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Properties of Fiber Cement Boards for Building Partitions

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Abstract

This work demonstrates the use of untreated coir fibers to produce fiber cement boards which can be used for building partitions. The untreated coir fiber was added in order to replace cement in these boards. The design mix ratio was selected as 3:1 (cement: sand), where cement was replaced by untreated coir fibers by weight percentage of 5%, 10% and 15%. A constant water cement ratio of 0.46 was taken. Samples with size 150×150×10mm were tested for density test, water absorption test, whereas samples with size 250×250×10mm were tested for impact test and determining drilling characteristics of the boards. The samples were analyzed after 28 days of curing and it was observed that the density of the boards decreased with percentage increase in fiber content, the impact resistance and the amount of water absorbed by the boards increased with increase in fiber content. The boards also showed good drilling characteristics.

Keywords: Fiber Cement Boards (FCB), coir fiber, copious, Water Displacement Method, Indentation diameter

INTRODUCTION

The modern era of construction focuses its attention on using new ingredients which can serve adequately for the production of construction materials which are both sustainable and environment friendly. For the same, the use of natural fibers along with engineering materials has become the new trend for construction purposes. Due to the versatile nature of natural fibers, a new material has been explored by researchers which can be blended with construction materials to produce a low cost building material.

Due to copious availability of coir fiber (a type of natural fiber) in India, a new composite material has proved its worth to serve as an adequate material for construction practices. Coir fiber is extracted from the husk of coconut by isolating the stringy layer from the hard shell. In India, 1.60 million tonnes of coconut fiber is produced annually. Coir fiber helps in increasing the quality and strength of cement based building products.

Y.W.Liu and coworkers carried a comparative study which involved addition of 10% of agricultural waste products (bamboo, coconut fibers, sugar-cane dregs and rice husks) in cement matrix for the production of cement fiber boards serving as a material for building partitions. L.K.Aggarwal emphasized on the optimization of certain parameters like fiber content, fiber length, casting pressure and demolding time necessary for coir fiber boards production. The paper concluded that a fiber content of 15% by weight, fiber length of 3cm and 3N/mm^2 of casting pressure are the optimum conditions for the production of cement-bonded coir fiber boards.

In this research work carried, physical and mechanical properties of fiber cement boards were investigated with varying percentage of fiber. The experimental results obtained can further be utilized in construction industry.

EXPERIMENTAL PROGRAM

Materials

Coconut fiber, a type of natural fiber was added to the cement-sand mixture to produce fiber cement boards. Ordinary Portland cement in accordance with IS 8112: 1989 was used. Some of the important characteristics of cement are mentioned in table 1.

Table 1. Important properties of Ordinary Portland Cement

Properties	Results
Fineness	316 m^2/kg
Specific Gravity	3.4
Consistency	28.75%
Initial Setting Time	70 minutes
Final Setting Time	425 minutes
Compressive Strength (3 days)	24.5 MPa
Compressive Strength (7 days)	33.75 MPa
Compressive Strength (28 days)	44.36 MPa

Coir fiber was extracted from the husk of coconut manually by isolating the stringy layer from the hard shell. The coir fiber was then prepared by cutting the fiber into pieces with 40mm length followed by manual disintegration of fibers (so that fibers get well separated), shown in figure 1 and figure 2.

Figure 1. Coconut Fibers before separation

Figure 2. Coconut Fibers after separation

Mixture Proportions

The design mix proportion selected for the preparation of fiber cement boards was 3:1 (cement: sand), with a constant water-cement ratio of 0.46. A varying percentage of coir fiber (5%, 10% and 15%) was added to replace cement by weight, shown in table2.

Table 2. Design Mix Proportion of fiber cement boards

Cement: sand	Water cement ratio	Coir fiber (by weight)
3:1	0.46	0%
2.85:1	0.46	5%
2.70:1	0.46	10%
2.55:1	0.46	15%

EXPERIMENTAL METHOD

The procedure followed to prepare the mix is as follows:

1. The constituents are weighed in accordance with table 3 and table 4.
2. Cement and sand are mixed together at dry conditions for two minutes.
3. Coir fiber is then added into the mixture of cement ad sand accompanied by constant mixing with the help of trowel.
4. Finally water is added into the mixture and the constituents are mixed until homogeneous slurry is obtained.
5. The moulds prepared are then completely filled with the homogeneous mix prepared and the surface of the fiber cement boards is then made smooth with the help of a trowel.

Table 3. Weight of constituents for fiber cement boards with size 150×150×10mm

Cement (g)	Sand (g)	Fiber (g)	Water (ml)
300	100	0	138
285	100	15	138
270	100	30	138
255	100	45	138

Table 4. Weight of constituents for fiber cement boards with size 250×250×10mm

Cement (g)	Sand (g)	Fiber (g)	Water (ml)
900	300	0	414
855	300	45	414
810	300	90	414
765	300	135	414

Three samples with size 150×150×10mm were prepared for each percentage (5%, 10% and 15% replacement of cement) to conduct Density test and Water Absorption test. Three samples with size 70×70×70mm were prepared to conduct Compressive test, and three samples with size 250×250×10mm were prepared for each percentage to conduct Impact test and to assess the Drilling characteristics of the boards.

The samples were de-molded after a period of 24 hours and were kept for curing for a span of 28 days in a water tank. Samples were removed from curing tank after 28 days for the purpose of testing.

RESULTS AND DISCUSSION

Density Test

The density of fiber cement boards was computed using the "Water displacement method" referring to ASTM C1185. Table 5 depicts the results that were obtained after the density test.

Table 5. Density of fiber cement boards

FCB (Fiber percentage)	Density (kgf/m³)
FCB1 (0%)	1780
FCB2 (5%)	1669
FCB3 (10%)	1588
FCB4 (15%)	1492

From table 5, it can clearly be seen that the value of density for boards with 0% fibers is highest, whereas the value of density decreases with percentage increase in content of natural fibers. Since, density of the boards is most likely to get influenced by the mass of its constituents, therefore the main reason that can be attributed for the decrease in density is the difference in mass of coconut fibers and cement.

Water Absorption Test

In order to assess the percentage of water that can be absorbed by the boards, water absorption in accordance with ASTM C1185 was conducted. Figure 3 shows a plot of water absorption expressed in percentage (plotted on y-axis) to the samples with varying percentage of coconut fiber (plotted on x-axis). It was observed that boards with 15% coir fibers displayed a water absorption value of 15.38%, whereas boards without coir fibers displayed the least value of water absorption being 9.30%. The cause for the increase in water absorption

with increase in fiber content is due to the property of fiber to absorb more water.

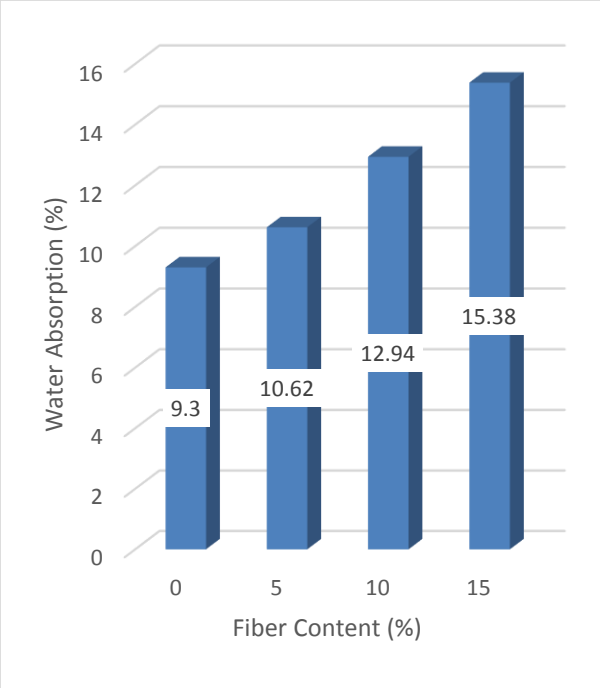

Figure 3. Water Absorption with varying fiber content

Compressive Strength

The compressive strength of the samples was evaluated at the sample age of 28 days. The results obtained from the compression test are enlisted in table 6.

Table 6. Compressive Strength of fiber cement boards

Sample (Fiber percentage)	Compressive Strength (N/mm²)
Sample 1 (0%)	41.2
Sample 2 (5%)	38.56
Sample 3 (10%)	45.72
Sample 4 (15%)	41.45

Table 6 shows an increase in compressive strength as the fiber content increases from 5% to 10%. On the contrary, a decrease in compressive strength is observed as the fiber content is further increased from 10% to 15%.

Drilling Characteristics of the boards

The fiber cement board with 5% fiber content showed defects (cracks and detachment) during drilling process, shown in figure 4.

Figure 4. FCB with 5% fiber content experienced cracks and detachment

On the contrary, fiber cement boards with fiber content of 10% and 15% displayed good drilling characteristics (figure 5) when a concrete drill was used to drill holes in them. The boards exhibited smooth and soft drilling process without development of cracks around holes, ensuring the adequacy of the boards against failure during installation.

Figure 5. FCB with 10% and 15% fiber content showed efficient drilling characteristics

Impact Test

The testing of cement boards was carried by impact loads conferring to CNS9961, where the impact ball having a diameter of 51mm weighed 530 grams, and the height of drop was kept 1400mm, respectively. The results of the impact test are listed in table where defects (cracks, detachment) if any were checked in both sides of the boards.

Table 7. Impact test of Fiber Cement Boards

FCB (Fiber percentage)	Indentation diameter (mm)	Impact Surface	Reverse Surface
FCB (0%)	22	Cracks, Detachment	Cracks, Detachment
FCB (5%)	20	Small Cracks	Cracks
FCB (10%)	18	No Cracks	Cracks
FCB (15%)	18	No Cracks	Small Cracks

After the conduction of impact test, it was found that small cracks were developed on the impact surface of boards with 5% fiber content and the reverse side of the boards showed a convex curvature with visible cracks. The impact surface of the boards with 10% fiber content had no cracks whereas the reverse surface of the boards displayed a convex shape containing visible cracks. No cracks were discovered on the impact surface of the boards with 15% fiber content. Small cracks were developed on the reverse side.

CONCLUSION

This research demonstrated the use of coconut fibers for the production of fiber cement boards which can be used for building partitions. On the basis of the research carried, following conclusions can be drawn:

1. As the percentage of fibers in fiber cement boards increased from 0% to 15%, the density of the boards decreased from 1780 kgf/m³ to 1492 kgf/m³. Therefore, an inverse relation between fiber content and density was observed.
2. The percentage of water absorbed by the boards increased from 9.30% to 15.38% with increase in fiber content from 0% to 15% respectively.
3. The compressive strength firstly increased with increase in fiber content up to 10% and then decreased upon further increment of fiber content.
4. An increasing pattern in the impact strength was observed with increasing content of fibers in boards.
5. Fiber cement boards with 5% fiber content displayed poor drilling properties. On the other hand, fiber cement boards with 10% and 15% fiber content showed effective drilling characteristics.

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