Journal of Tropical Forest Science 2(4): 267 - 273

CEMENT BONDED PARTICLEBOARD FROM *ACACIA MANGIUM* - A PRELIMINARY STUDY

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Received January 1989

RAHIM SUDIN & WAN ASMA IBRAHIM. 1990. Cement bonded particleboard from *Acacia mangium* - a preliminary study. Four-year-old *Acacia mangium* trees were examined for their suitability for cement bonded particleboard (CBP) manufacture under laboratory conditions; CBP produced at wood/cement ratio of 1:3.0 without any chemical additives satisfied the Malaysian Standard specifications for wood cement board. Better board properties were obtained with the addition of 2% aluminium sulphate or magnesium chloride at lower wood/cement ratio of 1: 2.5 .

Key words: *Acacia mangium* - cement bonded particleboard - hydration - chemical additives

Introduction

Acacia mangium is one of the three selected fast growing species under the Compensatory Forest Plantation Project (CFPP) launched by the Forestry Department, Peninsular Malaysia at the end of 1982. *Acacia mangium* now accounts for some 70% of the total planted area of CFPP (Johari & Chin 1986).

A. mangium has been reported to have good mechanical and working properties and is suitable for various general utility purposes such as furniture and joinery. However, being a light hardwood, the timber is not marked by good strength properties and is restricted to non-structural use (Peh & Khoo 1984). Chew and Jaafar (1986) reported that *A. mangium* from 2-y-old thinning can be manufactured into low density and medium density particleboards. This species was also reported to be suitable for sulphate pulping (Peh & Khoo 1982, Logan & Balodis 1982). Even though *A. mangium* could be easily peeled and sliced, the bond quality of *A. mangium* plywood using urea formaldehyde adhesive was poor. The logs which were also too small and of poor form, gave a low recovery rate (Wong *et al.* 1988).

Preliminary studies revealed that this species could be made compatible with Portland cement on treatment with either aluminium sulphate, calcium chloride or sodium silicate (Rahim & Ong 1983). We report here the mechanical and physical characteristics of cement bonded particleboard manufactured from *A. mangium.*

Materials and methods

Collection of samples

Three 4-y-old trees of *A. mangium* were taken from a thinning at the Batu Arang forest plantation, Selangor, Peninsular Malaysia. The average height and diameter (at breast height) of these trees were 12 *m* and 20.3 *cm*, respectively. Each tree was cut into two logs of 2 *m* length starting from above the ground and immediately brought back to Forest Research Institute Malaysia. All the felled trees were observed to have 'heart rot' especially at the bottom. The white to pale yellow sapwood and the dark brown heartwood differed distinctly.

Density and sugar determination

Two discs of about 2.5 *cm* thickness were cross cut from the bottom and top part of each tree for determination of density and chemical analysis (Figure 1). The density determination was carried out according to method TAPPI UM 12 (Anonymous 1976) while sugar content analysis was conducted by HPLC with Aminex HPX-87P column and double distilled water as the eluant.

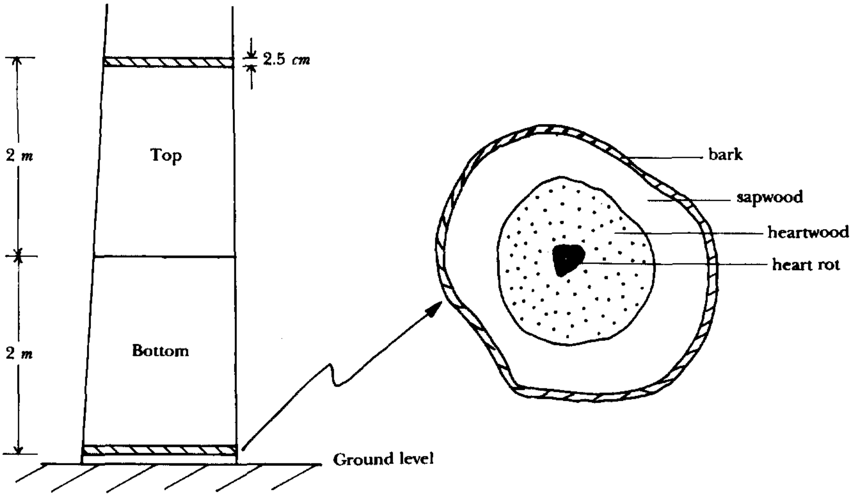

Figure 1. Sampling procedure of *Acacia mangium* for density and sugar analysis

For sugar content analysis, the wood was disintegrated by a Wiley mill and then further ground into fine powder (over 200 mesh) by Pulverisette Type 14.702. The wood powder was then dried in a dessicator with concentrated sulphuric acid as the drying agent. The extraction of sugars was carried out by soaking about 0.4 *g* of wood samples in 50 *ml* of methanol : water (75 : 25) with regular shaking at room temperature. After 24 *h*, the samples were filtered and 20 *ml* of the filtrate was pippetted into a petri dish to evaporate the methanol. Distilled water (3 *ml*) was added into the dish to dissolve the dry matter before filtering into the sampling bottle for HPLC determination. The wood residue that remained in the G3-fritte was dried in an oven and reweighed to calculate the total amount of methanol extract. The whole determination was carried out within three months.

Wood processing

Each log was debarked and cut into 20 to 30 *cm* billets which were passed into a disc flaker to produce 3 *cm* length flakes. The flakes were then fed into a Pallmann Knife-ring flaker with knife setting of 0.3 *mm* and screened to separate the coarse materials from fines. The particles of size 0.5 *mm* were used as fines for board surfaces and those $\geq$ 1.0 *mm* were used as coarse particles for the cores.

Hydration test

A hydration test on admixtures of 10 *g* *A. mangium* particles (35 mesh), 200 *g* cement and 80 *ml* water was carried out by incorporating separately calcium chloride, aluminium sulphate, magnesium chloride and sodium silicate at 2% level (based on cement weight). Based on the hydration test, three types of chemical additives such as calcium chloride, magnesium chloride and aluminium sulphate were used individually in board making.

Board manufacture

Six series of CBP with various cement to wood ratios of 1:2.0, 1:2.5 and 1:3.5 and different chemical additives were manufactured under laboratory conditions. Each series comprised four panels of CBP set at a density of 1250 $kg\ m^{-3}$ and dimensions 50 × 50 × 1 *cm*. The boards were clamped overnight and hardened at 65 ± 3°*C* in a hardening chamber. After the boards were cured at room temperature for about one month, each panel was cut into five test specimens for bending strength, ten specimens for tensile strength and four specimens for water absorption as well as thickness swelling tests. All tests were conducted according to Malaysian Standard MS 934 (Anonymous 1986).

Results and discussion

The mean density of the three *A. mangium* stem was 558 $kg\ m^{-3}$; the basic density decreased with the height of the tree. The bark, comprising about 13 to 15% (based on dry weight) of the stem was easily peeled and removed. Most of the wood particles ranged in size between 0.25 to 1.00 *mm* and the average thickness was 0.399 *mm*.

A. mangium contained a relatively low sugar content compared to rubberwood and oil palm (Rahim *et al.* 1987, Azizol *et al.* 1989). The maximum sugar content, 0.624% was found in the heartwood of the top part of tree number 2. The sugar content remained below 0.54% for the rest of wood samples. Generally, the amount of sugar was higher in the heartwood as compared to the sapwood except for tree number 3 (bottom) (Table 1).

Table 1. Average total sugars in *Acacia mangium* extracted by MeOH (75%) from different individuals, portions and zones

Tree number	Portion of the tree	Zone	Sugar content (%)	Weight * loss (%)
1	Bottom	Sapwood	0.004	0.79
		Heartwood	0.347	2.69
	Top	Sapwood	0.235	1.84
		Heartwood	0.340	4.17
2	Bottom	Sapwood	0.086	1.20
		Heartwood	0.537	3.03
	Top	Sapwood	Nil	0.42
		Heartwood	0.624	2.96
3	Bottom	Sapwood	0.262	0.82
		Heartwood	0.131	3.92
	Top	Sapwood	0.213	0.46
		Heartwood	0.508	4.28

* Weight loss of the wood particles after 24 *h* extraction with MeOH (75%) (This figure indicated the total alcohol extractives from each wood sample)

The amount of sugars in wood is an important factor, because above a critical value, identified to be 0.5 to 0.6% (Weber 1985, Arturo 1988) cement setting is inhibited. The amount of sugar can be easily reduced by natural storage for the first few days due to fungal and bacterial activities. The above results show that *A. mangium* can be considered suitable as wood aggregate after some storage.

The physical properties of CBP manufactured without any chemical additives at different wood-cement ratios are given in Table 2. Generally, the strength properties of CBP increased with increase in the proportion of cement in the wood cement mixture. It seems that only the CBP produced without chemical additives at wood:cement ratio of 1:3.0 could satisfy the requirements stipulated in the Malaysian Standard.

Table 2. The effect of wood cement ratios on the physical properties of CBP manufactured without chemical additives

Board number	Wood Cement ratios	Bending strength (*MPa*) (n=20)	Tensile strength (*MPa*) (n=40)	Water abs. (%) (n=16)	Thickness swelling (%) (n=16)
I	1 : 2.0	3.01(1.31)	0.02(0.01)	33.46(2.54)	4.87(1.36)
II	1 : 2.5	8.08(2.34)	0.63(0.16)	14.04(4.54)	1.61(1.53)
III	1 : 3.0	10.74(2.44)	0.91(0.40)	11.50(2.34)	1.65(0.77)

(Density = 1250 kgm^{-3}, water = 45 %, figures in parenthesis are standard deviation, n = no of test specimens for testing)

Hydration tests indicated that a higher temperature in a shorter hydration time was obtained for admixtures of cement, water and wood particles in the presence of calcium chloride, magnesium chloride and aluminium sulphate as compared with neat cement (Figure 2). These three chemicals were then selected to be used as chemical additives in this study. Lower hydration temperature and longer hydration time were observed in the admixture containing sodium silicate.

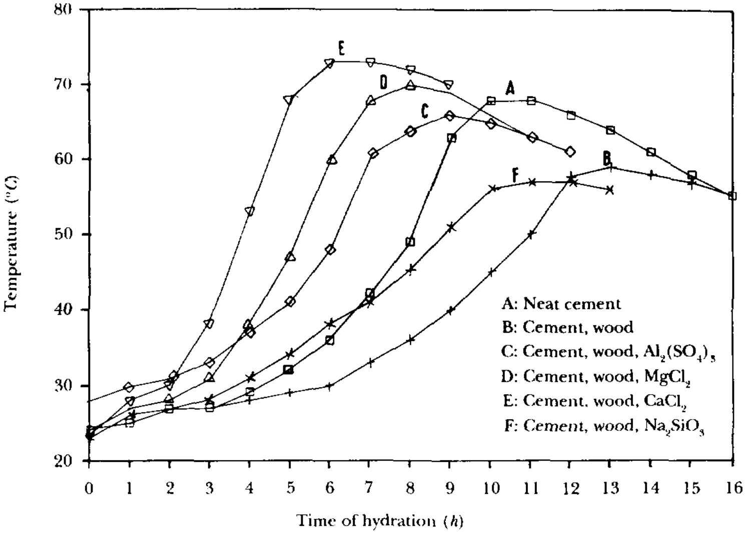

Figure 2. The influence of chemical additives on the hydration of cement, *Acacia mangium* particles in the presence of water

Further, CBP manufactured using wood:cement ratio of 1:2.5 in the presence of chemical additives showed improvements in board properties except for calcium chloride treated boards (Table 3). The best strength properties of CBP were obtained from aluminium sulphate treated boards followed by magnesium chloride. However, this study was based on limited wood samples and under laboratory conditions. Further studies on the economical and commercial aspects need to be continued in the future.

Table 3. The effect of chemical additives on the physical properties of CBP

Board number	Chemical additives	Bending strength (*MPa*) (n=20)	Tensile strength (*MPa*) (n=40)	Water abs. (%) (n=16)	Thickness swelling (%) (n=16)
IV	Calcium chloride	5.89(0.71)	0.05(0.04)	27.47(2.13)	3.33(1.01)
V	Magnesium chloride	11.98(1.09)	1.71(0.36)	10.12(1.25)	0.93(0.46)
VI	Aluminium sulphate	16.35(1.75)	1.68(0.47)	7.79(2.44)	0.78(0.47)
Malaysian Standard (MS 934)		9.0	0.50	ns	2.0

(Density = 1250 *kgm*$^{-3}$, wood/cement = 1 : 2.5, amount of chemicals added = 2% of cement weight, ns = not stated, figures in parentheses are standard deviation, n = no. of test specimens)

Conclusion

This preliminary study revealed that 4-y-old *A. mangium* thinings are suitable for use in CBP manufacture at a wood cement ratio of 1:3. Lower wood cement ratio of 1:2.5 could be employed on the addition of either 2% aluminium sulphate or magnesium chloride which improved the board properties.

Acknowledgements

We wish to express our gratitude to the Forestry Department for the supply of the *A. mangium*, Associated Pan Malaysia Cement (APMC), Rawang for the Portland cement and Jalali Hj. Salleh for his assistance in to this study. Thanks are also due to K. C. Khoo for his invaluable comments on the manuscript.

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