UNIVERSITI PUTRA MALAYSIA

PROPERTIES AND UTILISATION OF TROPICAL BAMBOO (*GIGANTOCHLOA SCORTECHINII*), FOR STRUCTURAL PLYWOOD

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By

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Thesis Submitted to the School of Graduates Studies, Universiti Putra Malaysia,

in Fulfilment of the Requirement for the Degree of Master of Science

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Specially dedicated to:

My beloved late mother

SITI ESAH BT YASIN
(Al-Fatihah)

Your love always in my heart

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Associate Professor Zaidon Ashaari, Ph.D.

Faculty: Forestry

The objectives of these study were to determine the physical and mechanical properties of 4-year-old *Gigantochloa scortechinii* culms and to evaluate the properties of plywood manufactured from the bamboo culms. Bamboo culms were split using hand splitter to produce splits. Strips were prepared by removing the epidermis and the inner skin using knife, whereas outer splits were prepared by removing the inner skin of the culm. For the bamboo plywood production, the bamboo strips were glued edge-to-edge using polyvinyl acetate resin into a 410 mm x 410 mm x 4 mm sized laminate. The laminates were then bonded perpendicularly to each other using phenol formaldehyde resin to produce three-ply bamboo plywood. The assembly time was set at 30 min and bamboo plywood was consolidated by hot pressing at $140^{O}C$ and pressure of 14 kg/cm^2 for 6.5 minutes. Commercial structural plywood (Grade A) Merawan species with the same thickness as the bamboo plywood (12 mm) was used for comparison purposes.

The results of the physical studies indicate that within the culm wall, the moisture content decreased from the interior towards the peripheral layer of the culm while the specific gravity increased. The moisture content decreased with height, whilst specific gravity increased. In the strip form, bamboo shrank more in both radial and tangential directions than in the longitudinal direction. Between radial and tangential, shrinkage occurs more in radial than in tangential. The mean value of modulus of rupture (MOR) for the bamboo strips (179.6 N/mm^2) showed no significant difference with splits (periphery layer oriented upward, 158.3 N/mm^2) but a significant difference was observed when compared with the periphery layer oriented downwards (134.2 N/mm^2).

The bonding strength of bamboo plywood meets the minimum requirement of Malaysian Standard (MS 228:1991 UDC674-419.23). The dry shear strength was in the range of 3.1 to 3.4 N/mm^2 and the bamboo failure between 44 to 66%. In comparisons to commercial plywood, the MOR, modulus of elasticity (MOE) and compression parallel to grain of the bamboo plywood were significantly higher. The values were 65.4 vs. 42.0 N/mm^2 for MOR and 8955 vs. 4583 N/mm^2 for MOE and 35.4 vs. 19.9 N/mm^2. Specific strength values (strength/density) were also higher for bamboo plywood than for commercial plywood. After 24 hours of soaking in water, the linear expansion perpendicular to the grain and thickness swelling of the bamboo plywood were markedly higher than that of the commercial plywood, i.e. respectively 1.51% and 0.43% for the former and 5.44% and 4.42% for the latter. Water absorption did not differ significantly between both types of plywood 33.9% and 35.9% in the bamboo plywood and commercial plywood respectively.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi syarat untuk memperolehi keperluan untuk ijazah Master Sains

CIRI-CIRI DAN PENGGUNAAN BULUH TROPIKA (*GIGANTOCHLOA SCORTECHINII*), UNTUK PAPAN LAPIS STRUKTUR

Oleh

MOHD KHAIRUN ANWAR BIN UYUP

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Objektif penyelidikan ini ialah mengenalpasti sifat fisikal dan mekanikal buluh semantan (*Gigantochloa scortechinii*) serta sifat buluh lapis yang dihasilkan daripada buluh ini. Bagi sifat-sifat buluh semantan, buluh dipecah menggunakan pemecah buluh bagi menghasilkan bilahan kemudian kulit luar dan dalam dibuang dengan menggunakan pisau. Dalam pembuatan buluh lapis, bilah buluh dilekatkan dengan PVAc dibahagian tepi bagi menghasilkan sekeping lapisan (410 mm x 410 m x 4 mm) kemudian digam dengan menggunakan fenol formaldehyde. Masa pembuatan ialah selama 30 minit dan suhu penekan panas ialah 140^{O}C dengan tekanan 14 kg/m^3 selama 6.5 minit. Sebagai perbandingan papan lapis (grade A) daripada sepsis Merawan digunakan bagi membandingkan kekuatan fisikal dan mekanikal.

Keputusan daripada sifat fisikal didapati kandungan lembapan menurun daripada dalam ke bahagian luar tebal buluh manakala ketumpatan bertambah. Kandungan lembapan

menurun dengan ketinggian buluh semantan tetapi ketumpatan menigkat. Dalam bentuk bilah (tanpa kulit luar dan dalam) ia mengecut lebih pada bahagian radial dan tangen berbanding longitud. Perbandingan antara arah radial dan tangen menunjukkan buluh Semantan mengecut lebih pada arah tangen. Nilai purata bagi kekuatan kenyalan untuk bilah (179.6 N/mm^2) tidak menunjukkan sebarang perbezaan dengan bilahan dalam bentuk asal (158.3 N/mm^2). Tiada perbezaan wujud apabila bilah diuji dengan meletakkan kulit ke atas atau ke bawah tetapi nilai menunjukkan ia lebih tinggi.

Kekuatan lekatan buluh lapis telah mencapai piawaian minimum dalam Malaysia Standard (MS 228). Ujian dalam keadaan kering memberikan nilai dalam lingkungan 3.1 – 3.4 N/mm^2 dan purata peratus kegagalan buluh pula ialah diantara 44 - 66%. Apabila dibandingkan dengan papan lapis komersial, kekuatan kenyalan, modulus kenyalan dan tekanan menunjukkan buluh lapis lebih kuat. Nilainya ialah 65.4 berbanding 42.0 N/mm^2, 8955 berbanding 4583 N/mm^2 dan 35.4 berbanding 19.9 N/mm^2. Nilai kekuatan spesifik (kekuatan / isipadu) adalah lebih tinggi bagi buluh lapis. Selepas 24 jam direndam dalam air, kadar pengembangan arah bertentangan dengan ira dan tebal adalah lebih tinggi berbanding papan lapis komersial dengan nilai 1.51 berbanding 0.43% dan 5.44 berbanding 4.42%. Manakala kadar resapan bagi kedua-dua produk ini tiada beza, 33.9 dan 35.9%.

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CHAPTER 1

INTRODUCTION

Bamboo is a cultural feature of the Asia region. Its plethora of essential uses has led to the use of terms such as "bamboo culture", "green gold", "poor man's timber", "bamboo friend of the people" and "the cradle coffin timber" (Tewari, 1992). Bamboo is also known as "the wood of the poor" in India, "the friend of the people" in China and "the brother" in Vietnam (Farrelly, 1984). Malaysia has more than 50 species of bamboo, 25 of them are indigenous, while the rest are known exotic. Genera that can be found in Malaysia are *Bambusa, Dendrocalamus, Gigantochloa, Chusquea, Dinochloa, Melocanna, Phyllostachys, Racemobambos, Schizostachyum, Thyrsostachys and Yushania.* (Wong, 1995).

The three species, which are the most widespread in Peninsular Malaysia, are *Gigantochloa scortechinii* (the most useful species), *Dendrocalamus pendulus* and *Scizostachyum grande* (Azmy, 1998). These species grows naturally in the foothills and valleys of series of mountain ranges that stand up most prominently in the northern half of the peninsular Malaysia, including the two most massive, *viz.*, the Main Range, running from Pattani in Thailand to Malacca on the southwest coast, and the Terengganu Highlands, at the northeastern flank of the peninsula up to about 1200 m (Wong, 1995).

Bamboo in its natural form are mainly used as construction material such as floors, walls and other household items and utensils. Therefore bamboo becomes a forefront as one of the most easily available resources within the rural communities. This is proven in several Southeast Asian and East Asian countries where the value of bamboo is extremely high if proper techniques are developed at processing and manufacturing stages (Salleh & Wong, 1987). In China, bamboo becomes more interesting and practical as substitute for timber because of their poor forest resources (Zhu, 1987).

In Malaysia, only 14 species have been used intensively in bamboo industry for making poultry cage, vegetable basket, incense stick and joss paper industry, skewer and chopstick, sunblind weaving industry and commercial handicraft (Azmy et al. 1994; Aminuddin, 1995). Due to its fast growth, availability, attractive and unique appearance as well as toughness, this material can be converted into engineered products such as laminated boards (Abd. Latif et al. 1989). However, in most bamboo producing countries, the techniques for bamboo processing are primitive and the products are low in quality (Zhu, 1995).

In China and Japan, bamboo composites and parquet products from bamboo have gained commercial importance and have been widely used as engineering structural material (Tang, 1996). Bamboo plywood is a panel consisting of an assembly of plies of bamboo sheets bonded together with a resin with the direction of the grain in alternate plies at right angles (Chen, 1987). There are three types of bamboo plywood: bamboo mat plywood, bamboo curtain plywood and laminated board. (Zhang, 1992).

Today, bamboo product has become more popular not only in India and China but also in Europe and America. Bamboo is regarded as eco friendly and can be used as an alternative to timber. The world is loosing its resource of wood due to higher demand and to recover the resources will take 15 to 20 years. Bamboo, due to its early maturity has potential to be used as an alternative material for wood. Many researchers agreed that the suitable age of the bamboo used is 3 to 4 years old (Thammicha, 1989; Abd. Latif et al. 1990; Jamaluddin, 1999). In Malaysia, the properties of laminated bamboo, cement bonded bamboo particleboard and bamboo particleboard have been evaluated (Razak et al.1997; Jamaluddin et al. 1999; Chew et al.1992). However before this can be achieved, a study need to be carried out to evaluate the properties of bamboo plywood. The need to understand the physical and mechanical properties of bamboo strips and splits forms. Hence, the 4-year-old *G. scortechinii* was chosen as raw material due to its availability and the its characteristics itself.

The objective of this study was to evaluate the suitability of *Gigantochloa scortechinii* as a raw material for structural bamboo plywood. This study aims to:

1. Determine the physical and mechanical properties of *G. scortechinii* strips (without periphery and inner skin) and splits (with periphery intact).
2. Evaluate the adhesion characteristics of *G. scortechinii* and its compatibility to phenolic resin
3. Assess the properties of bamboo plywood manufactured from *G. scortechinii*.

CHAPTER 2

LITERATURE REVIEW

Bamboo in Peninsular Malaysia

Bamboo is a unique group of giant arborescent grasses, in which the wood culms arise from rhizome (Thammicha, 1989). Current knowledge lists about 75 genera and 1250 species of bamboo. About 75% of these species are used locally for one or many purposes, and about 50 species are used extensively (Rao et al. 1998). Bamboo plays a very important role on the life of the rural people and now is more important economically, due to the development of several industries using bamboo as raw materials (Widjaja, 1991).

There are 14 genera and 59 species of bamboo in Peninsular Malaysia. Four of these genera (*Chimonobambusa, Melocanna, Phyllostachys and Thrysostachys*) are not native of Peninsular Malaysia (Wong, 1995). The bamboo species are grouped under genera *Bambusa, Chusque, Dendrocalamus, Dinochloa, Gigantochloa, Melocanna, Phyllostachys, Racembambos, Schizostachyum, Thyrsostachys* and *Yushania*. From the total of 59 bamboo species only 14 are commercially utilized while the rest are left idle in their habitat, mainly due to the with lack of knowledge on their properties and potential usage (Abd. Razak & Abd. Latif, 1995).

Genus *Gigantochloa*

Gigantochloa scortechinii is the most common type of bamboo found wild in the forest (Azmy & Abd. Razak, 1991). There are 13 species of *Gigantochloa* in Peninsular Malaysia. The species are *Gigantochloa albopilosa, G. rideleyi, G. hasskarliana, G. latifolia, G. ligulata, G. albovestita, G. rostrata, G. thoii, G. scortechinii, G. holtumiana, G. wrayi* and two other species only known as *Gigantochloa spp* (Wong, 1995). The culms of *Gigantochloa* usually have short branches at the nodes (Dransfield, 1980), and most species of *Gigantochloa* are useful for local people and are planted for everyday use in villages.

The culm sheaths green at the very base and flushed intense orange towards the top, covered with the dark brown to black hairs. The culms height usually achieves 20 meter tall, diameter of between 6 –12 cm and internodes length of 30 – 40 cm long (Wong, 1995). Azmy (1998) reported that the culm wall thickness ranges from 11 – 15 mm and young bamboo shoots grows vertically. The size of the culms varies from species to species. They can be as large as 20 cm in diameter and as tall as 30 m (Dransfield, 1980). This type of bamboo is considered as large diameter bamboo (Azmy & Abd. Razak, 1991). Azmy (1998) also added that the matured bamboo could be identified by the colour of bamboo while the young culm is usually covered with a fine white waxy powder (Abd. Razak & Abd. Latif, 1995). *Gigantochloa* can be recognized by the straight culms, the absence of prominent auricles on the culm sheaths and the long blade of the culm sheath (Azmy and Razak, 1991).