

EVALUATION OF BAMBOO AS FURNITURE MATERIAL AND ITS FURNITURE DESIGNS

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Abstract:

Bamboo is a rapid growing grass with an impressive variability. The chemical composition and mechanical properties of the bamboo culm allow a broad use such as construction material. Bamboo is an excellent source for furniture production too. Bamboo has some positive features like mechanical strength, easy processability and availability in many tropical and subtropical areas which confer it attributes to become a renewable material as substitute of wood. Many wood processing companies have recently come to prefer bamboos for sustainable building material and furniture design with the growing trends in environment awareness. Bamboo furniture has been called as a green or eco-friendly material for furniture since the natural resources are being depleted. It can be used both in building structure, interior design and furniture structures to make long-lasting and competitive products due of its many advantages.

Key words: building; furniture; bamboo; design; environment.

INTRODUCTION

The best ways of the green technology realization are to improve the production process, to minimize the ecological damage, balance the manufacturing technology costs, and reduce raw material consumption, health risk etc. (Guo *et al.* 2012). The environmental effect is important for furniture products including green or ecological products. In recent days, main efforts have been focused on the research of different environmental properties of wood based panels such as particleboard (PB), medium density fiberboard (MDF), plywood (PY) including various undesired emission factors or volatile organic compounds (VOC) (Brockmann *et al.* 1998, Anex *et al.* 1998, Bovea and Vidal 2004).

The furniture industry, which is a large sector of the wood processing, serves to all parts of human life providing the main necessities of people for living (Döngel *et al.* 2009). It is known that the improvement of design depends on the new trends of furniture production. New materials for this industry have to meet the requirements of manufacturers and customers (Petutschnigg and Ebner 2007). Regarding to Green Public Procurement (GPP), many furniture manufacturers realize the aware of their responsibility to make environmentally furniture (EU 2004, Maxwell and Van der Vorst 2003). The essential principles for development of green products include increasing the utilization ratio of resource, choosing less low pollution and energy consumption, and using environmentally raw materials which are easy for manufacturing. Regarding the principles of green or eco friendly products, bamboo for the furniture industry could be an ideal raw material. It ensures that the carbon stays locked in for a long time; in addition bamboo plants are a major non-wood forest product and play an important economic and cultural role since centuries. Bamboo based products are used as housing, panels, for flooring and roofing, as veneer, fabrics, for pulp and paper, oil, gas and charcoal (as burning will release the stored carbon back to environment) (Janssen 2000, FAO 2005, Malanit *et al.* 2009, Malanit *et al.* 2010).

The bamboo is extremely renewable material compared to other hardwood species which are growing at least 50 years. Bamboo grows quickly (6 months to 2 years) to its mature height and can be harvest after 3 to 5 years. Bamboo which is the fastest growing woody plant and counts over 1,200 species does not need to be replanted after each harvest because it can be harvested from the same stand every few years without harming the plant. It may not reach the height and volume of the trees, but they are fast growing, the culms are made by hard walls and stand tall in extreme weather. Bamboo plants, grow from seeds or rhizomes, are a major non-wood forest product (40 million ha) and play an important economic and cultural role in South-East Asia, Africa and South America. The bamboo selection of raw materials in furniture industry is ideal to ensure an easy recyclability too. The different designs of bamboo furniture can be developed for structural and decorative purposes. Because the bamboo can also be used for natural and modern-themed settings, it is possible to be curved into different 3D shapes and it is remarkable for use in building structures and furniture industry (Malanit *et al.* 2008, Janssen 2000, FAO 2005, Gyansah 2012, Pebble 2013).

Table 1.

Some mechanical properties for different bamboo species (Naik 2003, Malanit *et al.* 2008)

Species	Density (g/cm ³)	Tensile strength (MPa)	Compressive strength (MPa)	Shear strength (MPa)	Bending strength (MPa)	Bending elasticity modulus (MPa)
<i>Bambusa tulda</i>	0.91	207	79	9.9	194	18611
<i>Bambusa balcooa</i>	0.82	164	69	11.9	151	13603
<i>Bambusa bambos/ Bambusa arundinaceae</i>	0.71	121	61	9.9	143	14116
<i>Bambusa nutans</i>	0.89	208	75	10.5	216	20890
<i>Dendrocalamus giganteus</i>	0.74	177	70	10.6	193	16373
<i>Gigantichloa macrostachya</i>	0.96	168	71	9.6	174	14226
<i>Melocanna bambosoides</i>	0.72	210	81	7.1	137	16425
<i>Phyllostachys bambusoides</i>	0.73	140	63	8.7	127	10982

The bamboo can also be used in building materials. It is necessary to spend 50 times more energy for steel than for bamboo. In addition, the tensile strength of bamboo can reach 370MPa. It can be used in building structure because the ratio of tensile strength to specific weight of bamboo is six times higher than that of steel

(Bahrom 2009). Some mechanical properties for different bamboo species are presented in Table 1. It is shown that there is significant variability in mechanical properties from species to species but also inside of the same species and culm (Naik 2003, Malanit *et al.* 2008).

Bamboo provides more different look and advantages than the other furniture kinds. The main objective of this paper is to advise to use bamboo as a resource in furniture manufacturing based on renewable natural resources from forests with the growing trends in environmental.

Bamboo availability in world

In recent years the requirements of different alternative products for furniture design increase by the growing world population and improving living standards. Bamboo, commonly found in the tropical and subtropical areas, is especially the most important and valuable as non-wood forest product in India and China. The rate of world bamboo resources by continent is presented in Fig. 1. Asia has the richest continent with about 65% of total world bamboo resources.

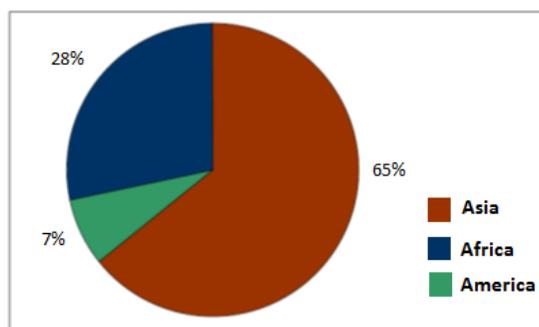


Fig. 1

Contribution of world bamboo resources by continent
(<ftp://ftp.fao.org/docrep/fao/010/a1243e/a1243e03.pdf>).

Table 2 shows the distribution of the bamboo resources in Asia (India, China, Japan, Indonesia etc.), Africa (Ethiopia, Kenya, Nigeria, Uganda, the United Republic of Tanzania, Zimbabwe etc.), and Latin America (Brazil, Chile, Colombia, Ecuador, Mexico etc.). The lack of bamboo resources is due to the current low economic value of bamboo in Latin America while many people in Africa use it as a weed plant (Lobovikov *et al.* 2007, Eurostat 2011).

Table 2.

Extent of bamboo forest in Asia, Africa and Latin America (Lobovikov *et al.* 2007, Eurostat 2011)

	Area of bamboo (1000 ha)			Forest area (million ha)	% of total forest area
	1990	2000	2005	2010	
Asia	21 230	22 499	23 620	581	15
Africa	2 758	2 758	2 758	674	17
Latin America	-	10 399	10 399	864	21

Table 3.

The list of bamboo furniture exporters and importers all over the world (1000 \$) (Saraç, 2009)

	2004	2005	2006	Percentage of Country 2006 (%)
Exporters	435.389	398.061	386.668	Indonesia (49) Vietnam (10) Italy (8)
Importers	453.071	454.179	424.127	USA (27) Germany (14) France (6)

A major issue after harvesting is the preservation of bamboo culms, which deteriorate easy and quick due to the amount of sugars and climate conditions. It is difficult to store wet bamboo for a longer time. China seems to lead the industrial bamboo processing especially for panels and flooring and replace about 10 million m³ with it. Over 300 companies processing flooring generate a turn over 1 billion USD in this country. The 1st OSB factory from bamboo started operation last year (Guanping 2011).

The list of bamboo furniture exporters and importers all over the world is given in Table 3. It is indicated that Indonesia is the biggest bamboo furniture exporter with a 387 million USD while USA is the biggest bamboo furniture importer with a 424 million USD in 2006 (Saraç 2009).

Furniture made of bamboo

The benefits of using bamboo for furniture

Bamboo is an excellent material for indoor and outdoor furniture's with its lightweight structure, superior mechanical properties and naturally resistance against biological attacks (Solomon-Ayeh 2002, Chele *et al.* 2012). It is easy to produce different bamboo furniture designs because it is a versatile material, easy to shape and process with simple equipment. The knowledge of a proper processing of bamboo is still not well distributed over the world. Green bamboo processing is quite different than in dry state (Hidalgo 2003, Zehui 2007). The furniture obtained from bamboo has a different look and aesthetic value (Chele *et al.* 2012).

Bamboo can also be used to produce a wide range of laminated furniture such as tables, desks, chairs, cabinets etc. (Cross-) laminated bamboo furniture is new type of furniture as the same laminated wood furniture. It is found that the mechanical properties of bamboo veneers, stripes, strands, particles and fibers are comparable and sometimes better to those generated from wood (Hidalgo 2003, Zehui 2007, Malanit *et al.* 2010). The tensile strength of bamboo is higher than teak or walnut and twice as stable as oak.

The obvious economic and environmental advantages of bamboo follow as: it grows quick as a straight reinforced segmented culm, after drying it is resistant to swelling or shrinkage due to climate changes, it is extremely durable and resistant after some treatments for preservation, it has a very fine grain, allowing it to come in different styles. Bamboo which is an excellent material for eco-friendly furniture products has drawn as a green building material. It decreases the atmospheric concentration of carbon dioxide which is the main reason of global warming (Yiping *et al.* 2010).

Some bamboo designs products

Bamboo is usually used as office, home, garden furniture, interior design, decorative purposes etc. It is often combined with other various environmentally friendly materials to obtain the piece of furniture. These materials which are recyclable, natural, and biodegradable materials enable to generate strong building material and furniture parts for a large office or a small home. Glass, plastics, fabric, and other materials are also combined to produce bamboo furniture (<http://www.green-furniture.com/bamboofficefurniture.html>). The bamboo furniture includes beds, chest of drawers, workstations, desks, tables, stools, rockers, chairs, couches, kitchen cabinets, and bathroom cabinets etc. The various bamboo furniture designs samples are shown in Fig. 2-12. Fig. 2 shows an award winning furniture piece produced by Philip Sell. He won this award as best-in-show at the Texas furniture maker's show.



Fig. 2

Award-winning piece made by bamboo

(<http://www.finewoodworking.com/item/27432/how-to-use-bamboo-for-fine-furniture>)

Some bamboo furniture design samples are shown in Fig. 3, respectively. Fig. 3(a) and (b) present a cathedral and a Normadic museum provisional exhibited in Central Place of Bogota (world biggest building 5,000 m²) designed by Simon Velez in bamboo (*Guadua angustifolia*). Fig. 3(c) shows a chair farm designed by Werner Aisslingers, Fig. 3(d) shows a lamp called name "Kina" designed by David Trubridge. Fig. 3(e) shows a clicdiner chair produced by Pelidesign. Fig. 3(f) also presents a chair called dutch design produced by Tejo Remy and Rene Veenhulzen (Makowsky 2013).

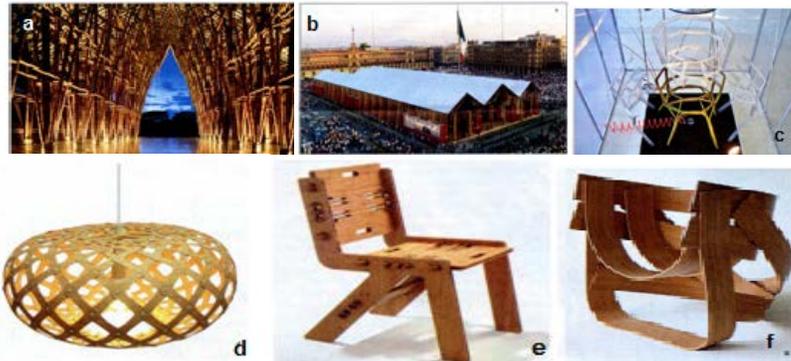


Fig. 3
Some bamboo furniture design products (Makowsky 2013).

Fig. 4 indicates a bamboo bench, bamboo stools at the green village in Indonesia, and bamboo bench produced by the University of Wisconsin in Madison, respectively.



Fig. 4
a - Bamboo bench; b - Bamboo stools; c - Bamboo bench
(<http://inspirationgreen.com/bamboo-furniture.html>).

Fig. 5(a) and (b) show a bamboo chair designed by Sebrae Tres Rios and Zuarq builders in Colombia. A bamboo bench composed of ten different types of bamboo produced by Elena Goray and Christoph Tönges from Colombia, China, and Indonesia is also shown in this Fig. 5(c). It was noted these bamboos samples had the various colors and diameters. Four belts of stainless steel kept the bamboo bench shape without screws or glue.

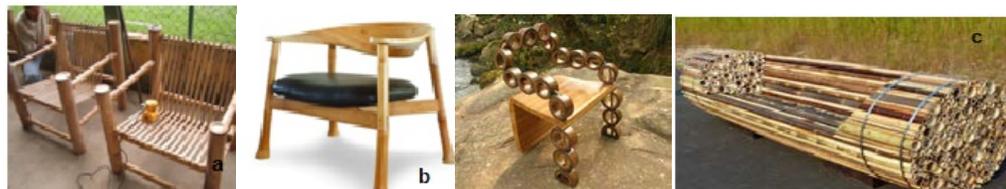


Fig. 5
a; b - Bamboo chairs; (<http://inspirationgreen.com/bamboo-furniture.html>)
c - A bamboo bench (Makowsky 2013).



Fig. 6

a - A bamboo car; b - A bamboo truck; c - A bamboo bicycle
a - (<http://inspirationgreen.com/bamboo-furniture.html>).

Fig. 6(a) presents that the bamboo is a single-seat electric car. The 60 kg ecologically friendly design car was developed by Kyoto University. It can run for 50km on a charge. Fig. 6(b) and Fig. 6(c) shows a truck produced for green school in Indonesia and an Indonesian bamboo bicycle, respectively.

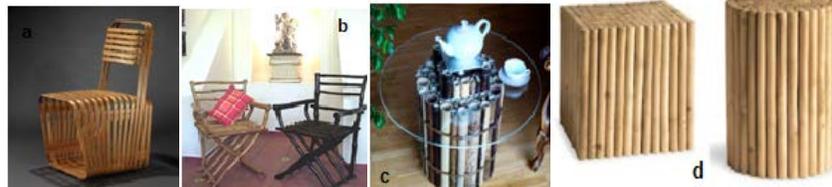


Fig. 7

a - Bamboo chair; b - Bamboo Jefe chairs; c - The bamboo table; d - Bamboo stools
(<http://inspirationgreen.com/bamboo-furniture.html>).

A bamboo chair made of moso bamboo designed by Jeff Dah-yue Shi and a bamboo by designed by Jefe Chairs are shown in Fig. 7(a) and (b). Fig. 7(c) shows the some table base consists of bamboo culms in variety of different sizes and colours held together by metal belts, which eliminate the need for any glue and screw were produced by Elena Goray and Christoph Tönges. Fig. 7(d) also shows some bamboo sofa and tables for kitchens and living rooms. Fig. 8(a) and (b) are taken by Green Village in Indonesia. Fig. 8(c) is also taken in Colombia.



Fig. 8

a - Bamboo sofa and tables; b - Bamboo kitchen; c - Bamboo Kitchen
(<http://inspirationgreen.com/bamboo-furniture.html>).



Fig. 9

a - Green School Classroom; b - Bamboo wash basin; c - Bamboo Dining Set
(<http://inspirationgreen.com/bamboo-furniture.html>).

A green school classroom which contains 100% bamboo, even the blackboard is made from bamboo is presented in Fig. 9(a). A bamboo wash basin and a bamboo dining set at Green Village in Indonesia present Fig. 9(b) and (c). Fig. 10(a), (b), (c) presents a bamboo spectacle frames inspired by Chinese Ming Dynasty Furniture, a motorcycle helmet, the roof, which consists of a shell constructed entirely from bamboo fiber, a bicycle bamboosero designed by Craig Calfee, respectively.



Fig. 10

a - Bamboo spectacle frames; b - A motorcycle helmet; c - A bicycle bamboosero (Chele et al. 2012).



Fig. 11

a - A tea chair; b - Bamboo table and chairs; c - Bamboo Gazebo (www.sabaiideco.com); d - A bamboo table (Makowsky 2013).

A tea ceremony chair which is designed by Hiroki Takada is shown in Fig. 11(a). Fig. 11(b) also shows some bamboo tables and chairs in Green Village in Bali and a photo taken in France. Fig. 11(c) shows a bamboo gazebo in France. A bamboo table designed in "Bamboo Collection" is also presented in Fig. 11(d). Fig. 12(a) shows a terminal Barajas airport upper right, (b) a German Chinese house in the middle. The Spanish pavilion is shown in Fig. 12(c) upper left. It was made by rattan, wicker and bamboo.



Fig. 12

a - Terminal Barajas Airport; b - German Chinese house; c - The Spanish pavilion (Chele et al. 2012).

CONCLUSIONS

The suitability of bamboo as raw material and specific adaptations of processing equipment for the furniture production should be determined to meet the growing demand of designer and users of modern, simple and convenient (price) furniture. Some environmental challenges call for a more efficient production and use of furniture which should decrease the quantity of hazardous raw materials used for its manufacture. Bamboo can be used as a valuable supporting system in building structure, traditional housing, furniture the world over. As it is renewable and fast growing natural resource it will become a source for inexpensive furniture materials in an increasingly eco-conscious world. It is a highly resilient material and has credible strength after appropriate preservation treatment.

It has a natural durability of less than two years because it contains high levels of starch which make it (untreated) easy vulnerable to fungi and rot and attract insects such as termites. The cost of the bamboo furniture is directly affected by the distance between plantation and processing site and of course the aesthetical decision of client. According to the demand of the furniture industry, some tasks can recommend for future

research and development such as the effects on mechanical properties of the joints between other materials and bamboo and also the preservation treatment directly in the region of the world where it is growing. The use in multi-store wood based building and lightweight furniture with effective design for easy processing could be other challenges for the new future.

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