Influence of Age of *Bambusa vulgaris* on Particleboard Properties

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Abstract

The properties of particleboard produced from 1-,2-,3- and 4-year old *Bambusa vulgaris* Schrad, the commonest village bamboo in Malaysia, were ascertained. Culms of two years old or more were found to yield good particles for particleboard manufacture. Three particleboards with the density of 561, 641 and 721 kg/m^3 were produced by using urea formaldehyde resin as the binder at the resin contents of 6, 8 and 10%, pressing time of 6 minutes and temperature of 160^{o}C. All the boards tested passed the minimum requirements of the British Standards BS 5669-1989. This indicates the suitability of this bamboo species for the manufacture of particleboard.

সারসংক্ষেপ

মালয়েশিয়ার গ্রামাঞ্চলে *Bambusa vulgaris* প্রজাতির বাঁশ অতি পরিচিত। এ প্রজাতির ১, ২, ৩ এবং ৪ বছর বয়স্ক বাঁশ থেকে প্রস্তুতকৃত পার্টিকেল বোর্ডের গুণাগুণ পরীক্ষা করে দেখা যায় যে দুই অথবা ততোধিক বছর বয়স্ক বাঁশ থেকে ভাল মানের পার্টিকেল বোর্ড প্রস্তুত করা যায়। শতকরা ৬, ৮ ও ১০ ভাগ রেসিন সমৃদ্ধ ইউরিয়া ফরমালডিহাইড রেসিন বাইণ্ডার হিসেবে ব্যবহার করে ১৬০^o সেঃ তাপমাত্রায় ৬ মিনিট চাপ প্রয়োগ করে তিন ধরনের পার্টিকেল বোর্ড তৈরী করা হয় যাদের ঘনত্ব ছিল প্রতি ঘনমিটারে ৫৬১, ৬৪১ এবং ৭২১ কিলোগ্রাম। পরীক্ষিত সবগুলো বোর্ডই ব্রিটিশ ষ্ট্যান্ডার্ড.বি এস ৫৬৬৯-১৯৮৯ এর সর্বনিম্ন যোগ্যতার মানে উত্তীর্ণ হয়। এতে প্রতীয়মান হয় যে এ প্রজাতির বাঁশ পার্টিকেল বোর্ড তৈরীর জন্য উপযুক্ত।

Key words : Bamboo, *Bambusa vulgaris*, particleboard

Introduction

Particleboards are generally made of softwoods. The advancement of technology, however, has enabled hardwoods, agricultural wastes and other industrial by-products to be utilized in the manufacture of particleboard. At present, rubberwood is the most abundant fibrous material for particleboard manufacture in Malaysia. Since rubberwood has also a large demand in the furniture industry in the country, alternative lignocellulosic materials have to be looked after for particleboard manufacture. Bamboo seems to be a promising alternative material for this purpose.

Of the 50 bamboo species found in Peninsular Malaysia, 31 are widely utilized. *Bambusa vulgaris*, as such, is the most common cultivated species which is either planted for its shoots or culms. The abundant availability of the species justifies the suitability of *B. vulgaris* for particleboard making (Chen *et al.* 1991). For economic reasons it is imperative to study the effect of age of the bamboo species on particleboard making. With this aim in view the study was undertaken.

Materials and methods

Ten culms of *B. vulgaris* from each age group of 1-,2-, 3- and 4-year old were collected within the vicinity of Forest Research Institute Malaysia (FRIM) Forest Reserve in August 1993. All the culms were then subjected to longitudinal splitting before being fed into a Pallman drum chipper. The chips produced were then flaked in a Pallman Knife-Ring flaker set at 0.6 mm. Since flakes were of the desired sizes no further processing was carried out. The flakes were later screened into 0.5, 1.0, 2.0 and 3.0 mm sizes before being ovendried at 60°C to a moisture content of about 5%. Particle size analysis was also carried out simultaneously.

In the making of single layered urea particleboard of 12 mm thickness of three density levels (561, 641 and 721 kg/m^3) and resin content (RC) of 6, 8 and 10%, a measured quantity of flakes was mixed with a resin containing urea-formaldehyde, hardener (ammonium chloride; 20% w/w) and water within the Drais mixer. The sprayed particles were laid afterward in a wooden mould and prepressed at 3.5 kg/m^3. The consolidated mat was finally pressed for about six minutes at 160°C in a Taihei hot-press.

The methods used for determination of physical and strength properties of the boards *viz.*, thickness swelling (TS), water absorption (WA), modulus of rupture (MOR), internal bond (IB) and screw-withdrawal (SW) were based on British Standard: BS 5669 (Anon. 1989).

Results and discussion

The physical and mechanical properties of the boards are given in Table 1. Almost all the boards tested passed the minimum requirements of mechanical properties outlined by the British Standard : BS 5669. Boards made of 4-year old bamboo flakes with 10% resin and a density of 721 kg/m^3 were observed to possess the highest values of MOR (30.2 MPa), IB (1.03MPa) and SW (1029N). Boards produced from the 1-year old bamboo and with a resin content of 8% and below, however, were found to be inferior in respect of TS values. In general, bamboo particleboards produced from 2-year old and older culms with the combination of more than 8% resin surpassed the minimum requirements of the British Standards. It is thus expected that with the incorporation of wax, the dimensional stability of the bamboo boards will further be enhanced.

Table 1. Physical and mechanical properties of particleboards made from *Bambusa vulgaris*.

Age (yr)	Resin (%)	Density (kg/m^3)	MOR (MPa)	MOE (MPa)	IB (MPa)	SW (N)	TS (%)
1	6	561	15.23	2275	0.42	391	16.26
		641	19.26	2739	0.46	601	19.50
		721	22.47	3135	0.53	785	22.01
	8	561	15.67	2435	0.48	488	11.78
		641	21.22	3023	0.50	664	15.21
		721	27.26	3507	0.58	798	16.18
	10	561	17.97	2848	0.46	542	5.66
		641	24.64	3521	0.74	746	6.49
		721	27.99	3686	0.80	797	10.10
2	6	561	14.82	2488	0.34	508	12.71
		641	18.84	2914	0.37	698	15.16
		721	23.29	3275	0.36	950	19.64
	8	561	14.67	2421	0.43	529	9.01
		641	21.33	3149	0.53	777	7.90
		721	24.97	3454	0.55	943	10.06
	10	561	16.32	2580	0.53	474	6.70
		641	21.00	3084	0.64	738	7.19
		721	28.78	3939	0.75	1095	8.06

Contd. Table 1

Age (yr)	Resin (%)	Density (kg/m^3)	MOR (MPa)	MOE (MPa)	IB (MPa)	SW (N)	TS (%)
3	6	561	9.31	1692	0.40	393	10.94
		641	15.64	2484	0.42	491	10.79
		721	19.55	2799	0.40	648	14.68
	8	561	14.94	2469	0.56	476	5.00
		641	18.95	2054	0.64	642	7.05
		721	22.26	3152	0.57	778	9.65
	10	561	15.83	2474	0.64	494	4.83
		641	20.91	3191	0.82	665	7.01
		721	26.94	3553	0.86	897	9.21
4	6	561	13.64	2298	0.45	551	12.46
		641	18.57	2815	0.51	589	14.54
		721	19.88	2985	0.55	842	17.13
	8	561	15.36	2478	0.36	439	7.00
		641	23.68	3348	0.62	782	7.60
		721	25.89	3414	0.50	875	7.46
	10	561	15.73	2455	0.59	512	5.68
		641	25.45	3450	0.81	729	6.25
		721	30.19	4123	1.03	1029	8.68
BS 5669			>13.8		>0.34	>360	<12.00

Note : Values are average of 8 readings.

The respective summary of analysis of variance and Duncan's Multiple Range Tests on the effects of age, resin and density on the particleboard properties are shown in Tables 2 and 3 respectively. The results indicated that all the properties were influenced significantly by age, resin contents, density and their interactions (except for MOR and MOE in age and density interaction). The older the bamboo culms, the superior are the particleboard properties (especially MOR, MOE, IB and TS). This is explainable in the sense that less particles are consumed (due to higher density of particles within the older culms) which thus allow for more bonding sites to be occupied.

Table 2. Summaries of the analysis of variance (ANOVA) on the board properties.

Source of variation	df	MOR	MOE	IB	SW	TS
Age (A)	3	15.82**	14.84**	16.79**	24.45**	101.31**
Resin (R)	2	74.72**	86.56**	23.26**	24.92**	540.92**
Density (D)	2	286.42**	264.50**	63.90**	329.54**	105.63**
A X R	6	2.17*	3.07**	8.53**	1.71ns	23.78**
A X D	6	1.34ns	1.20ns	3.20**	4.27**	2.38*
A X R X D	12	2.10**	2.70**	5.66**	2.80**	3.31**

Note : ns, * and ** are not significant at P <0.05, significant at P <0.05 and highly significant at P < 0.01 respectively.

Table 3. Duncan's Multiple Range Test on the effects of age, resin contents and density on particleboard properties.

			Properties		
Age	MOR	MOE	IB	SW	TS
1	21.30a	3019a	0.55b	646b	13.69a
2	20.45a	3034a	0.50c	746a	10.72b
3	18.26b	2752b	0.59ab	609b	8.79d
4	20.93a	3041a	0.60a	705a	9.64c
Resin	MOR	MOE	IB	SW	TS
6	17.54c	2658c	0.44c	621c	15.48a
8	20.52b	2984b	0.53b	683b	9.49b
10	22.65a	3242a	0.72a	716a	7.15c
Density	MOR	MOE	IB	SW	TS
561	14.96c	2409c	0.47b	483c	9.00c
641	20.79b	3056b	0.59a	677b	10.39b
721	24.96a	3418a	0.62a	870a	12.74a

Means having the same letter down the column differ insignificantly at P <0.01.

The increment of resin contents, on the other hand, increased the strength properties but decreased the thickness swelling of the particleboard simultaneously. Table 3 further indicates that with the increment of 2% resin content (i.e., from 6-8%), the MOR, MOE, IB and SW increased by about 3 kg/cm^2, 326 MPa, 0.09 MPa and 62 N respectively. At the same time the thickness swelling properties of the particleboard decreased by about 6%. Similar observations on the strength properties-resin contents linear relationship were also reported by other works on materials like solid wood (Burrows 1961, Talbot and Maloney 1957, Kelly 1977, Moslemi 1974 and Siti Norralakmam and Razali 1992), bamboo (Chen *et al.* 1991) and oil palm fruit bunches (Shaikh *et al.* 1993) However, an increment of 4% resin content retarded the thickness swelling by more than 50%. This produced more stable board.

Density plays an important role on the physical and mechanical properties of the boards produced. A higher density is usually associated with higher strength properties. In this investigation, the MOR, IB and SW increased with the linear increase of density levels. This could be related to the higher compaction ratio due to higher density. Shaikh *et al.* (1993), Chen *et al.* (1991) and Chew *et al.* (1992) in their studies on the respective oil plam fruit bunches, bamboo and solid wood also found similar trends of linear relationship. TS, on the other hand, was also found to increase significantly with density. As stated by Chen *et al.* (1991) and Chew *et al.* (1992), more spaces (due to higher density) between the bamboo particles are made available thus turning it into more porous condition.

Conclusion

Bamboo particles are suitable as a raw material for the production of particleboard. The study indicated that with a minimum resin content of 8%, acceptable board properties can be made easily to meet the British Standards requirements. Bamboo culms of two-year old and more were observed to yield good particles for particleboard manufacture. Further studies on the addition of wax and its effect on the dimensional stability of bamboo particleboards are suggested.

Acknowledgements

The authors would like to extend their appreciation to Mr. Saimin Basir of FRIM and Azman Aznan of MARA Institute of Technology for their invaluable assistance during the whole experimental period.

References

Anonymous 1989. *British Standards Methods for Particleboard* BS 5669.

Burrows, C.H. 1961. Some factors affecting resin efficiency in flakeboard. *In :* Moslemi, A. A. (ed.). *Particleboard, Vol.10.* Southern Illinois University Press, USA. pp. 96-97.

Chen, F. W. ; Jamaludin, K. and Chew, L. T. 1991. Particleboard from bamboo. FRIM Reports No. 59. Forest Research Institute Malaysia. 12 pp.

Chew, L. T.; Rahim, S. and Jamaludin, K. 1992. *Bambusa vulgaris* for urea and cement-bonded particleboard manufacture. *Journal of Tropical Forest Science* 4 (3) : 249-258.

Kelly, M. W. 1977. Critical literature review of relationships between processing parameters and physical properties of particleboard. General Technical Report FPL - 10, May. 64 pp.

Moslemi, A. A. 1974. *Particleboard Vol. 1 : Materials. In* : Moslemi, A. A. (ed). *Particleboard, Vol. 10.* Southern Illinois University Press, USA. pp. 98-101.

Shaikh, A. K. Y.; Abdul Jalil, A. and Jamaludin, K. 1993. The properties of particleboard from oil palm empty fruit bunches. Paper presented at the School of Applied Sciences Seminar Series, September, 1993, Shah Alam, Malaysia.

Siti Norralakmam, Y. and Razali, A. K. 1992. Properties of particleboard manufacturing from less-used species II : *Bombax valvetonii.* National Seminar on Wood-Based Panel Products, 23-24 November, 1992, Kuala Lumpur, Malaysia.

Talbot, J. W. and Maloney, T. M. 1957. Effect of several production variables on the MOR and IB strength of boards made from green Douglas-fir shavings. *In:* Moslemi, A. A. (ed). *Particleboard Vol. 1: Materials.* Southern Illinois University Press, USA. pp. 96-97.