is the slump test and compaction factor test.

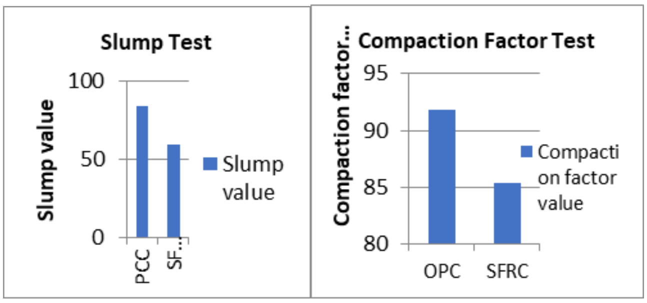
3.2.1 Workability of concrete

To determine the workability of concrete without fiber as well as sisal fiber reinforced concrete, various tests on fresh were performed according to code IS: 1199-1959. The table 1.1 shows the properties of the workability tests.

Table 1.1: Workability values

Specimen	Slump value	Compaction Factor
Without Fiber	84	91.82%
With fiber	59	85.33%

From the varies of slump test it is concluded that the water-content required to obtain required workability is higher for fiber concrete. The workability of fiber reinforced concrete is lesser than normal concrete for equal amount of water. This may because of the water-absorption ability of dry sisal fiber. It indirectly gives that compaction of concrete is difficult as increase fiber content.



Graph 1-1: Comparison of Workability for concrete with fiber and without fiber

3.2 Durability test

Durability test was performed at the curing period 28, 56, and 90 days. Total 24 cubes (12 with fiber + 12 without fibre) of size 150 mm x 150 mm x 150 mm were casted. Then cubes were exposed to solution of 5% $MgSO_4$ and then durability of cubes measured in term of (1) percentage loss in weight and (2) percentage loss in compressive strength. For a single test, three samples were tested with an average of 3 as the final result. Durability test was conducted as per IS-516:1959.

3.2.1 Percentage loss in Weight

Table 1.1: Initial and final weight of concrete specimen (Without fiber)

Initial and final weight of each specimen (Without fibre)						
Age	Initial weight			Final weight		
	Specimen 1	Specimen 2	Specimen 3	Specimen 1	Specimen 2	Specimen 3
(days)	kg	kg	kg	kg	Kg	kg
28	9.02	8.88	9.00	8.82	8.78	8.85
56	8.92	8.90	8.90	8.61	8.64	8.65
90	8.97	8.92	9.00	8.57	8.62	8.60

Table 1.2: Initial and final weight of each concrete specimen (With fiber)

Initial and final weight of each specimen (With fibre)						
Age	Initial weight			Final weight		
	Specimen 1	Specimen 2	Specimen 3	Specimen 1	Specimen 2	Specimen 3
(days)	kg	kg	kg	kg	kg	kg
28	7.738	8.10	8.66	7.66	7.92	8.55
56	8.45	7.95	8.14	8.20	7.85	7.95
90	8.13	8.33	8.82	7.92	8.03	7.61

Above table 1.2 and 1.3 shows the weight of each concrete cube specimen of SFRC before immersion to magnesium Sulphate and after removing from it after 28, 56 and 90 days.

Table 1.4: Average weight % weight loss of specimens (without fibre)

Average weight and % Loss in Weight (Without fibre)			
Age	Average Initial weight	Average final weight	% Loss
(days)	kg	kg	
28	8.97	8.82	1.67%
56	8.91	8.63	3.07%
56	8.96	8.60	4.09 %

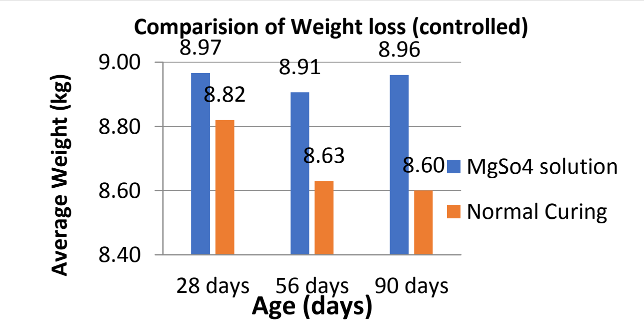
Table 1.5: Average weight and % loss in weight (With fibre)

Average weight and % Loss in Weight (With fibre)			
Age	Average initial weight	Average final weight	% Loss
(days)	kg	kg	
28	8.17	8.04	1.50%
56	8.18	8.00	2.20%
90	8.09	7.85	2.97%

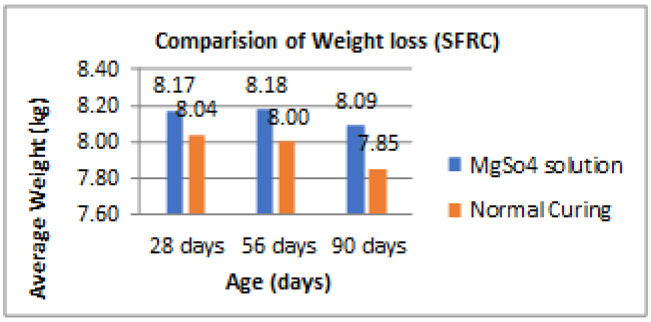
Above table 1.4 and 1.5 shows the results for initial and final weight of each concrete specimen with and without sisal fibre after 28 and 56 days.

- Tables show that percentage loss in weight at 28 days for concrete specimen without fiber is 1.67% as compared to concrete specimen with sisal fiber having 1.50% weight loss.

- Also, for 56 days curing period, percentage loss in weight for concrete specimen without fiber is 3.07% as compared to concrete specimen with sisal fiber having 2.20% weight loss.
- For 90days curing period, percentage loss in weight for concrete specimen without fiber is 4.09% as compared to concrete specimen with sisal fiber having 2.97% weight loss.

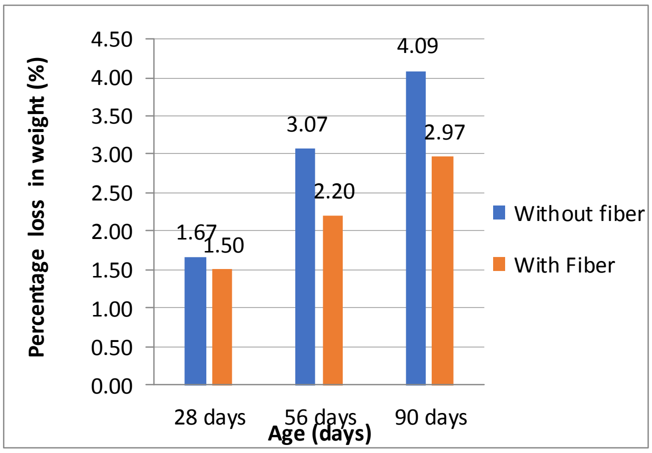


Graph 1-2: Average weight loss for controlled concrete specimens



Graph1-3: Average weight loss for concrete specimens with fibre

Graph 1-2 and 1-3 compares average weight loss for concrete specimens both controlled and concrete with Sisal fibre subjected to normal curing with water and exposed to $MgSO_4$ solution.



Graph1-4: percentage weight loss for concrete specimens

Graph 1-4 compares percentage weight loss for concrete specimens both controlled and concrete with Sisal fibre subjected to normal curing with water and exposed to MgSO4 solution. Here, it shows that percentage loss in weight for concrete without fibre is more compared to concrete with sisal fibre. Hence, concrete with sisal fibre (SFRC) is more durable than plain concrete with respect to percentage loss in weight.

3.2.2 Loss in compressive strength

Table 1.6: Compressive strength for controlled cube

compressive strength for controlled cube						
	Normal			MgS04 solution		
Age	Specimen 1	Specimen 2	Specimen 3	Specimen 1	Specimen 2	Specimen 3
Units	(N/mm²)	(N/mm²)	(N/mm²)	(N/mm²)	(N/mm²)	(N/mm²)
28	23.91	24.22	24.00	22.22	22.44	22.84
56	27.20	27.60	28.49	25.87	26.22	25.78
90	30.67	30.22	31.73	27.20	28.67	28.89

Table 1.7: Compressive strength for cubes with fibre

compressive strength for cubes with fibre						
Age	Normal			MgS04 solution		
	Specimen 1	Specimen 2	Specimen 3	Specimen 1	Specimen 2	Specimen 3
Units	(N/mm²)	(N/mm²)	(N/mm²)	(N/mm²)	(N/mm²)	(N/mm²)
28	23.2	23.46	23.91	22.75	22.00	23.33
56	27.46	27.06	27.64	26.44	25.42	26.04
90	30.53	30.36	30.84	28.27	28.98	25.58

Table 1.6 and table 1.7 shows the results for compressive strength for concrete specimens both controlled and concrete with Sisal fibre subjected to normal curing with water and exposed to $MgSO_4$ solution.

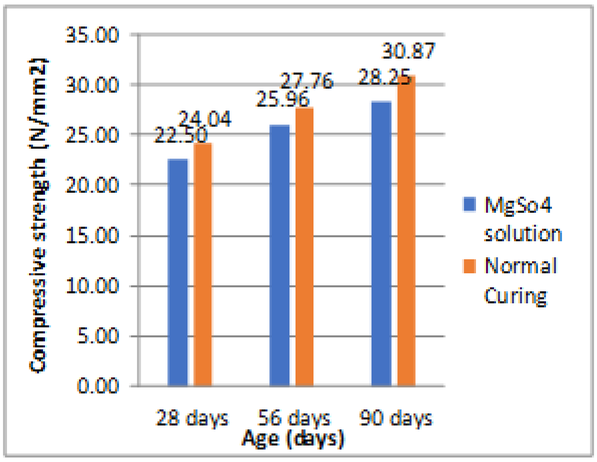
Table 1.8: Percentage loss of compressive strength for controlled cube

% Average compressive strength and % loss for controlled cube			
	Normal	MgS04 solution	% Loss
Age	(N/mm²)	(N/mm²)	
28	24.04	22.50	6.41%
56	27.76	25.96	6.51%
90	30.87	28.25	8.49%

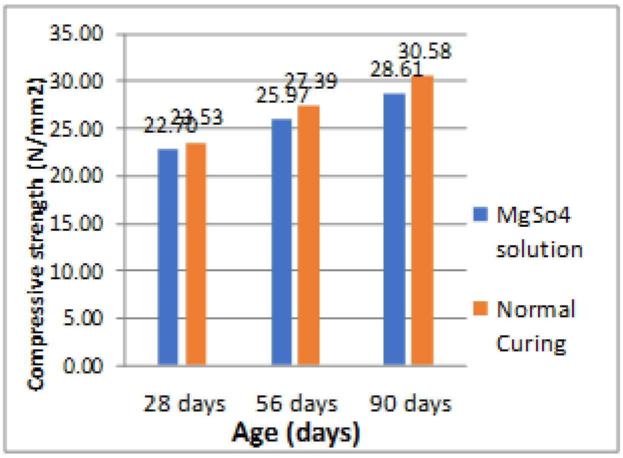
Table 1.9: Percentage loss of compressive strength for cube with fibre

Average compressive strength for cube with fibre			
	Normal	MgS04 solution	% Loss
Age	(N/mm²)	(N/mm²)	
28	23.53	22.70	5.53%
56	27.39	25.97	5.19%
90	30.58	28.61	6.44%

Table 1.8 and table 1.9 shows the results for average compressive strength and percentage compressive strength loss for concrete specimens both controlled and concrete with Sisal fibre subjected to normal curing with water and exposed to $MgSO_4$ solution.

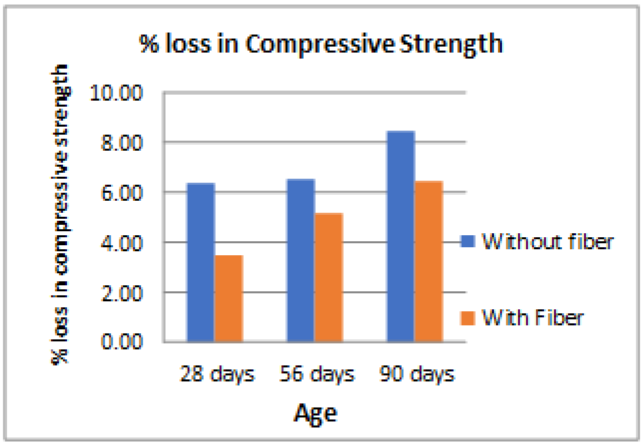


Graph 1-5: Comparison of compressive strength of cubes for normal curing and $MgSO_4$ exposure (controlled)



Graph 1-6: Comparison of compressive strength of cubes for normal curing and $MgSO_4$ exposure (SFRC)

Graph 1-5 and 1-6 compares the average weight loss in compressive strength for concrete specimens both controlled and concrete with Sisal fibre subjected to normal curing with water and exposed to Magnesium Sulphate solution.



Graph 1-7: Comparison of percentage loss in compressive strength for concrete with fibre and without fibre

Graph 1-7 compares percentage compressive strength loss for concrete specimens both controlled and concrete with Sisal fibre subjected to normal curing with water and exposed to $MgSO_4$ solution. Here, it shows that percentage compressive strength loss for concrete without fibre is more compared to concrete with sisal fibre. Hence, concrete with sisal fibre (SFRC) is more durable than plain concrete with respect to percentage loss in compressive strength too.

4 CONLUSION

From the experimental work, result and discussion, various concluding points are summarized:

- From the Slump values it is concluded that the amount of water required to obtain workability is higher for fiber concrete. The workability of fiber reinforced concrete is lesser than normal concrete for same water content.
- Compare to normal concrete Sisal fiber reinforced concrete (SFRC) is more durable. Here, after exposed to Magnesium Sulphate, compressive strength loss for SFRC is average 4% compared normal concrete having 6.5% compressive strength loss. Also, the weight loss is around 1.75% compared to 2.75% weight loss for PCC.

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