VOL. 1 NO. 1 JUNE 1994 ISSN 0128 - 7141

BRC JOURNAL

Journal of the Bureau of Research and Consultancy,
MARA Institute of Technology.
(Jurnal Biro Penyelidikan dan Perundingan, Institut Teknologi MARA)

BUREAU OF RESEARCH & CONSULTANCY
INSTITUT TEKNOLOGI MARA

ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM ITM

WOOD-CEMENT BOARDS (WCB) FROM *BAMBUSA VULGARIS*

by
Jamaludin Kasim,
Chen Fung Woo and
Rahim Sudin

ABSTRACT

Bambusa vulgaris taken from the riverside of Sg. Benus, Bentong, Pahang was found to be suitable in the manufacture of (WCB). It contains a high amount of sugars and was found to have a retarding effect on cement setting. In the study, higher cement ratio gives better board properties. Board with a bamboo-cement ratio of 1:2.75 with the addition of 2% chemical additives produces an acceptable board which meets the requirements of the Malaysian Standard MS934.

Keywords: Bamboo-B. *vulgaris*, bamboo cement boards, cement setting

Jamaludin Kasim and Chen Fung Woo are Lecturers, School of Applied Sciences MARA Institute of Technology, Shah Alam, Malaysia.

Rahim Sudin is a Senior Research Officer, Forest Research Institute Malaysia.

BUREAU OF RESEARCH & CONSULTANCY
INSTITUT TEKNOLOGI MARA

INTRODUCTION

Bamboo is a member of the grass family Gramineae and is a fast growing and high yielding renewable resource. In Peninsular Malaysia, bamboo covers an estimated area of about 329,000 ha of the total forested area with an estimated standing stock of about 7 million tonnes. About 60,000 tonnes of bamboo with a market value of RM 3 million have been utilized (Abd. Latif, 1987).

The uses of bamboo are unlimited, but proper utilization of this resource would be greatly beneficial especially to the rural community. Malaysia has a long tradition in the use of bamboo. Many interesting traditional uses of bamboo have been documented (Burton, 1979, Wong, 1982). However, this use has not reached the level of sophistication that other agricultural products have achieved. In the industrial sector, it may be used as a supplement for timber in the near future. It is with this objective that this study was conducted to highlight the possibility of using bamboo as a raw material for the building industry in the form of bamboo-cement bonded boards.

MATERIALS AND METHODS

Bamboo Sample

About 300 kg of *Bambusa vulgaris* was taken from Bentong in Pahang. The stem of about 2 m in length was chipped with a Taihei chipper at the Forest Research Institute Malaysia laboratory. The chips which passed through a 2 x 2 cm screen were taken for further flaking. Wood flakes were screened to various particle sizes. The wood flakes retained at 0.5 mm screen were used as fine materials and those retained at 1.0 mm screen were used as core materials for manufacturing cement-bonded particleboard.

Particle Size Analysis

Wood particles in flakes form were randomly taken for particle size analysis. The particles size distribution of the flakes were determined by using the lab-siever with the screen size of 0.25 to 3.35 mm. The average thickness and length of the flakes were determined based on at least 100 specimens.

Suger Content Analysis

Sugar content analysis was carried on randomly sampling of wood flakes. The flakes were further ground with Fritz-Pulvirizer to about 200 mesh size and 12 determinations was carried out. About 400 mg. of fresh wood samples (200 mesh) were soaked in about 40 ml MeOH : H_2O(75 : 25) overnight with regular shaking. After 24 hours, the volume was made to 50 ml and filtered with a crucible glass no. 3. Twenty five ml of the filterate was evaporated to dryness before being dissolved with 3 ml distilled water. The aqeous solution was then filtered by 0.45 u prep-disc membrane filter into a sampling bottle before being injected into HPLC system (Model HP 1084 B). The sugars were detected by RI detector with Aminex HPX-87 P column and doubled distilled water as the mobilizer.

Wood-Cement Board (WCB) Manufacture

Several series of 3-layered WCB were made based on the variation of wood to cement ratios and with the inclusion of various types of mineralising chemicals. Five pieces of boards were produced for each series. The size of the boards was 45 x 45 cm and 10 mm thickness. The target density of the boards was 1250 kg/m^3. The wood-cement admitures were mat-formed on a caul plate by using a wooden mould. Every mat was stacked one on top of the other, pressed up to the required thickness and clamped for overnight in a hardening chamber set at a temperature of 60-65°C. After 24 hours, the pressure was released and the WCB was allowed for further curing process at room temperature. All boards were tested after 28 days curing.

Board Testing

All boards manufactured were tested according to the Malaysian Standard Specification for Wood Cement Boards (MS 934 : 1986). The tests comprised of bending strength, tensile strength, water absorption and thickness swelling.

RESULTS AND DISCUSSION

Particle Size Analysis

The particle size distribution of the flakes is given in Table 1. Most of the particles belong to the particles retained at the screen size of 0.5-2.0 mm. Besides that, a significant amount of bigger particles (retained at 3.35 mm sieve size) was also observed.

This portion of flakes was fed once again into the flaker to produce smaller particles suitable for WCB manufacture. The average thickness and length of the flakes are in the range of 0.39 - 0.61 mm and 14.0 - 17.1 mm respectively.

Sugar Content Analysis

Sugar content on freshly felled bamboo showed that glucose, fructose and sucrose were the main sugars component in this species (Table 2). Glucose and fructose are basically the major components compared to sucrose. These three type of sugars were also reported in oil palm trunk, however, sucrose was the major component in freshly felled oil palm trunk (Rahim *et al.* 1987). The average total sugars presence in this bamboo species is about 2-4 times higher than rubberwood (Azizol & Rahim, 1989) and half of those reported in oil palm trunk (Halimahton & Rahim 1990).The amount of sugars in *B. vulgaris* (4.92%) is considered too high for WCB manufacture which specify the allowable amount of sugars in wood aggregate should be less than 0.5% based on dry weight of wood (Bever, 1986, Arturo, 1988 and Schwarz, 1988).

Table 1 Particles size distribution of *B. vulgaris*

Sieve size (mm)	Percent by weight (%)
<0.25	2.06
0.25	5.19
0.50	15.89
1.00	16.90
1.40	20.42
2.00	20.88
2.80	5.87
3.35	12.78
Total	100.00%

Note: Analysis are based on three determinations

Table 2 Sugar content analysis on *B. vulgaris*

Analysis No.	Percent of sugars Fructose	Glucose	(%dry wt) Sucrose	Total Sugars(%)
2	2.046	2.372	0.537	4.955
3	2.074	2.430	0.516	5.020
4	2.231	2.415	0.488	5.134
5	2.156	2.376	0.466	4.998
6	2.145	2.385	0.499	5.029
7	2.080	2.358	0.505	4.943
8	2.027	2.295	0.548	4.870
9	2.062	2.311	0.516	4.889
10	1.947	2.296	0.488	4.731
11	1.998	2.236	0.509	4.743
12	2.057	2.397	0.417	4.871
Average	2.070	2.350	0.503	4.923
Std. dev.	0.073	0.055	0.035	0.111

The hydration test carried out by incorporating the B. vulgaris wood particles into the cement matrix confirmed that the materials had delayed the hydratuon time and reduced the hydration temperature of Portland cement. The hydration properties of wood-cement mixtures improved to almost neat cement when the extracted wood particles was added into the cement matrix. Utilisation of water extract to be mixed with cement had prolonged the hydration time of ordinary Portland cement to about 10 hours compared to about 8 hours with neat cement. This study confirmed that water extracts from B. vulgaris had a set-retarding effect on cement setting. However, the addition of about 2% aluminium sulphate ($Al2SO4$) improved the hydration characteristics of cement-water extracts system.

Physical and Mechanical Properties

The physical and mechanical properties of WCB manufactured from *B. vulgaris* are given in Table 3. The data was analysed by SAS for ANOVA and Duncan Multiple Range T-test for the effect of bamboo:cement ratio and chemical additives on the board properties.

Table 3 The physical and mechanical properties of WCB from *B. vulgaris*

Bamboo:Cement ratio	Chemical additives	BS (MPa)	IB (MPa)	WA (%)	TS (%)
1:2.50	-	2.43	0.07	29.00	2.15
1:2.75	-	3.87	0.12	26.10	1.17
1:3.00	-	5.04	0.23	20.40	1.26
1:2.75	CaCl2	5.48	0.19	24.64	2.26
1:2.75	MgCl2	6.93	0.43	15.97	1.11
1:2.75	Al2SO4	9.25	0.63	14.40	0.76
1:2.75	Al2SO4 + Na2SiO3	9.41	0.77	12.57	0.82
Ms 934		9.00	0.50	-	<2.00

Effect of Bamboo:Cement Ratio

Table 4 shows the analysis of Variance for the effects of bamboo :cement ratio on the BS, IB, WA and TS. Highly significant effect was observed on BS, IB, WA and TS. The mean value for BS, IB, WA and TS are 3.78MPa, 0.1MPa, 25.16% and 1.53% respectively.

Table 4 Mean squares[1] from the analysis of variance for bending strength (BS), internal bond (IB), water absorption (WA) and thickness swelling (TS).

	df	Bs	IB	WA	TS
Ratio	2	30.46*	0.124*	344.85*	5.29**
Error	51	1.35	0.0005	15.72	1.14
C. Total	53	2.44	0.0052	28.14	1.29
Mean		3.78	0.14	25.16	1.53
Std. dev.		1.56	0.057	5.30	1.14

[1]*Mean squares *,** are significant at the 5% and 1% probability level.*

Variation in board properties among the bamboo:cement ratio was also observed as indicated in Table 5. The ratio of 1:3.00 indicated the highest board properties for BS(5.04MPa), IB(0.23MPa) and lowest Wa(20.40%).However, according to Moslemi

1989, too high a cement ratio might cause CBP to be brittle and increases the cost of materials unneccesarily. The common wood:cement ratio used by the mill is in the range of 1:2.2 to 1:2.75, depending on the species, density and retardation effect of the wood (Bison 1984).

Table 5 Bamboo-cement ratio means for bending strength (BS), internal bond (IB), water absorption (WA) and thickness swelling (TS)

Bamboo-cement Ratio	BS (MPa)	IB (MPa)	WA (%)	TS (%)
1:2.50	2.439 c	0.0678 c	28.99 a	2.153 a
1:2.75	3.867 b	0.1200 b	26.10 b	1.171 a
1:3.00	5.036 a	0.2306 a	20.40 c	1.264 a
MS : 934	9.00	0.50	-	<2.00

Mean are averages of 18 replicates

The water absorption and thickness swelling of all the boards were higher than those manufactured by the mill. Ahmad Shakri and Rahim (1989) reported that the water absorption and thickness swelling in the bamboo-cement particleboard is probably due to the fact that there is loose binding between cement and bamboo particles which thus caused a series of gaps within the board.

Effect of Chemical Additives

Table 6 shows the analysis of variance for the effects of chemical additives on the BS, IB, WA and TS. The addition of chemical additives during board manufacture shows a significant effect on all the board properties at the 1% probability level. The mean value for BS, IB, WA and TS are 6.99 MPa, 0.43 MPa, 18.22% and 1.20% respectively.

All board properties show a remarkable improvement when 2% of chemical additives are added into the bamboo-cement ratio as shown in Table 7. In WCB manufacture, chemical additives so called mineralising fluid is normally added in small quantities in order to counter the poisoning effect on cement and also boost the hydration process of cement (Chittenden 1976). Among the three chemicals : aluminium sulphate $(A12SO4)^3$, magnesium chloride (MgCl2) and calcium chloride (CaCl2) ; alumunium sulphate seems to be the best mineralising agent and produce the board just meeting the minimum requirement as stipulated in the Malaysian Standards MS 934. Addition of 2% aluminium sulphate and sodium silicate (Na2Si03) to enumerate the formulation set by the mill practice for WCB manufacture shows much better results. The bending strength, internal bond and thickness swelling of the board are 9.41 MPa, 0.77 MPa and 0.82% respectively, surpassing the minimum requirements of MS 934.

Table 6 Mean squares[1] from analysis of variance for bending strength (BS), internal bond (IB), water absorption (WA) and thickness swelling (TS)

	df	BS	IB	WA	TS
Chemical	4	90.94*	1.215*	568.18*	5.97*
Error	75	1.95	0.0005	3.26	0.29
C. Total	79	6.46	0.066	1.86	0.58
Mean		6.99	0.43	18.22	1.20
Std. dev.		2.54	0.26	5.64	0.76

[1] *Mean aquares * is significant at the 1 % probability.*

Table 7 Chemical additive means for bending strength (BS), internal bond(IB), water absorption (WA) and thickness swelling (TS)

Chemical additive	BS(MPa)	IB(MPa)	WA(%)	TS(%)
Al2(SO4)3 + Na2SiO3	9.405a	0.766a	12.57d	0.82c
Al2SO4	9.254a	0.625b	13.43d	0.76c
MgCl2	6.990b	0.433c	15.95c	1.11b
CaCl2	5.477c	0.194d	23.69b	2.26a
No. Chemical	3.910d	0.120e	25.44e	1.05bc
MS : 934	9.00	0.50	-	< 2.00

Means having the same letter down the column indicates that they are not significantly different.

CONCLUSION

From this study the following conclusion are made:

a. freshly felled Bambusa vulgaris contains a high amount of sugars (4.92%)

b. the sugars were found to have a retarding effect on cement setting.

c. higher cement ratio gives better board properties.

d. bamboo-cement ratio of 1:2.75 with addition of 2% Al2SO4 alone or in combination with Na2SiO3 produces an acceptable board which meets the requirement of the Malaysian Standard MS 934.

References

Abd. Latif Mohmod 1987. Guideline on the production of bamboo products. *FRI Technical Information* No. 2

Ahmad Shakri and Rahim Sudin. 1989. Finishing properties of coated cement-boarded particleboard. *JTFS* 2(2) : 122-128.

Anon, 1983. *Cemboard. The all purpose cement building board. Brochure produced by Cemboard Sdn.Bhd.*

Anon, 1986. *Malaysian Standard specification for Wood Cement Board MS 934.*

Arturo, G.R. 1988. Experience of manufacturing wood-cement particleboard in Mexico. Paper presented *at the Seminar on Fiber and Particleboard bonded with inorganic binders*, Idaho, USA.

Azizol Abd. Kadir and Rahim Sudin. 1989. Carbohydrates in rubberwood. *Holzforchung* 43(3) : 173-178.

Bever, M.B. 1986. *Wood-cement Boards in Encyclopaedia of Materials Science and Engineering,* 1st edition, Pergamon Press Ltd.: 5399-5402.

Burton, J.S. 1979. Joss stick makers of Selangor. *Nature Malaysian* 4:30-37.

Chittenden, A.E. Hawkes, A.J. and Hamilton, H.R. 1975. *Wood Cement System.* Paper presented at the World consultation on Wood-based Panels, New Delhi, India, 6-16 Feb.

Halimahton Mansor and Abd Rashih Ahmad. 1990. Carbohydrates in the oil palm stem and their potential use. *JTFS* 2(3) : 220-226.

Rahim Sudin. 1987. Wood Cement Boards. *Timber Digest* Nov.

Rahim Sudin, Abd. Razak Mohd Ali and Zakaria Mohd Amin. 1987. Chemicals component in oil palm trunk influencing wood-cement board manufacture. *Proceeding of the regional symposium on Waste Utilisation in Asia and the Pacific.* Kuala Lumpur : 23-27.

Schwarz, H.G. 1988. Cement-bonded boards in Malaysia. Paper presented at the *Seminar on Fiber and Particleboards Binded with inorganic binders.* Idaho, USA.

Wong, K.M. 1982. Malaysian bamboos in use. *Nature Malaysian* 7:34:39.