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"Agro-Waste and Their Utilization on the Bending Properties of Sisal Fiber Reinforced Composites"

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Abstract - **An experimental program was undertaken to study the effect of Sisal fiber as agro waste and its utilization bending properties of Sisal fiber reinforced composites, for the improvement of its static and dynamic properties. Based on this experimental work it has been concluded that wherever possible Sisal fibers should be used, as it improves properties of concrete and at the same time helps to prevent environment degradation.**

The addition of Sisal fiber can improve the properties of traditional concrete. From the results It was found that the bending strength was increased by 11% to 15% in R-Series containing 50% Cement, 20% Fly Ash and 30% Gypsum which shows better bending strength results after 28 days of curing.

Also increasing in moisture content, results reduction in bending strength.

Keyword - Agro-Waste, Bending Properties mm, Sisal Fiber Reinforced

INTRODUCTION

Background

India has a vast resource of different natural fibers viz., jute, sisal, banana, coir and so and so forth., which are abundantly available in many parts. Presently, the production of natural fibers in India is more than 400 million tonnes.India requires 8 million tonnes of fibers - cement products per annum for housing. Currently, asbestos-cement sheets contain asbestos fibers. These fibers, apart from being carcinogenic, have to be imported to meet the material demand as they are not available in our country. Due to the deficiency of high quality asbestos fibers and health hazards associated with them a search for an alternative material is being made since decades.

OVERVIEW OF THE PROJECT WORK

In this project work Sisal fiber reinforced cement composites were prepared and tested on the 3rd, 7th and the 28th day for bending strength and water absorption. Cement, fly ash, gypsum and Sisal fibers were mixed in twelve different proportions. Water was added to these mixes as per the workability requirement and specimens were prepared in the size of 300mm x 300mm x 30 mm. The specimens were cured for 3, 7 and 28 days before testing. The results then obtained were tabulated and analyzed.

RAW MATERIAL

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

(i) Cement

The cement confirming to IS 12269-1987 made by Uitratech of grade 53(OPC) is used in the investigation of the composite material.

(ii) Fly Ash

Pozzocrete 60, which is certified fly ash of Dirk India Brand, was used in the current investigation. It confirms to IS 3812 Part 1.

(iii) Gypsum

Universal plaster powder of India Gypsum brand was used in the investigation. The gypsum powder was initially intended to be used in the process of manufacturing gypsum plasterboard that is extensively used in the internal and ceiling plastering works. The most common used of the powder is for making office partitions.

(v) Sisal Fiber

Sisal fibers were used in the investigation. Fibers were obtained and brought from the Sisal leaves.

(vi) Water

Ordinary clean tap water is used.

MATERIAL SAMPLING, MIXING, CASTING AND CURING

The sequence of the process for the whole investigation from sampling to mixing to casting and to curing could be described as below:

(i) Fly ash, Gypsum, cement and sisal fibers were weighted accordingly. The sisal fiber was weighted according to the percentage ratio of binder weight.

(ii) Dry mix for each series was prepared.

(iii) Each batch was divided into three portion of dry, semidry and wet.

(iv) Water was added to the above portions accordingly and was mixed thoroughly.
(v) Moulds were greased.
(vi) Moulds were filled with layers and subjected to hydraulic pressure.
(vii) Samples were demoulded and air cured in rack for 4 hours.
(viii) After 4 hours, samples were kept for curing in water in tanks for 3, 7 and 28 days.
(ix) The specimens were taken out from the curing tank 2 hours before testing which was expected to be sufficient to drain out excess water.
(x) Lastly the specimens were tested and the results recorded and tabulated according to the requirements of the investigation with appropriate equipments and procedures.

SAMPLE IDENTIFICATION

Three sets of series of samples with different binder ratios for various Sisal fibers percentages were prepared for the investigation works. Sets of control samples without Sisal fiber were also prepared for comparison purposes. Below are the details of the series characteristics:

1. Series R

Cement fly ash and gypsum were used as a matrix in this series. The cement: fly ash: gypsum ratios are 50: 20:30 in percentages. The Sisal fibers were added in the percentage of 0%, 0.5%, 1% and 1.5% of the weight of the binder with identification marks Rl, R2, R3 and R4 respectively.

2. Series Y

Cement fly ash and gypsum were used as a matrix in this series. The cement: fly ash: gypsum ratios are 50: 30:20 in percentages. The Sisal fibers were added in the percentage of 0%, 0.5%, 1% and 1.5% of the weight of the binder with identification marks Yl, Y2, Y3 andY4 respectively.

3. Series G

Cement fly ash and gypsum were used as a matrix in this series. The cement: fly ash: gypsum ratios are 40: 20:40 in percentages. The Sisal fibers were added in the percentage of 0%, 0.5%, 1% and 1.5% of the weight of the binder with identification marks Gl, G2, G3 and G4 respectively.

The series identification was done as per the colours given with form of the first letters of the colours to the different specimens of each series. R stands for Red, Y for Yellow and G for green. The details of casting chart are given in table.

TYPE OF TEST

1 Bending strength Test

The size of specimen for the flexural strength test was taken exactly as the size of the mould. Bending test was carried out by applying the load at the center of the specimen between the two supports that was 250 mm apart. The load was increased until the fracture occurred and the maximum load applied was recorded based on the reading on the equipment. Bending test was conducted on a tile flexural testing machine. The actual dimension of the specimen in term of length, width and thickness was measured before testing. This was necessary in order to obtain the relevant strength with regards to the dimension and loads applied.

The test was carried out on all three series of sampling, R, Y and G inclusive of the control specimens. The testing was carried out on days 3, 7, and 28 day after curing. The test specimens were prepared for 4 samples each for the 3 days 7 days and 28 days test for each series.

2 Moisture Content

Same size of the specimen was used for moisture content. The size of the specimen was 300 mm x 300 mm x 30 mm thickness. Testing for moisture content was conducted for days 3, 7, and 28 . Meanwhile, testing for moisture content was done after 7 and 28 days only. For moisture content, the specimen was required to be placed in a circulating oven at a temperature of 105oC ± 2oC, cooled, and reweighed and the mass recorded.

Table 3.1- Casting Chart

Sr. no.	Mix	Colour	Control No.	(%)	(gm)	Cement (Kg)	Flyash (Kg)	Gypsum (Kg)	Total Material	Tiles no.
1	50:20:30	Red Oil paint colour	R 1	0	0	35	14	21	70	20
			R 2	0.5	350	35	14	21	70	20
			R 3	1	700	35	14	21	70	20
			R 4	1.5	1050	35	14	21	70	20
Total					2100	140	56	84	280	80
2	50:30:20	Yellow Oil paint colour	Y1	0	0	35	21	14	70	20
			Y2	0.5	350	35	21	14	70	20
			Y3	1	700	35	21	14	70	20
			Y4	1.5	1050	35	21	14	70	20
Total					2100	140	84	56	280	80
3	40:20:40	Green Oil paint colour	G1	0	0	28	14	28	70	20
			G2	0.5	350	28	14	28	70	20
			G3	1	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

RESULTS AND DISCUSSION

Bending Strength

A total specimens of the size 300 mm in length, 300 mm in width and 30 mm in thickness were tested for bending strength. The specimens were tested on day 3, 7, and 28 after curing in water. Observations and comparisons on the strength were made between the controlled specimen and the specimen with various fiber content of different water to binder ratios.

The length between the supports was taken as 250 mm for all the specimens. The load was applied perpendicular to the plane of the board. The machine was applied until a fracture occurred and the maximum load readings were taken by weighing the lead shots used for breaking the specimen.

The bending strength, Rf (N/mm2) was calculated and expressed by using the following equation:

$$Rf = \frac{3Pl}{2be^2}$$

where,
P = Breaking Load, in N;
l = Distance between axes of support, in mm;
b = width of the test piece, in mm;
e = Average thickness of the test piece, in mm.

3 - Days Test

The average results of the bending strength test for each specimen are shown in Table 1 and Chart 1.1 shows the average of the results. Twelve specimens for each series were tested in which three specimens for each fiber content of 0%, 0.5%, 1% and 1.5% were tested; water binder ratio used was as per the workability requirement. The control specimen Rl shows greater bending strength than the other ones. It can be observed that there is an increase in the bending strength with increase in Sisal fibers percentage up to 1% fiber content and decrease in the same for 1.5% fiber content. R2 and R3 show the increase in the bending strength by 16% and 18% respectively over Rl.

Y and G series shows the same pattern of increase in the bending strength with an increase in Sisal fibers percentage up to 1% fiber content and a decrease for 1.5% fiber content. Y2 and Y3 shows an increase in the bending strength by 11% and 15% respectively over the Yl while G2 and G3 show an increase in the bending strength by 9% and 13% respectively over Gl. Over all the bending strength values of R series are on a higher side than that of Y and G series.

7- Days Test

The results of the bending strength test for each specimen are shown in Table 1 and Chart 1.1 shows the average of the results. Twelve specimens for each series were tested in which three specimens for each fiber content of 0%, 0.5%, 1% and 1.5% were tested. Water binder ratios used was as per the workability requirements. The control specimen Rl shows greater bending strength than other ones. It can be observed that there is an increase in the bending strength with an increase in the Sisal fiber percentages up to 1% of fiber content and a decrease in the same for 1.5% fiber content. R2 and R3 show an increase in the bending strength by 10% and 2% respectively over the Rl.

In case of the Y series, the pattern does not continue and a decrease in the bending strength was observed for the Y3 series by 13% over the control specimen values. But, for the G series, the same pattern of an increase in the bending strength with an increase in the Sisal fiber percentage up to 1% of fiber content and a decrease for a 1.5% fiber content was observed. G2 and G3 show an increase in the bending strength by 33% and 1% respectively over the Gl. Over all the values for the bending strength of the R series are on a higher side than that of Y and G series.

3 28 - Days Test

The avg results for the 28 day-test for the bending strength is shown in Table 1 for all specimens tested. The trend of the result is very similar to that of the 3 day's and 7 day's test result. Adding fiber to the composite shows little improvement in the bending strength. Chart 1.1 is the graph of the test of the bending strength on day 3, 7 and 28.

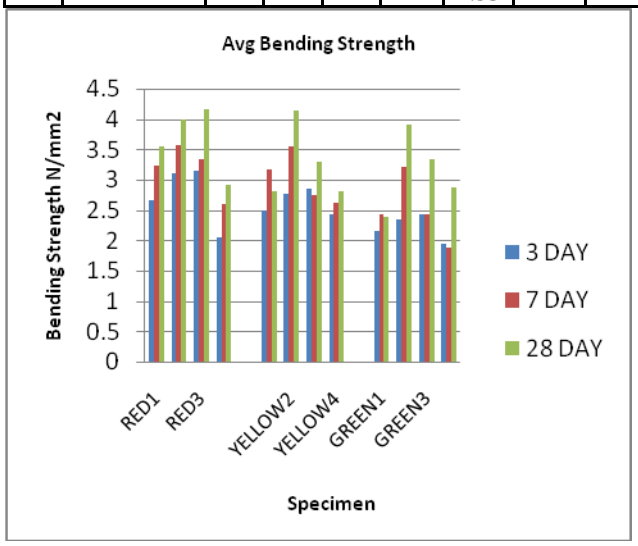
It can be observed that there is an increase in the bending strength with an increase in Sisal fiber percentages up to 1% fiber content and a decrease in the same for the 1.5% fiber content. Samples R2 and R3 show an increase in the bending strength by 16% and 18% respectively over the Rl.

Y and G series show the same pattern of increase in the bending strength with an increase in Sisal fiber percentage up to 1% fiber content and a decrease for the 1.5% fiber content sample was observed. Y2 and Y3 shows an increase in the bending strength by 11% and 15% respectively over the Yl while G2 and the Gl sample.

Table 4:7:3days, 7days, 28 days avg. Bending Strength

Sr. No.	Specimen	Composition%				Bending Strength (N/mm2)		
		Cement	Fly ash	Gypsum	Fibre	3 day	7 day	28 day
1	RED1	50	20	30	0.0	2.67	3.24	3.55
2	RED2				0.5	3.11	3.57	3.99
3	RED3				1.0	3.15	3.33	4.16
4	RED4				1.5	2.04	2.59	2.91
5	YELLOW1	50	30	20	0.0	2.49	3.16	2.81
6	YELLOW2				0.5	2.76	3.55	4.14
7	YELLOW3				1.0	2.86	2.75	3.29
8	YELLOW4				1.5	2.42	2.63	2.81
9	GREEN1	40	20	40	0.0	2.15	2.42	2.38
10	GREEN2				0.5	2.35	3.22	3.90

11	GREEN3				1.0	2.43	2.43	3.33
12	GREEN4				1.5	1.95	1.88	2.88



4 Moisture Content

The most likely influential factors in determining the strength of the gypsum binder is water. Small amount of atmospheric moisture can cause reduction in strength. In this investigation, the moisture content of the specimen is determined by measuring the loss of mass of a test specimen dried to constant mass at temperature of 105o ± 2o C in the air circulating oven. In this method, the moisture within the composite or the material in the composites can be determined.

The specimens were weighted, dried in the circulating oven to a constant mass at 105o ± 2oC and reweighed to measure the mass before drying and after drying. The results can be calculated from the equation:

$$\text{Percentage Moisture content} = \frac{M_1 - M_2}{M_1} * 100$$

Where,
Ml = the mass of the test specimen before drying, in kg,
M2 = the mass of the test specimen after drying, in kg.
Moisture content is expressed as the percentages of weight of the surface moisture over weight of saturated and surface dried composite material.

The avg results of the moisture content of all the series for 7days and 28 days of curing are shown in Table 2. Chart1.2 represents average moisture content of all series for 7 and 28 days.

Adding fibers produce a change on the moisture content and an increase is observed. On an average, the percentage of moisture content between the control specimen and specimen with fibe does not vary much. The percentage is in the range of 11% to 18%.

Table 4;19: 7days, 28 days avg. Moisture content

Sr. No.	Specimen	Composition%				Moisture Content	
		Cement	Fly ash	Gypsum	Fiber	7 day	28 day
1	RED1	50	20	30	0.0	12.46	13.37
2	RED2				0.5	13.80	15.29
3	RED3				1.0	16.53	17.97
4	RED4				1.5	18.67	18.57
5	YELLOW1	50	30	20	0.0	16.07	12.39
6	YELLOW2				0.5	17.25	14.19
7	YELLOW3				1.0	16.92	15.06
8	YELLOW4				1.5	15.08	14.60
9	GREEN1	40	20	40	0.0	14.54	13.36
10	GREEN2				0.5	11.76	14.53
11	GREEN3				1.0	18.57	17.66
12	GREEN4				1.5	16.17	18.05

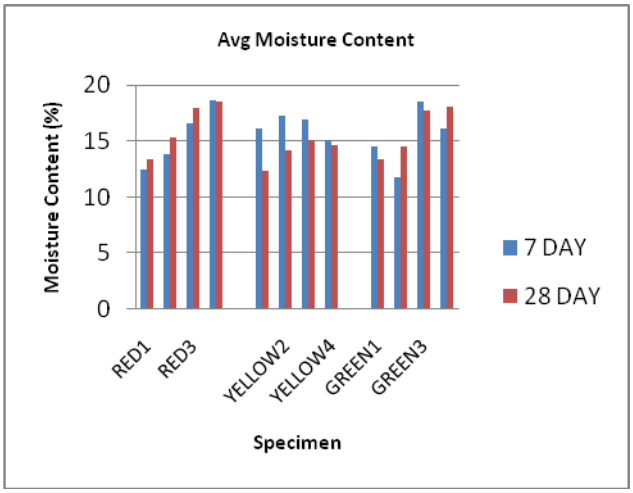


Chart 4:11 Average Moisture Content

CONCLUSIONS

Adding sisal fibers which are randomly distributed and with length between 20 mm to 45 mm to the binder of gypsum, fly ash and cement improves bending strength. Improvement in bending strength of composite with addition of Sisal fiber continues till 1 % fiber content and decreases with further increase of Sisal fiber content.

Bending strength increases with time for all series. The R series i.e. series containing 50 % Cement, 20% fly ash and 30% gypsum shows better bending strength results at 28 days than that of other seri

Even though adding fiber contributes to increasing strength, the strength does not increase with increasing fiber content (percentage). Increase in moisture content results reduction in bending strength.

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