A study on the physical properties of a bamboo moulding compared with wood and MDF mouldings

Wang Zheng Ren Yiping
(Research Institute of wood Industry, CAF, Beijing China)

Abstract: Recently, glue-laminated bamboo normally used for flooring and panelling has been made into mouldings. The physical properties of such a bamboo moulding were studied, and the properties of it have been compared with other four kinds of mouldings, one MDF moulding and three solid wood mouldings. The bamboo moulding has excellent surface hardness and anti-nicking property, but its density is quite high, which may influence its utilization. The research has also shown that the bamboo moulding has a lower volume shrink coefficient, and good dimensional stability.

Key words: Bamboo, Wood, Medium density fibreboard, Moulding, Physical property, Comparison.

Introduction

Mouldings have become important component of forest products in world trade and production.

World imports of "shaped wood" (Custom's Code 4409 in the Harmonised System) which includes mouldings were $2.6 billion in 1999 having increased from $2 billion in 1994. The United States of America is the largest importer taking 32% of world imports. (Source : UN-COMTRADE data 2001). Although most trade is regional, Asia provides a substantial percentage of the imports into USA, Italy and the UK. Softwood mouldings constitute nearly 15% of Chile's wood exports. The U.S. imported $122.0 million in softwood mouldings and builder's carpentry in 1997, and $140 million of these products in 1998. Chilean softwood moulding imports into the USA have surged from $6.6 million in 1992 to $99.1 million in 1997.

Mouldings are used in buildings to trim around and smarten plaster edges and door and window fittings (Figure 1) . Mouldings (Figure 2) are profiled lengths of wood or fibreboard varying in width from 25 to 75 mm and in thickness from 7 – 25 mm (depending on the precise application). The wood used for mouldings is usually clear of knots because knots lead to unsightly changes in profile and problems with sanding and painting. Hardwood is preferable because mouldings receive many knocks and abrasions in use. Suitable material for mouldings has become scarce recently and both softwood and medium density fibreboard have been used instead of hardwood.

Recently mouldings have been made from glue-laminated bamboo in China and are now routinely sold into the European mouldings market.

The objective of this study was to measure the physical properties of bamboo mouldings and to make a comparison with mouldings from MDF and solid woods.

Figure 1: Mouldings in use.

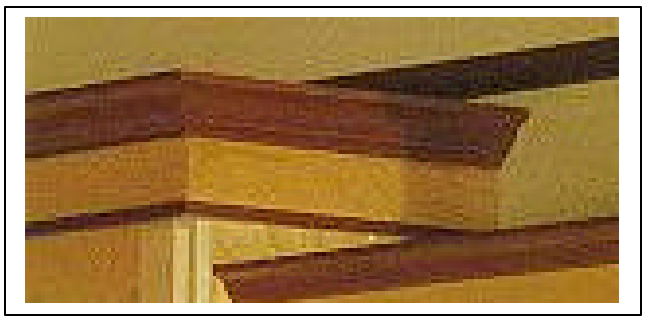

Figure 2: Typical Mouldings

Materials and Experimental methods

1. Materials

Glue-laminated bamboo moulding sample was supplied by a Chinese manufacturer. Four samples of mouldings available "over-the-counter" in Europe were purchased from a Dutch DIY chain.

The five kinds of mouldings assessed in this study are shown in table 1 and fig. 3.

Table 1. The material and number of the mouldings*

Specimen No.	Materials	Species	Dimensions (width by thickness)
1#	Medium Density Fibreboard with paper, wood-effect, veneer	/	60mm by 10mm
2#	Solid wood with red color: Red Hardwood	Cloth alarm (vitex sp. verbenaceae)	45mm by 8mm
3#	Solid wood with white color: Coniferous softwood	Hard pines (pinus sp. Pinaceae)	53mm by 8mm
4#	Solid wood with white color: Coniferous softwood containing small knots	Spruce (picea sp. Pinaceae)	55mm by 12mm
5#	Glue-laminated Bamboo	P. heterocycla var. pubescens (Mazel) Ohwi	93mm by15mm

Photo see Fig.3

Fig. 3 the moulding samples studied in the paper

2. Experimental methods

Four properties of the samples, relevant to the performance-in-service of the mouldings, have been determined in the paper. They are moisture content, density, surface nick, and surface hardness. The standards used to judge the samples are as follows:
GB 1931-91 for the moisture content determination of the samples;
GB 1933-91 for density measurement of samples;
GB/T 15102-94 for surface nick determination of the samples;
JIS Z2117 for surface hardness measurement of samples.

Experimental results and discussions

1. Moisture content

There are five test specimens determined in the paper. They are one kind of bamboo moulding

($5^{\#}$), three kinds of wood moulding ($2^{\#}$,$3^{\#}$,$4^{\#}$) and one decorated moulding of medium density fiberboard ($1^{\#}$).

The test result of the 5 samples is shown in table 2.

Table 2 Result of moisture content of specimens

Sample	Testing No.	Weight after drying (g)	Weight before drying (g)	Moisture content (%)	Average value of the MC (%)
$1^{\#}$	1	2.742	2.864	4.45	4.44
	2	2.782	2.905	4.42	
	3	2.817	2.942	4.44	
$2^{\#}$	1	1.903	2.088	9.72	9.47
	2	2.091	2.286	7.32	
	3	2.090	2.286	9.38	
$3^{\#}$	1	1.546	1.645	6.4	6.44
	2	1.581	1.684	6.51	
	3	1.514	1.611	6.41	
$4^{\#}$	1	1.789	1.906	6.54	6.51
	2	1.630	1.725	6.48	
	3	1.655	1.763	6.52	
$5^{\#}$	1	3.314	3.472	4.77	4.76
	2	3.634	3.808	4.79	
	3	3.211	3.373	4.72	

The results of the table 2 show that the solid wood mouldings (2#, 3# and 4#) have higher moisture contents (MC) but the MDF and bamboo mouldings have lower MC. This might be important for dimensional stability in use.

2. Densities and volume shrink coefficient

Test specimens determined here are the same as above . Three kinds of data have been obtained in the experiment: density at the W% moisture content; coefficient of shrink volume and the density of an absolutely dried sample.

The density of specimens whose moisture content is at W% is calculated as follows:

$$\tilde{n}_{W=}\frac{m_W}{V_W} \quad \text{.....(1)}$$

Where:
P_w=density of specimens which moisture content is W%. g/cm$^{3.}$
M_w=quality of specimens which moisture content is W%. g.
V_w=volume of specimens which moisture content is W%. cm$^{3.}$.
Round calculated density of specimens which moisture content is W% to the nearest 0.01 g/cm^3.

The coefficient of shrink volume of specimens can then be calculated as follow:

$$K=\frac{v_w-v_0}{v_0 w}\times 100 \quad \text{.....(2)}$$

Where :
K=coefficient of shrink volume of specimens.%.
V_0=volume of absolute dry specimens. cm^3.
W=moisture content of test specimens.%.
Rounded result to nearest 0.001%.

The density of specimens dried absolutely can be calculated as follow:

$$P_0 = \frac{m_0}{v_0} \text{ ……..(3)}$$

Where:

P_0=density of specimens dried absolutely. g/cm^3.

m_0=quality of specimens dried absolutely. g.

v_0=volume of specimens dried absolutely. cm^3.

Test data and results have shown in the table 3.

Table 3. The densities and volume shrink coefficient of the mouldings

Sample	Testing No.	V_w	G_w	P_w	P_w'	W%	W'%	V_0	G_0	P_0	P_0'	K	K'
1#	1	3.92	2.864	0.730	0.738	4.45	4.44	3.84	2.742	0.715	0.725	0.516	0.582
	2	3.92	2.905	0.740		4.42		3.82	2.782	0.727		0.591	
	3	3.95	2.942	0.745		4.44		3.84	2.817	0.733		0.639	
2#	1	3.29	2.088	0.635	0.666	9.72	9.47	3.14	1.903	0.605	0.636	0.481	0.480
	2	3.37	2.286	0.679		9.32		3.21	2.091	0.652		0.535	
	3	3.34	2.286	0.684		9.38		3.21	2.090	0.650		0.425	
3#	1	3.46	1.645	.0.475	0.477	6.40	6.44	3.33	1.546	0.464	0.463	0.60	0.571
	2	3.46	1.684	0.486		6.51		3.39	1.581	0.466		0.490	
	3	3.43	1.611	0.469		6.41		3.30	1.514	0.459		0.624	
4#	1	4.98	1.906	0.382	0.363	6.54	6.51	4.85	1.789	0.369	0.351	0.438	0.463
	2	4.87	1.725	0.354		6.48		4.75	1.620	0.341		0.419	
	3	4.98	1.763	0.354		6.52		4.82	1.655	0.344		0.532	
5#	1	4.33	3.472	0.802	0.799	4.77	4.76	4.20	3.314	0.788	0.782	0.638	0.538
	2	4.82	3.808	0.789		4.79		4.73	3.634	0.768		0.419	
	3	4.18	3.373	0.806		4.72		4.08	3.221	0.790		0.556	

.The P_w and P_w' are the density and average density of the samples with w% MC respectively.

.The P_0 and P_0' are the density and average density of the samples at the absolutely drying condition.

. The K and K' are the coefficient and average coefficient of shrink volume of specimens respectively.

The results of table 3 show that the bamboo moulding has the highest densities comparing with other four products and the solid wood mouldings have the lowest densities. Within the three solid wood mouldings, the 2#moulding (the hardwood) has the highest density and the secondary is 3#, the 4#moulding has the lowest densities at the absolute drying condition and the balance moisture content. From the table 3, it can be seen that the volume shrink coefficient of the bamboo moulding is lower than that of MDF moulding and 3# solid wood moulding, which shows that the bamboo moulding has the better dimension stability.

3. Surface nick property of specimens

The surface nick test measures the ability of the samples to resist minor abrasions such as might be inflicted during use by contact from appliances and furniture. The specific test measures the ability to resist marking from the force by a moving diamond edge. The capability of the surface to resist scoring by standing nick is assessed over increasing weights of contact.

The results have shown in table 4.

Tab4. Result of capability of surface standing scored.

Sample	Weight position (N)					
	0.3	0.5	1.0	1.5	2.0	2.5
1#	0	0	+	+	++	
2#		+	++	+++	+++	
3#		+	++	+++	++++	
4#	+	+	++	+++	++++	
5#		0	0	+	+	++

Explanation: '0' means no nick. '+' means making nick. The more of the '+' mark, the more obvious of nick.

From table 4, we can see that the order of capability of specimens surface standing scored as follow : 5# 1# 2# 3# 4#, showing that the bamboo moulding has the most strength of surface anti-nicking. This means that in use it would not show scratches or marks easily.

4. Surface hardness of specimens

Surface hardness measures the ability of the moulding to resist denting such as might occur in service from a hard contact from a piece of furniture or an appliance. The surface hardness of the specimens was determined by the follow process:

A steel ball is pressed into the surface of specimen to a fixed depth. The force can be recorded by a mechanics instrument. The intensity of pressure by the steel ball is related to the surface hardness of the specimen.

Hardness value of surface of specimens can be calculated as follows:

$$H_B = \frac{P}{\pi Dh} = \frac{p}{10} \quad \text{.....(4)}$$

where:
H_B=hardness value of surface of specimens. N mm^2.
P=force of max distance. N.
D=diameter of steel ball. mm.
h=Regulated depth of steel ball press in the surface of specimens. mm.

The results of five sample surface hardness is shown in the table 5.

Table 5. Data of measurement of hardness value and calculate result

Samples	Force of max distance for each time (N)						Average value (N)	Average value for sample (N)	Hardness of surface (N/mm^2)
1#-1			61.5	76.7	80	64.0	70.6	83.0	8.3
1#-2	112.0	98.0		110.5	113.5	117.7	110.3		
1#-3			54.0	64.0	71.5	83.0	68.1		
2#-1	62.0	84.2	68.7	71.5	82.5	75.5	74.1	87.2	8.72
2#-2	78.5	79.5	64.2	66.0	77.2	77.5	73.8		
2#-3	100	132.0	94.0	116.7	133.5	105.5	113.6		
3#-1	67.7	46.7	74.7	79.0	77.2	72.7	69.7	56.0	5.60
3#-2	33.5	48.0	41.0	40.0	76.5	66.5	50.9		
3#-3	34.5	34.7	44.7	53.0	67.7	51.2	47.5		
4#-1	41.0	51.2	49.0	24.7	30.0	43.5	39.9	37.7	3.77
4#-2	43.2	34.7	27.5	40.0	37.5	36.7	36.6		
4#-3	34.7	33.2	36.2	41.2	37.7	36.5	36.6		
5#-1	164.7	148.0	184.5	196.0	167.5	183.0	174.0	227.9	22.79
5#-2	315.2	233.7	262.5	274.5	178.2	217.0	246.8		
5#-3	331.0	219.5	221.2	337.0	241.7	227.2	262.9		

From the table 5, it can be seen that the bamboo moulding has by far the greatest surface hardness than that other four kinds of mouldings. The index of the hardness reaches 22.79 N/mm2, nearly 3 to 6 times of that of other four mouldings.

Conclusions

Comparing with other four mouldings, the bamboo moulding has the excellent surface hardness and surface anti-nicking properties, but its density is quite high, which may influence its utilization. The research result has also shown that the bamboo moulding has lower volume shrink coefficient, and good dimension stability. Among the other four mouldings, the MDF moulding has the highest density and surface anti-nicking properties, but its surface hardness is lower than that of 2# solid wood moulding. The three kinds of solid wood mouldings have quite low surface anti-nicking properties.

Acknowledgement

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References

1. GB 1931-91 Test Method for measurement of wood moisture content.
2. GB 1933-91 Test Method for measurement of density of wood.
3. GB/T 15102-94 Surface decorated wood-based panels with paper impregnated thermosetting resins
4. JIS Z2117 Test Method for measurement of hardness of wood.