Development of a Composite Board by Mixing Cement, Coir Fiber and Calcium Carbonate

P.N. Jathunarachchi, N.S. Withanage
Uva Wellassa University, Badulla, Sri Lanka

and

J.A.K.M. Fernando
Mechanical engineer, Coconut Research Institute, Lunuwila, Sri Lanka

Introduction

Coir fiber products have a great potential in domestic and international market in view of the world trend towards natural products. Now a days coir fiber reinforced cement boards are becoming more popular than harmful synthetic fiber reinforced cement boards. Their natural abundance, relative cheapness and instantaneous replacing ability are the strongest arguments to utilize them in the construction industry in Sri Lanka. In the Acetylene plant, calcium carbonate is the waste material. Due to its excellent filling ability and the availability, it can be used in composite board manufacturing. For the development of the coir industry and to add value to the wasting coir surplus and calcium carbonate waste from acetylene plant, it is required to investigate the possibility of using coir fiber and calcium carbonate in composite board manufacturing.

This research was aimed at developing a coir fiber reinforced composite board by mixing cement, coir fiber and calcium carbonate via the determination of weight fraction of the constituents of the boards. In addition to that, the effect of various coir fiber types (Bristle fiber, Mattress fiber and Baby fiber) as well as various calcium carbonate ratios (10%, 20% and 25%) on board properties such as dry weight, thickness, density, water absorption and flexural strength were also determined. Then the possibility of using these composites in ceiling sheet manufacturing was studied.

Methodology

Three types of coir fibers (Bristle fiber, Mattress fiber and Baby fiber), Calcium Carbonate ($CaCO_3$) and Ordinary Portland cement (OPC) were obtained locally. Calcium carbonate precipitates were ground and sieved using 0.5 mm sieve to obtain the calcium carbonate in powder form. Then bristle fiber and the mattress fiber were cut into 2 cm length in pieces. Preliminary studies were conducted to find out the suitable composition for the development of composite board using cement, coir fiber andcalcium carbonate. In the preliminary trials ten different composites were manufactured and evaluated its weight and other physical properties and it was observed that the composite C34B was not acceptable condition. Accordingly nine composite mixtures were selected for further testing of the physico-mechanical properties. Compositions of mixtures were given in table no 1.

Ordinary Portland cement and calcium carbonate in various ratios were manually mixed with water and also coir fiber. The mixing of these ingredients was continually done until the cement, calcium carbonate and fiber paste were uniformly distributed. Then the mixture was spread out in a metal frame placed on a polythene sheet to form a board using mason's trowel. The board was inserted in between the two plates of hydraulic press machine and it was densified by compressing it to a desired thickness using a hydraulic press. The pressure was maintained for 24 hours. The boards were removed from the press after 24 hours and soaked in the water for 7 days for curing and conditioning. The cement: calcium carbonate ratios were varied in

400:160,400:120,400:50 while cement and CaCO3 to fiber ratio was kept at a constant (10%) and the fiber types were also changed. The amount of water was fixed at 400ml per board.

Table 1. Treatment combinations.

Specimens code	Cement (g)	$CaCO_3$ weight (g)	Types of fiber	Fiber wt. (10% of cement & $CaCO_3$ weight)	Water (ml)	Wt. % of $CaCO_3$ in final product
C34B	500	300	Bristle	80	500	34
C10B	400	50	Bristle	45	400	10
C10M	400	50	Mattress	45	400	10
C10Y	400	50	Baby	45	400	10
C20B	400	120	Bristle	52	400	20
C20M	400	120	Mattress	52	400	20
C20Y	400	120	Baby	52	400	20
C25B	400	160	Bristle	56	400	25
C25M	400	160	Mattress	56	400	25
C25Y	400	160	Baby	56	400	25

Dimensions of boards, density, water absorption and flexural strength properties were tested for the determination of the quality of the boards according to SLS 9: Part 1: 2001.The properties of the boards as affected by the various fiber types and calcium carbonate ratios and the interactions among them were analyzed using analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) in a complete randomized design (CRD). All statistical analysis was performed with SAS package.

Result and Discussion

According to the analysis of variance, there was a significant influence on fiber type on thickness, density, water absorption and bending strength of boards (Table 2). The calcium carbonate ratio was shown a significant influence on the dry weight, thickness, density and the bending strength of boards. Interaction of fiber type and calcium carbonate was significantly influenced on bending strength of boards.

Table 2. Effect of fiber treatments on physical properties of composite boards

Duncan's Multiple Range Test (DMRT)					
Treatment			Results		
Fiber type	Dry weight (Kg)	Thickness (mm)	Density (Kgm^3)	Water absorption %	Bending strength (Mpa)
Bristle	0.608733 ^{a}	4.28444 ^{b}	1524.47 ^{a}	25.024 ^{b}	4.7089 ^{a}
Mattress	0.6138 ^{a}	4.38222 ^{b}	1504.77 ^{a}	23.67 ^{b}	3.9644 ^{b}
Baby	0.607678 ^{a}	4.58778 ^{a}	1422.44 ^{b}	30.434 ^{a}	2.8311 ^{c}

Means followed by same letter in each column are not significantly different at P=0.05.

DMRT in table 2 shows the variation of Dry weight, Thickness, Density, Water absorption and bending strength of composite boards with respect to fiber treatments. There was a significant difference in the density of boards with baby fiber. Boards with baby fiber led to lower density than bristle / mattress fiber reinforced boards. Expected water absorption of boards (amount of water absorbed shall not exceed 28% of the dry mass) which was met with the boards produced using bristle and mattress fibers. Average water absorption of bristle fiber was 25.0%. The maximum bending strength of 4.70 Mpa was attained by bristle fiber reinforced boards (Table 3). There was decreasing trend of average flexural strength from bristle to mattress to baby fibers. Results indicate on how the bending strength of boards was influenced by the tensile strength of coir fibers. Tensile strength of bristle fiber is greater than mattress and baby fibers.

According to the Duncan's Multiple Range Test, there was an increasing trend in the average dry weight from 10% to 25% calcium carbonate weight ratios. Minimum dry weight was 533.4 g at 10%calcium carbonate ratio.There was asignificant difference in bending strength with respect to boards of 10%, 20% and 25% calcium carbonate ratios. Maximum and minimum bending strengths were attained at the 10% and 25% calcium carbonate ratios. The increase of calcium carbonate ratiogreater than 10 % led to a reduction in bending strength. This may be due to two "contradictory effects" of calcium carbonate powder. Replacing of cement with calcium carbonate could lead to a reduction in flexural strength because calcium carbonate powder does not have cementitious properties. (Khorami, 2012).There was a significant interaction effect of Calcium carbonate and fiber type of bending strength of boards. Maximum flexural strength was met at C10B (10% $CaCO_3$ with Bristle fiber) composite boards. Minimum flexural strength was met at C25Y (25% $CaCO_3$ with baby fiber) composite boards. Calcium carbonate as a filler in coir fiber reinforced composite boards at a higher filler loadings leads to losses in bending strength which may be due to insufficient bonding between interfaces of cement and fibers (Eusebio *et al.*, 1998). Table 3shows the comparison of Physico-mechanical properties of coir fiber composite boards with asbestos sheets.

Table 3. Comparison of properties of coir fiber composite boards with asbestos sheets

Properties	Coir fiber reinforced composite board	Asbestos ceiling sheets
Density	1524.77 Kgm^{-3}	1700 Kgm^{-3}
Water absorption	25.04 %	8.5%
Bending strength	5.2 Mpa	13.5 Mpa

Conclusions

Calcium carbonate is a potential admixture to ordinary portland cement as filler in coir fiber reinforced cement composite board production. Flexural strength decreases as the calcium carbonate content is increased and fiber content change as bristle fiber, mattress fiber and baby fiber respectively. The highest flexural strength and lowest dry weight values for coir fiber reinforced cement and calcium carbonate mixed composite board samples are obtained in 10% calcium carbonate content with bristle fiber. (C10B)The physical parameters such as thickness, density and water absorption of composite board named C10B satisfy the standards. The product is better for applying as suspended ceiling and also interior partitioning boards.

References

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