Sisal Fiber as an Economical and Ecologically Sound Material

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Abstract:
In order to better understand the impact of sisal fiber as a fiber reinforcement composite and enhance both its static and dynamic properties, an experimental program was started. The results of this experiment indicate that sisal fibers should be utilized whenever possible since they enhance the qualities of concrete while also assisting in the prevention of environmental deterioration. Up until now, natural fibers have been more conventional than technical when it comes to reinforcement materials. This research examines the experimental work conducted on Sisal fiber reinforcement composites to enhance their mechanical properties while mitigating environmental degradation and demonstrating their viability as an economical and environmentally friendly material. The application of plant fibers is creating jobs. Natural plant fibers are added to conventional concrete to improve its qualities, and their use is creating jobs in the rural sector.

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Introduction

Sisal has several benefits, including the ability to flourish in waste areas and provide good fiber consistently for six to eight years with the least amount of management.

Sisal is not grown in India, and the industry is disorganized. However, a joint approach was used to do so by the District Rural Development Agency (DRDA) and the JawaharRojgharYojana (JRY).Sisal fibre has superior mechanical qualities and is recyclable, which makes it a viable raw material for composites that are utilized in the construction, automotive, railroad, geotextile, and packaging industries, among other industries. Composite materials reinforced with sisal fiber, such as wood substitute products, doors, panels, and corrugated roofing sheets, are made to be durable and reasonably priced, making them attractive to potential investors and entrepreneurs in areas susceptible to natural disasters like floods, tsunamis, and earthquakes.

Most residential construction interior wall partition systems currently in use are constructed from clay and cement sand bricks, which need to have 20 mm plaster applied on both sides. These have the inherent drawbacks of a large load, limited productivity, significant waste, and the need for expert labour in their application, yet they are easily accessible and reasonably priced to build. Additionally, aerated concrete blocks are being used. This material is brittle, fragile, and has a high water absorption rate, while being determined to be lightweight, having strong fire resistant So, in comparison to the conventional plastering of brick walls, the development of an alternative material, such as a natural fiber reinforced panelling wall, is anticipated to give better improvement in terms of the weight, speed of erection, and superior quality. In the building business, the use of fiber-reinforced cement in plasterboards for wall partitioning has gained widespread acceptance.

Materials and Method:

Sisal fiber reinforced cement composites were made for this study and tested for bending strength and compression strength on days 3, 7, and 28. moisture level and absorption of water. Twelve distinct ratios of cement, fly ash, gypsum, and sisal fibers were combined. These mixtures were mixed with water in accordance with the workability requirements, and specimens measuring 300 mm by 300 mm by 30 mm were created. Before testing, the specimens were cured for 3, 7, and 28 days. After that, the data was tallied and examined.

Materials listed below were used in the preparation of the material in the study:

1.Cement: The cement confirming to IS 12269-1987 of grade 53(OPC) is used in the investigation of the composite material.

2. Gypsum: India's universal plaster powder originally, it was intended to employ gypsum brand powder in the production of gypsum plasterboard, which is widely used in interior and ceiling plastering projects.

3. Flyash: Pozzocrete 60 confirming to IS 3812 Part 1, which is certified fly ash of Dirk India Brand, used.

4. Sisal Fiber: Sisal fibers were employed in the study. Fibers were extracted and transported from sisal leaves.

5.Water: Clean tap water having Ph 6.5 to 7.5 is used

The steps involved in the entire study, including sample, mixing, casting, and curing, can be outlined as follows:

1. Cement, fly ash, gypsum, and sisal fibers were all weighted appropriately. The weight of the sisal fiber was calculated using the binder weight % ratio.
2. A dry mix was made for every series.
3. There were three portions—dry, semidry, and wet—for each batch.
4. Water was correspondingly added and well mixed with the quantities mentioned above.
5. The moulds were lubricated.
6. Layers were inserted into moulds and hydraulic pressure was applied.
7. In a rack, samples were demoulded and allowed to air cure for four hours.
8. After four hours, samples were left in water in tanks for three, seven, and twenty-eight days to cure. It was anticipated that removing the specimens from the curing tank two hours prior to testing would be adequate to remove any surplus water.
9. Finally, using the proper tools and techniques, the specimens were examined, and the test results were noted and tallied in accordance with the investigation's specifications.

For the investigation, three series of samples with varying binder ratios for different percentages of Sisal fibers were prepared. For comparison, sets of control samples devoid of Sisal fiber were also made. The specifics of the series' attributes are shown below:

1. R Series

In this series, gypsum and cement fly ash were utilized as a matrix. The percentages of cement, fly ash, and gypsum are 50:20:30. With the identification markers RI, R2, R3, and R4, respectively, the sisal fibers were added to the binder at the following percentages: 0%, 0.5%, 1%, and 1.5% of the total weight.

2. Y Series

In this series, gypsum and cement fly ash were utilized as a matrix. The percentages of cement, fly ash, and gypsum are 50:30:20. With the identification markers Yi, Y2, Y3, and Y4, respectively, the sisal fibers were added to the binder at the following percentages: 0%, 0.5%, 1%, and 1.5% of the total weight.

3. Group G

In this series, gypsum and cement fly ash were utilized as a matrix. The percentages of cement, ly ash, and gypsum are 40:20:40. Sisal fibers with the identification marks GI, G2, G3, and G4 were added to the binder in the following percentages: 0%, 0.5%, 1%, and 1.5% of the total weight.

The series was identified using the colours assigned to the various series specimens in the form of the colour's initial letters. R is the letter Red. G stands for green and Y for yellow. The casting chart data are provided in the table.

Table 1: Casting Chart

Sr. No	Mix	Colour	Identification	Fiber %	Fiber Weight g	Cement kg	Fly Ash kg	Gypsum kg	Total Material	Tiles No.
01	50:20:30	Red	R1	0	0	35	14	21	70	20
			R2	0.5	350	35	14	21	70	20
			R3	1.0	700	35	14	21	70	20
			R4	1.5	1050	35	14	21	70	20
Total					2100	140	56	84	280	80
01	50:30:20	Yellow	Y1	0	0	35	14	21	70	20
			Y2	0.5	350	35	14	21	70	20
			Y3	1.0	700	35	14	21	70	20
			Y4	1.5	1050	35	14	21	70	20
Total					2100	140	56	84	280	80
03	40:20:40	Green	G1	0	0	28	14	28	70	20
			G2	0.5	350	28	14	28	70	20
			G3	1.0	700	28	14	28	70	20
			G4	1.5	1050	28	14	28	70	20
Total					2100	112	56	112	280	80
Grand Total					6300	392	196	252	840	240

Type of tests

Compressive Strength Test

Cutting the sample tiles produced the specimen for compression. To prepare the samples for the compressive strength test, they were divided into smaller specimens with a width, thickness, and length of T and 4T, respectively.

The test specimen was positioned with its length horizontally between the loading surfaces of the apparatus. To acquire the maximum compressive load, the specimen was subjected to an increasing compressive load until failure. Prior to the test, the specimen's dimensions were obtained. After the cure, the test was conducted on days 3, 7, and 28. For every series, three specimens were tested on days 3, 7, and 28.

Absorption Test

The specimen's mass had to be measured both before and after it was submerged in water for 24 hours in order to perform the absorption test.

Results and discussion:

<u>Compressive Strength</u>

Tests are conducted on the fiber-containing material and the control specimen for 3, 7, and 28 days. By applying increasing compressive pressure until failure, the specimen's compressive strength was measured parallel to the board's plane. As a result, it is possible to read the maximum load for failure. Before that, measurements of the test specimens' length, thickness, and width were made in order to determine their cross section area values, which were 1. Because the specimens' thickness was limited to 35 mm and because of the compressive testing machine 2's capacity, the specimens' length was maintained horizontally rather than vertically. The following equation yields the value for compressive strength:

$$Compressive\ Strength = \frac{P}{A}$$

P= The maximum load applied to the test specimen (N)

A= The cross section of the test specimen (mm^2)

3- Days Tests

Table 1 displays the composite's compressive strength for each series, and Chart 1.2 shows the average of the test results after three days. Compressive strength increases as fiber content rises in Series R and G. According to the R and G series, 1.5% is the ideal fiber content for compressive strength.

7-Days Test

Table presents the average of the findings for the compressive strength of the composite for all series during the seven-day tests. The average results graph is displayed in Chartl.1. Compressive strength increased in all series, with and without fiber, according to the findings of the 7-day test.

The strength of the composite rises with increasing fiber content for all three series up to a fiber content of I%; at a fiber content of I.5%, the compressive strength of all three series decreases. This strength loss is in the range of 10% to 17%.

28 -Days Test

Table displays the average findings for all specimens tested during the 28-day compressive strength test. A graph of each series' average compressive strength on day 28 is displayed in Table 2.

The average compressive strength of R3, Y3, and G3 is greater than that of the series with a lower amount of fiber. Additionally, all R4, Y4, and G4 specimen data indicate that compressive strength decreases as fiber content increases; that is, at 1.5% fiber content, day 28 compressive strength results are lower than those obtained at 1% fiber content.

Table2: 3days, 7days, 28 days avg. Compressive Strength

		Composition Percentage				Compressive Strength N/mm^2		
Sr. No.	Specimen	Fiber Weight g	Cement kg	Fly Ash kg	Fiber %	3	7	28
1	R1	50	20	30	0.0	4.27	17.33	16.80
2	R2				0.5	4.67	21.60	22.13
3	R3				1.0	6.80	21.33	24.00
4	R4				1.5	11.20	19.73	16.27
1	Y1	50	30	20	0.0	7.07	13.87	12.00
2	Y2				0.5	11.60	22.40	25.60
3	Y3				1.0	6.53	18.13	20.80
4	Y4				1.5	7.73	16.53	11.73
1	G1	40	20	40	0.0	3.73	13.33	12.53
2	G2				0.5	4.93	14.13	16.80
3	G3				1.0	5.87	14.40	16.27
4	G4				1.5	6.93	10.67	12.00

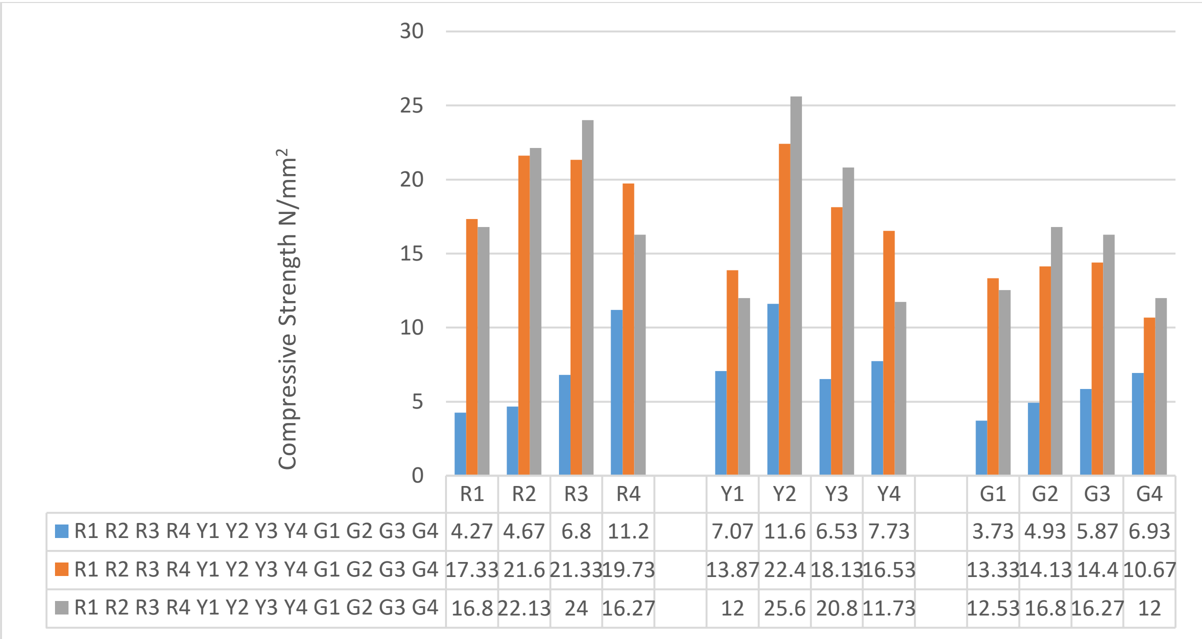

Chart 1- Average Compressive Strength

Table3: 3 days, 7 days, 28 days Avg. Water Absorption

		Composition Percentage				Water Absorption %		
Sr. No.	Specimen	Fiber Weight g	Cement kg	Fly Ash kg	Fiber %	3	7	28
1	R1	50	20	30	0.0	5.63	4.12	3.45
2	R2				0.5	5.80	3.37	4.54
3	R3				1.0	6.83	6.31	4.45
4	R4				1.5	9.58	8.89	4.95
1	Y1	50	30	20	0.0	3.46	3.80	1.46
2	Y2				0.5	5.20	4.09	2.10
3	Y3				1.0	8.16	4.35	4.34
4	Y4				1.5	11.39	5.17	4.70
1	G1	40	20	40	0.0	4.37	4.24	3.35
2	G2				0.5	7.83	4.62	4.15
3	G3				1.0	10.13	5.46	4.93
4	G4				1.5	19.30	6.13	5.23

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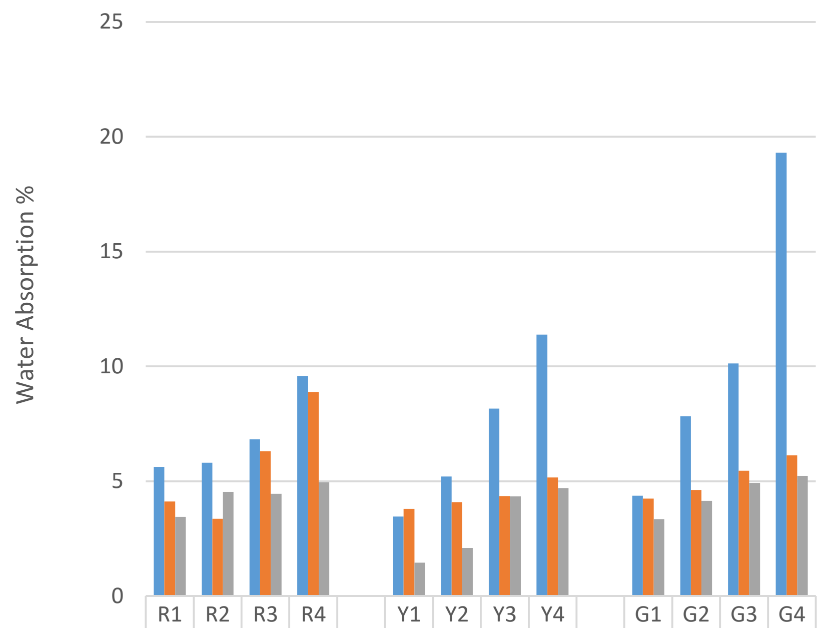

	R1	R2	R3	R4		Y1	Y2	Y3	Y4		G1	G2	G3	G4
R1 R2 R3 R4 Y1 Y2 Y3 Y4 G1 G2 G3 G4 (blue)	5.63	5.8	6.83	9.58		3.46	5.2	8.16	11.39		4.37	7.83	10.13	19.3
R1 R2 R3 R4 Y1 Y2 Y3 Y4 G1 G2 G3 G4 (orange)	4.12	3.37	6.31	8.89		3.8	4.09	4.35	5.17		4.24	4.62	5.46	6.13
R1 R2 R3 R4 Y1 Y2 Y3 Y4 G1 G2 G3 G4 (grey)	3.45	4.54	4.45	4.95		1.46	2.1	4.34	4.7		3.35	4.15	4.93	5.23

Chart 2- Average Water Absorption

<u>Water absorption</u>

In the absorption test, the specimen's mass is measured both before and after it is submerged in water at 27 + 2° C for 24 hours in a container with a flat bottom. For comparison, water absorption tests were conducted on days 3, 7, and 28. The following formula is then used to determine the percentage of water absorption:

Percentage Absorption $= \frac{W2-W1}{W1}$

where,

W_1 is the test specimen's mass in kg prior to immersion.

W_2 is the test specimen's mass in kg following immersion

The percentage of the weight of water absorbed by the composite divided by its dry weight under saturated, dry conditions is the expression for water absorption. One crucial characteristic of this composite that requires more research is its water absorption capacity. The material's volume and any potential water seepage into the composite's pores can both be precisely measured.

Table 3 displays the average moisture content data for all series on days 3, 7, and 28 of curing. Based on the average values of the data, Chart 1 displays the graph of the results. The results indicate that adding sisal fiber to any series of specimens reduces the percentage of water absorption by a very small amount. Absorption falls between 0.1% and 0.3% of the total. The proportion of absorption or higher water content remains unchanged when the amount of sisal fiber is increased. The percentage of water absorption is greatly increased by increasing the fiber content. It might have something to do with the Sisal fiber's capacity to absorb water. Increased water absorption may also result from poor casting technique and workmanship.

Conclusion

According to an analysis of compression test data, sisal fiber (1% Max.) added to composites boosts their strength. Strength does not increase with increasing the proportion of fiber content, even if adding fiber helps to boost strength. Compressive strength decreases with increasing moisture content. Almost all of the series see an increase in compression strength over time. The 50% cement, 30% fly ash, and 20% gypsum mixture known as the Y series exhibits a higher 28-day compressive strength than the other series. The addition of sisal fiber to all specimen series increased the percentage of water absorption, according to the results of the absorption test.

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