BORNEO SCIENCE 12: 43-50, DECEMBER 2002

PROPERTIES OF BOARDS FROM 3-LAYERS LAMINATED AND COMPOSITE-PLY FROM TROPICAL BAMBOO *Gigantochloa scortechinii*

Razak Wahab[1], Hashim W. Samsi[2] & Azmy Hj. Mohamed[3]

[1]School of International Tropical Forestry
University Malaysia Sabah , 88999 Kota Kinabalu, Malaysia
[2]Forest Rersearch Institute Malaysia
Kepong 52109, Kuala Lumpur, Malaysia
[3]UniversitiPutra Malaysia,
43400 Serdang, Selangor, Malaysia.

ABSTRACT. Boards of laminated and composite-ply were produced from tropical bamboo species Gigantochloa scortechinii. These are consisted of laminated three-layers bamboo strips, and single-layer bamboo strips with two layers of wood veneers respectively. Polyvinyl Acetate (PVAc) and Phenol Resorcinol Formaldehyde (PRF) were used in binding these boards together. Both, boards and a single strips were tested for their physical, mechanical and gluing properties. The results of the tests shows that both boards possess about the same values in density, MoE and MoR. These boardss have means density of 780 (kg/m^3), modulus of elasticity (MoE) between 15,000 to 16,200 N/mm^2, modulus of rupture (MoR) in bending tests between 98 to 118 N/mm^2 and means compression strength of 63 N/mm^2 at 12% moisture content. Both boards were found to possess good gluing strength. The overall strength of this boards passed the requirements of standard studies. These results are equivalent to some wood species in the structural strength groups.

KEYWORDS. Composite-ply, tropical bamboo, 3-layers lamited

INTRODUCTION

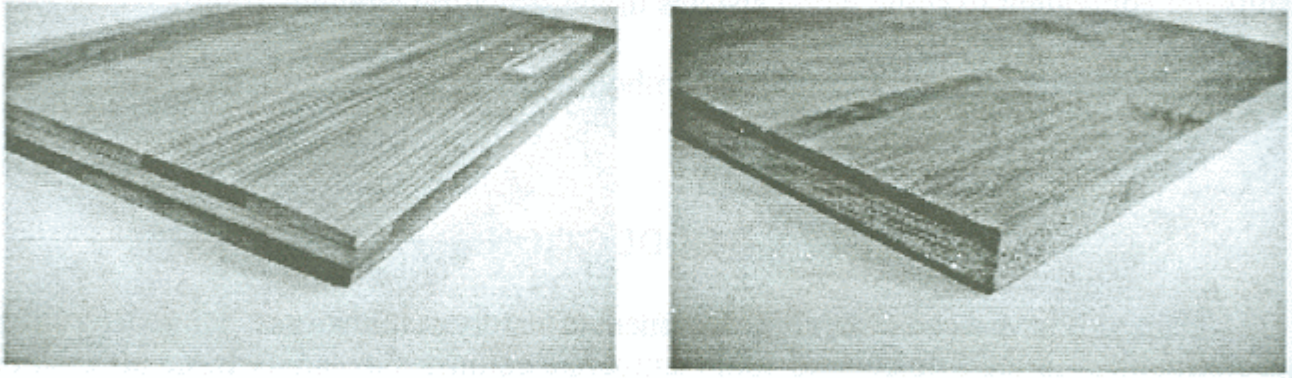
Bamboos have a centuries-long documented history of human use. It has been utilized by communities in the tropical and some temperate countries to satisfy basic necessities – food, fuel, shelters, agriculture tools, cooking vessels, water jugs, arts, crafts, furniture, musical instruments, weapons and a host of other items. This plants has either directly or indirectly contributed to the substance of over one billion people, mostly in the developing countries. Although bamboo has numerous uses, most of these are associated to traditional, low-value and temporary products (Razak, *et al.,* 1997). The potential used of bamboo as a viable substitute for wood for high value added products has not been fully explored, despite the fact that timber is becoming increasingly scarce.

In order for the bamboo industry to have the competitive edge in the international market, there need a shift - from the production of low end to high value added products. Bamboos possess properties that are at par and in some cases even better to certain timbers species. Such advantages should be exploited to make fit bamboo into an ideal form of resource supplement for manufacturing and construction sectors.

This paper present and discuss properties of boards from laminated bamboo and composite-ply encountered in a series of studies conducted in Malaysia.

MATERIALS AND METHODS

The bamboo species used for making the three-layer laminated and composite-ply boards for these studies was *Gigantochloa scortechinii*. It is one of the most important and extensively used species in the bamboo industry and is the most widely distributed in Malaysia. All bamboo culms used in this study were taken from the Forest Research Institute of Malaysia's (FRIM) research trial plot in Nami, Kedah in Malaysia. Selected culms of young and matured age (2 and 4 year-old) were harvested, split into smaller sizes, treated with borax and boric acid (ratio 1:1.5) at 4% concentration and kiln dried (Razak, 1998). A very mild drying schedule were used as to avoid drying defects (Razak *et al.*, 2000). After reaching about 12 % moisture content, all strips were than manufactured into three-layer bamboo strips and a mixture of bamboo-wood consisting of one-layer of bamboo and two-layers of wood strip. The arrangement of layer are illustrated in Figure 1. Two types of adhesive were used in binding these strips together. They were phenol resorcinol formaldehyde (PRF) and polyvinyl acetate (PVAc) with moisture resistance capability. These adhesives were chosen since it is commonly used by the furniture industry in Malaysia and easily obtained in the market. The manufacturing was carried out manually with hand-held roller and clamping. For testing purposes, all boards were made from bamboo of internodes 6, 7, 8 and 9.



(A): Three-layers laminated bamboo strips

(B): Composite-ply consisting of a single-layer bamboo and two layers of wood veneers

Figure 1. Configuration of layer arrangement.

The strength tests for shear, compression parallel to grain and static bending were conducted using the Shimadzu Computer Controlled Universal Testing Machine on split and laminated bamboo-ply. The tests were conducted in the Structural and Mechanical Laboratory of Forest Research Institute Malaysia (FRIM). The preparation of the test blocks and methods were made according to the ASTM D 143-52 (Anon, 1974a) and BS 373 (Anon, 1957) with some modifications. Ten (10) replicates were used for each test.

RESULTS AND DISCUSSION

The results of the of studies conducted on boards of laminated bamboo-ply on 2 and 4 years-old boards are tabulated in Tables 1, 2 and 3.

Table 1. Means comparative strength on single bamboo strip (with skin) of the 2 and 4-years old culms

		Compression Strength (N/mm^2)	Bending Strength (N/mm^2)
Culm age	Young (2-year old)	55	160
	Mature (4-year old)	60	171

Table 2. Means comparative strength of 3-layers bamboo board anufactured from 2 and 4-years old culms

			Compression Strength (N/mm^2)	Bending Strength (N/mm^2)
Type of glue used	PRF	2-year	59	113
		4-year	65	125
	PVAc	2-year	58	110
		4-year	63	118

Note: PRF is phenol resorcinol formaldehyde, PVAc is polyvinyl acetate (moisture resistance type).

The strength of bamboo boards from matured bamboo culm show slightly higher values than the younger culm. These were expected as matured culms posses thicker cells wall materials and higher basic densities (Razak, 1998). Whilst, strength properties of laminated bamboo boards applied with different type of adhesives indicate that the PRF treated board shows slightly higher values in the compression and bending strengths when compared to the PVAc (see Table 2).

Table 3. Means physical and mechanical properties of single strips, laminated 3-layers and composite bamboo boards of 4-years old bamboo

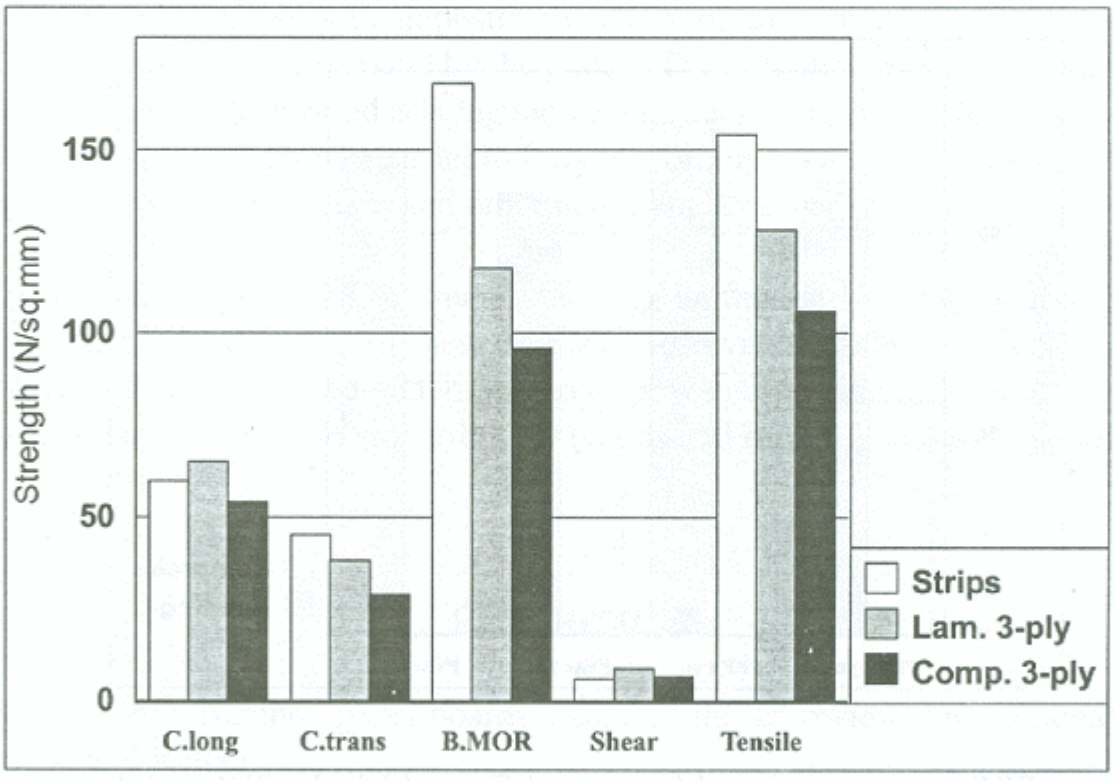
	Properties	Bamboo strip (single)	3-layer bamboo strip boards	Composite bamboo ply boards
1.	Moisture Content	12 %	12 %	12 %
2.	Density (kg/m^3)	670	780	590
3.	Compression Strength			
	Longitudinal (N/mm^2)	60	63	54
	Transverse (N/mm^2)	44	38	26
4.	Bending Strength			
	MOR (N/mm^2)	171	118	98
	MOE (N/mm^2)	15,515	16,210	15,830
5.	Shear Strength (N/mm^2)	4.5	9.4	7.2
6.	Tensile Strength (N/mm^2)	154	125	101
7.	Swelling in 2 hours			
	Width	0.3%	0.4%	0.7%
	Length	0.6%	0.8%	1.2%
	Thickness	3.4%	4.9%	6.2%
8.	Surface absorption in 2 hours	4.1%	6.6%	7.8%

Table 4. Means comparative strength of laminated bamboo (4 years old) and some common tropical timber species.

	MoR (N/mm^2)	MoE (N/mm^2)
Teak	98	12,839
Shorea species	101	12,545
Bamboo strip (single)	171	15,515
Laminated bamboo 3-laye	118	16,210
Laminated bamboo 4-layer	109	15,940
Composite bamboo ply 3-layer	98	15,070

The 3-layer bamboo strip (TLS) exhibited highest basic density as compared to the single strip and bamboo composite board (CBP). The CBP however, showed a lower value of their basic density compared to single-layer. The basic density of single-layer strip, TLS and CBP were 670, 780 and 590 kg/m^3 respectively. A lower basic density of CBP was probably due to the usage of LRM, a low density species. In general, laminated bamboo boards, regardless of its matrix arrangement or mixture of species, were found to possess equivalent or higher strength properties than some of the commercial hardwood species. (Table 3 and Figure 4). This observation is in agreement with other findings such as Zoolagud and Rangaraju (1991) and Anon (1999).

In comparison to strength properties, a single bamboo strip possesses higher bending strength than TLS and CBP. However, data run under statistical analysis indicated that there were no significant different on MOE between all samples tested. This confirms earlier studies that MOE is not influence by the number of layers, as its is a function of stiffness.



Legend: C.long=compression longitudinal, C.trans=Compression transverse
B.MOR=Bending MOR, Lam.=Laminates bamboo, Comp=Composite ply

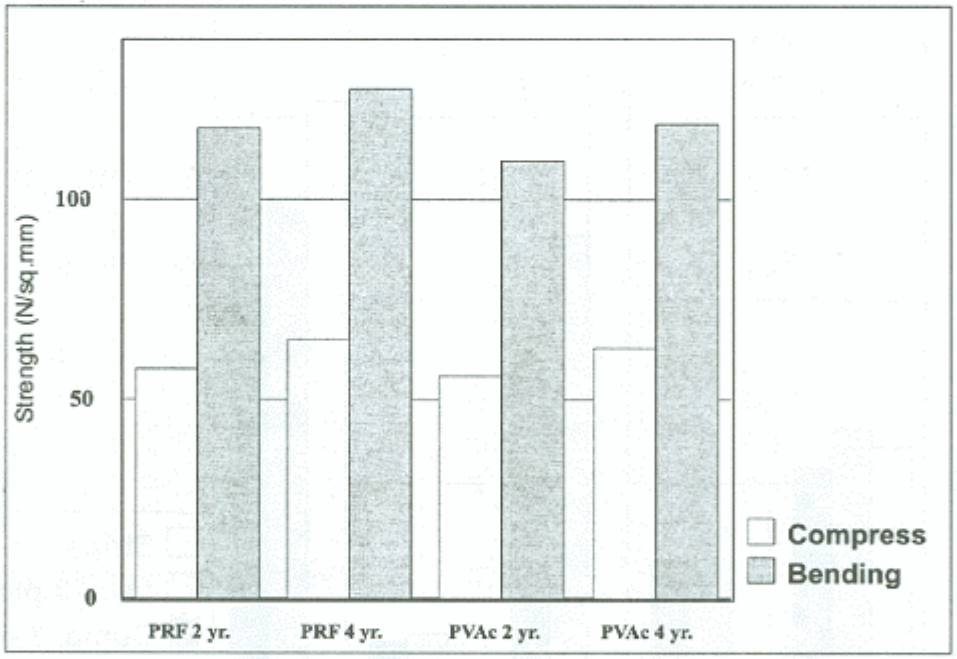
Figure 3. Comparative mechanical properties between bamboo strips, laminated 3-ply and composite 3-ply of 4 years old culms.

Laminated bamboo possesses excellent mechanical properties especially with regards to tensile strength. Sekhar & Bhartari (1960) also made similar finding in his studies on the

strength properties of bamboo. Tensile strength and compressive strength of laminated bamboo in the longitudinal direction were also found to be higher than those of wood. However, it has low parallel to grain shear strength and low resistance to splitting compared to wood (Janssen, 1980). Therefore, this property has been advantageously utilized in splitting the bamboo into strips for laminated boards.

Laminated bamboo-ply boards with higher ply layers have greater strength value compared to the boards of lesser ply layers (Table 3 and Figure 3). This property can be of advantage when used in making construction and building materials when strength is the most crucial factor.

In dimensional stability aspects, the change of moisture content was significantly less than compare to most common tropical hardwoods (Anon, 1999). This makes bamboo laminated boards most suitable for used as flooring and paneling materials.



Legend: *PRF* = *Phenol Resorcinol Formaldehyde, PVAc=Polyvinyl Acetate,*
Compress = *Compression test, Bending=Bending test*

Figure 4. Strength of laminated bamboo 3-ply with PRF and PVAc

Studies on the strength properties of laminated bamboo boards applied with different types of glue indicated that the PRF treated samples possess slightly higher values in the compression and bending strength when compared to the PVAc (Table 2 and Figure 4).

CONCLUSIONS

Laminated bamboo-ply boards possess higher strength properties and usage, as well as having better dimensional stability than bamboo composite boards and some solid wood. These boards are expected to be more important in the future furniture and construction industry. They have high strength properties in term of MOR and MOE values. However, composite bamboo that has strength of slightly lower can also be used as substitute to laminated bamboo in order to cut cost especially in panel products.

PVAc adhesive with moisture resistance, proof to be slightly better than the PRF. This type of glue would be recommended for used by the bamboo-based industry as they are cheaper to the PRF and are more available commercially in the local market.

With the sourcing of wood from natural forest is becoming increasingly scarce, the used of laminated bamboo and composite boards for future substitute to the wood industry is expected to receive good respond by the public. The potential of bamboo, particularly in laminated form, to replace wood is being increasingly acknowledged. Hence, it is important to address the issues mentioned earlier to fully exploit the versatility of bamboo not only in furniture but also in construction and other major applications.

Some technologies of the manufacturing laminated bamboo boards have been generated during the duration of these studies. However, despite these accomplishment, further R & D still needs to be undertaken to improve processing techniques especially in systematically turning bamboo to laminated boards and furniture at industrial scale.

REFERENCES

Anonymous. 1999. Bamboo panel boards a state of the art review. International Network for Bamboo and Rattan.

Anonymous. 1974. Annual book of ASTM standard: D 143-52

Anonymous. 1957 *Standard Method for Testing Small Clear Specimen of Timber. British Standard 373, 1957.* British Standard Institution, London. 71.

Janssen, J.J.A. 1980. The mechanical properties of bamboo used in construction. In: Bamboo Research in Asia, *Proceedings of a workshop held in Singapore 28-30 May, 1980*, pp 173-188; (Ed) G.Lessard and A.Chouinard, IDRC, Ottawa, Canada.

Razak, W., Hashim, W.S., Tarmeze, W.A. & Tarmizi, M. 2000. Bamboo lamination as an alternative to wood. *National Seminar on Alternatives to Rubberwood. FRIM*, Kuala Lumpur.

Razak, W., Hashim, W.S., Tarmeze, W.A. & Tarmizi, M. 1997. *Industri pembuatan pepapan laminasi buluh. FRIM* Technical Information Handbook No. 11.

Razak, W. 1998. *Effect of selected preservatives on the durability of Gigantochloa scortechinii.* A Ph.D. dissertation, University of London (Unpublished).

Sekhar, A.C & Bhartari, R.K. 1960. Studies on strength properties of bamboo; a note on its mechanical behavior, Indian For. 86: 296 – 301.

Zoolagud, S.S & Rangaraju. 1991. An improved and economical process for manufacture of bamboo mat board. *Proceeding 4th International Bamboo Workshop "Bamboo in the Asia Pacific".*