Proceedings of the 3rd WSEAS/IASME International Conference on ENGINEERING EDUCATION, Vouliagmeni, Greece, July 11-13, 2006 (pp180-184)

The Innovative Development of Bamboo Furniture in Thailand

V. LAEMLAKSAKUL[1], S. KAEWKUEKOOL[2]
[1]Department of Industrial Engineering Technology, King Mongkut's Institute of Technology North Bangkok, 1518 Pibulsongkram Rd. Bangsue, Bangkok 10800, THAILAND
http://www.kmitnb.ac.th
[2]Department of Production Technology Education, King Mongkut's University of Technology Thonburi, 126 Pracautit Rd. Bangmod Thongku, Bangkok 10140, THAILAND
http://www.kmutt.ac.th

Abstract: - The development of wood substitute is essential to resolve the shortage of wood resource and consequently increase environmental protection and conservation. The aim of this research was to assess the feasibility study of producing a laminates from Pai Tong *(Dendrocalamus asper* Backer*)* bonded with urea formaldehyde resin. The approach was to compare the mechanical properties of bamboo according to British Standards for Testing Small Clear Specimens of Timber (BS373:1957). The strength properties of bamboo wood are comparable to those of teak wood (*Tectona grandis*). The laminated bamboo has higher modulus of rupture (MOR), modulus of elasticity (MOE) and crushing strength than teak. In addition, laminated bamboo armchair was designed and fabricated, to indicate the suitability of material for wood furniture.

Key-Words: - Pai Tong (*Dendrocalamus asper* Backer), laminated, mechanical properties, armchair

1 Introduction

Rapid depletion of natural forests such as in Thailand occurred during the last 40 years. To preserve the forest areas, Thai government has banned logging in natural forest since 1989 [1]. Due to the reduction of wood resources and increasing of the restriction of wood harvest, the development of wood substitute is essential to resolve the shortage of wood resources in many countries. Bamboos are recently rediscovered as a potential source of wood substitutes owning to its properties of excellent strength, easy processing and rapidly growing than other common trees.

Bamboos possess several types of advantages including rapid growth rate, low cost and offering friendly environment. The plants are botanically considered as a special group in grass family which can be planted easily into any kind of land. They are also excellent for rejuvenating degraded areas and typically could grow much faster than other common trees as their daily growth rate is merely 80–300 mm [2]. Unlike other trees, bamboos can attain a maximum growth in one year and they take only 4-6 years to grow to maturity. Furthermore, they can be applied for several purposes including food, handicrafts, and musical instruments [3]. From the past decade, the use of bamboo accommodated to modern factory-based such as production of paper, bamboo blinds and barbeque skewers. In rural area, the use of bamboo is based on traditional or cultural practice than technical knowledge.

Most of bamboo researches focused on ecological aspects and a management of bamboo forests despite of the fact that the technology for developing useful material from bamboos such as laminated bamboo is equally importance [3]. Laminated bamboo, a wood substitute product made from bamboo strip, became available in Europe and America but for flooring material. However, laminated bamboo perhaps can also be used in many other applications including for furniture manufacturing. Bamboo is not commonly used in modern furniture production due to its round shape and a concern of poor moth resistant.

Upon the literature survey, one finds that moth in bamboo can be killed by heating with superheat steam at 100 to 250°c [4]. Due to high bamboo availability, laminating of bamboo strips to timber-like would be a sustainable solution for wood resource problem and a development of laminate product would enhance the value of bamboos. Therefore, the objectives of this research are to study the feasibility of the production of laminated bamboo for furniture manufacturing. In this study, mature *Dendrocalamus asper* Backer bamboos from Prachin Buri was used. A laminated bamboo production was developed and the mechanical properties of this composite were investigated in terms of bending and compression after impact. The experiment results show that laminated bamboo has high flexural strength and outstanding toughness which is comparable to the strength of teak wood.

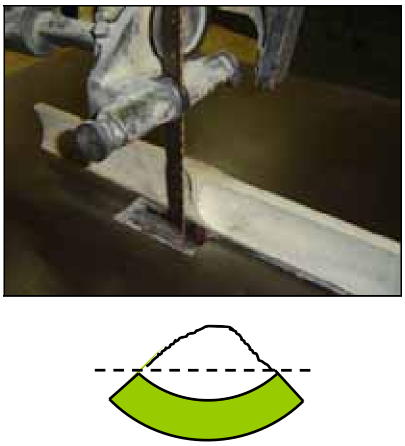
2 Materials and Method

All the growth in bamboo occurs longitudinally and there is no lateral or radial growth as in trees. Characteristically, bamboo has a hollow stem or culm (solid in some species only) which is closed at frequent intervals call nodes. Bamboo culm comprises about 50% parenchyma, 40% fibres and 10% vessels and sieve tubes [5].

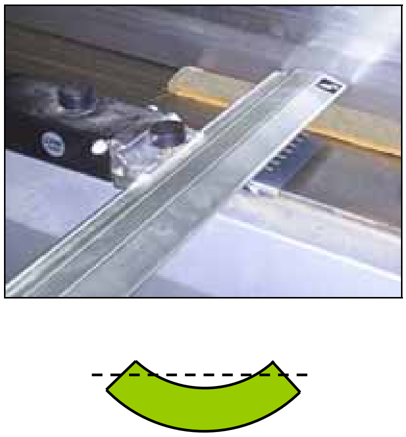
2.1 Preparation of Material

Bamboos were cut at least one meter above the ground to remove hard solid stem. The first few meters at the bottom of the culm were in general stronger than that at the top. A selected bamboo culms has approximate 120 mm outer diameter and wall thickness 12 mm. Round bamboos were spited with parallel grain into strips as seen in Fig.1. To obtain uniform rectangular shape, strips were sawn by band saw to remove the surface nodes (Fig.2a), then the inner side thickness with a jointer were planed (Fig.2b), then trimmed to predetermined width by circular saw (Fig.2c) and the upper and the lower curvature were then removed by planner (Fig.2d). The strips were preventing from insect by using boron compound.

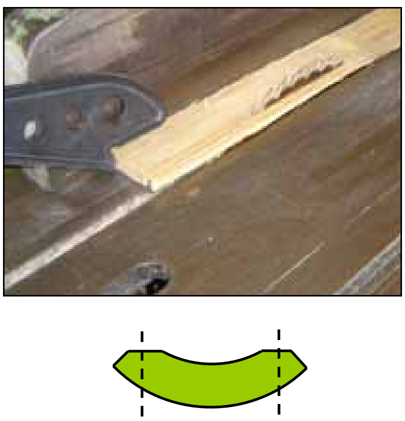
Fig.1 Bamboo splitting



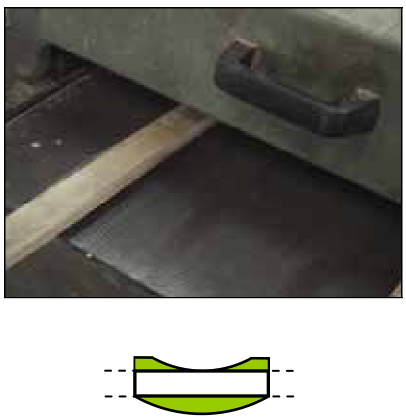
(a)



(b)



(c)



(d)

Fig. 2 Strips bamboo preparation

Bamboo strips were dried to low moisture content (12%) as part of the manufacturing process. Drying of bamboos used for laminated bamboo is essential for effective bonding using urea formaldehyde adhesives.

2.2 Testing of Laminated Bamboo

As statistical analysis, mechanical properties of thirty two laminated bamboos were determined. The modulus of rupture (MOR), modulus of elasticity (MOE) and compression strength were tested according to British Standards for Testing Small Clear Specimens of Timber (BS373:1957) using Universal Testing Machine, LLOYD Instruments 6000S [6]. Teak (*Tectona grandis*) is known as a standard species for the evaluation of timber suitability therefore the properties of teak were used for comparison to laminated bamboo in this study.

2.3 Engineering Design

The basic design of armchair was created by revolution in bamboo armchair shown in Fig.3. As shown in Fig.4, to begin the proposed processes starts with drawing of chair. The computer model is constructed from the drawing by used human factor. It basically has the following elements: seat, back, legs and armrests. Figure 5 shows the forms of the seat feature, back feature, leg feature and armchair feature. Figure 6 shows the solid model of the final result of 3-D model constructed from the drawing.

Fig. 3 Bamboo armchair

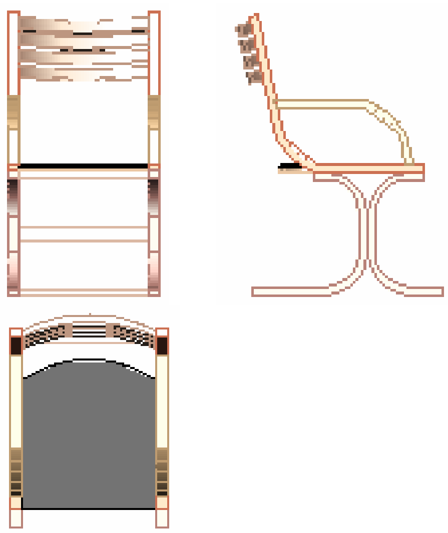


Fig. 4 3 Views drawing

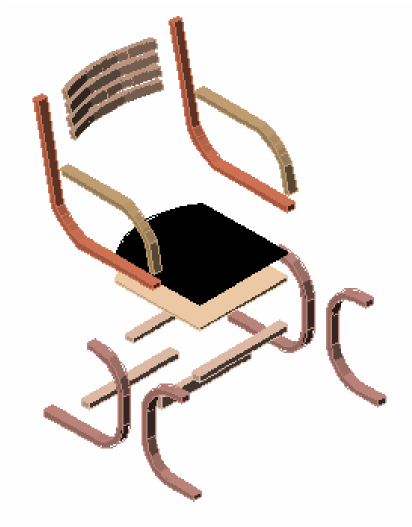


Fig. 5 Assembled parts

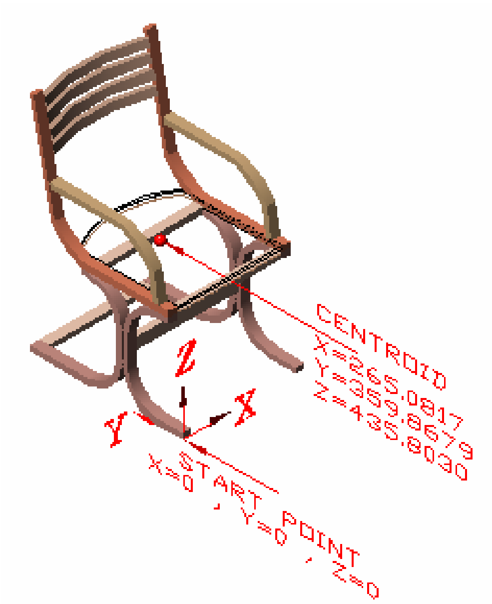


Fig. 6 3D Model construction

3 Results and Discussion

The conversion of bamboo into strips is average potential output to 34.3%. Although the utilizable portion of bamboo for producing laminates is low, it offers good potential for processing bamboo into a wood substitute material. The remaining portion from the process could be used for particle board production or as fuel.

3.1 Engineering Properties

The mechanical properties of laminates, as well as the relevant values for teak wood, were shown in table 1. It is clear that the properties of laminated bamboos are comparable to those of teak wood by determining wood strength and stiffness in a standard static bending at 12% moisture content. In this research, the MOR and MOE of laminated bamboo are higher than teak. There for, it could be used as a substitute for solid wood in flooring and furniture production.

3.2 Laminated Bamboo Armchair

Laminated bamboo furniture could be designed into modern and ergonomic shapes. Curved units of a chair (Fig.7) are formed by placing coated strips in shaping moulds and allowing them to set confirming a huge variety of shapes. This could be formed for the component parts, and a wide range of furniture product.

Table 1. Properties of Laminated Bamboo

Mechanical Properties	Teak* (Tectona Grandis)		Laminated Bamboo	
	Average (Mpa)	Standard Deviation (Mpa)	Average (Mpa)	Standard Deviation (Mpa)
- Modulus of Rupture (MOR)	98	13	133.4	11.9
- Modulus of Elasticity (MOE)	13,740	2,749	14,085.5	2,503
- Crushing Strength	56	6	59.1	5.6

*From CIRAD forestry department (at 12% moisture content: 1 Mpa = 1 N/mm^2)

Fig. 7 Laminated Bamboo Armchair

4 Conclusion

Laminated bamboo made from *Dendrocalamus asper* Backer bamboo has higher MOR, MOE and crushing strength values than teak. Due to excellent mechanical properties and high availability, laminated bamboo is suitable to use as wood substitute in Thailand.

Bamboo can be easily processed with adhesive to form desirable sizes and shapes to meet the specific needs of design professionals. Laminated bamboos have low shrinkage and expansion properties when the moisture content changes. This is due to the strong adhesive bonding between each bamboo strips and its relatively low moisture content. Laminated bamboo has higher MOR and MOE than those teak woods. Unique look furniture made from laminated bamboos is lighter but stronger than that made from round bamboo culms. Laminated bamboos improve the product value and utilization of natural bamboo. The development of laminated bamboo furniture would create employment opportunities for people in rural areas.

Based on this study, it was found that the excessive amounts of solid waste are generated and solid part of bamboo culms cause a malfunction of cawing equipment. Further research and development of production technology is needed to resolve process operation difficulties and to maximize yield. Better understanding of bamboo could lead to an improvement of this unique wood for commercial manufacturing in the future. The use of laminated bamboo reduces dependence of solid wood resources and increases environmental protection and conservation.

Acknowledgement: -
The researcher would like to express thanks to Commission on Higher Education, Thailand for funding this research.

References: -

[1] Pattanavibool R. Bamboo research and development in Thailand. Royal Forest Department. Bangkok; 2000.

[2] Li Z, Liu C, Yu T. Laminate of Reformed Bamboo and Extruded Fiber-Reinforced Cementitious Plate. *J. of Mat. in Civil Engineering* 2002 Sep/Oct:360-365.

[3] Wong KM. The Amazing Grass. International Plant Genetic Resource Institute (IPGRI) University of Malaya; 2004.

[4] Raj V. Treatise on utilization of bamboo as reinforcement in ferrocement. *J. of Ferrocement* 1991; 21(4):371-382.

[5] Liese W. Research on Bamboo. *Wood Science & Technology* 1987; 21:189-209.

[6] BS 373:1957. Methods of testing small clear specimens of timber. British Standards Institution. London; 1957.