UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF PARTICLEBOARD AND PARTICLE-FILLED THERMOPLASTIC COMPOSITE FROM BAMBOO (GIGANTOCHLOA SCORTECHINII)

JAMALUDIN KASIM

PROPERTIES OF PARTICLEBOARD AND PARTICLE-FILLED THERMOPLASTIC COMPOSITE FROM BAMBOO (*Gigantochloa scortechinii*)

By

JAMALUDIN KASIM

Thesis Submitted in Fulfilment of the Requirement for the Degree of Doctor of Philosophy in the Faculty of Forestry, Universiti Putra Malaysia.

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Read ! In the name of ALLAH and Cherisher,
Who created-
Created man, out of a (mere) clot of congealed blood,
Read ! And thy Lord is Most Bountiful-
He Who Taught (the use of) the Pen-
Taught Man that which he knew not.
(Quran XXVI : 1-5)

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LIST OF ABBREVIATIONS

AB	Alcohol Benzene Solubles
A.D	Air Dry
ANOVA	Analysis of Variance
BS	British Standards
CWT	Culm Wall Thickness
CW	Cold Water Solubles
DIA	Diameter
DMRT	Duncan Multiple Range T-Tests
Elong	Elongation at Break
FRIM	Forest Research Institute Malaysia
HW	Hot Water Solubles
IB	Internal Bond
MAPP	Maleated Anhydride Polypropylene
MC	Moisture Content
MPa	Mega Pascal
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
MS	Malaysian Standards
MUF	Melamine Urea Formaldehyde
p	Probability
PP	Polypropylene
PS	Particle Size
rpm	Revolution per Minute
r	Correlation Coefficient
R^2	Coefficient of Determination
SWS	Screw Withdrawal Surface
SWE	Screw Withdrawal Edge
TAPPI	Technical Association of Pulp and Paper Industry
TEN	Tensile Strength

TMOE	Tensile Modulus of Elasticity
TS	Thickness Swelling
UF	Urea Formaldehyde
WA	Water Absorption

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Doctor of Philosophy

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Chairman : **Jalaluddin Harun, Ph.D**

Faculty: **Forestry**

The mensurational attributes of culm basal diameter, weight and volume (except for culm wall thickness) were found to be significantly affected by age. Initial moisture content was observed to decrease while oven dry density increases significantly with age and culm portion. Cold water, hot water and alkali solubles were significantly influenced ($p < 0.05$) by the age and culm portion while the holocellulose content increased significantly ($p < 0.05$) with age but remained almost constant with culm height.

In the manufacture of single-layer urea formaldehyde particleboard, all the board properties were observed to be significantly influenced at $p < 0.05$ by the main factors of age, particle size, resin and wax content. For the three-layer particleboard, the age of culm, core particle size and wax content had significant effects on all the board properties. Single-layer melamine urea-formaldehyde particleboards

manufactured from various age culms varied significantly ($p < 0.05$) in all the mechanical and physical properties with age (except for internal bond), resin content, particle size and wax addition. For three-layer particleboards, age showed significant effects on all the board properties (except for modulus of rupture, modulus of elasticity and screw withdrawal surface), while core particle size significantly affected all the board properties. Wax addition improved the board dimensional stability but decreased the mechanical properties (except for modulus of elasticity).

Bamboo-filled thermoplastic composite board properties varied significantly with age of culm, particle size, filler loading and maleated anhydride polypropylene addition. The bamboo density and its chemical properties affected some of the particleboard properties but their influence on the final bonding of the board were neglegible. However, bamboo-filled thermoplastic composite board properties were not affected by the variation in the chemical composition of the material. Regardless of age of bamboo, the bamboo particles were found to be suitable materials for the manufacture of particleboards and thermoplastic composites.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi syarat untuk memperolehi Ijazah Doktor Falsafah

SIFAT PAPAN SERPAI DAN KOMPOSIT TERMOPLASTIK BERPARTIKEL DARI BULUH (*Gigantochloa scortechinii*)

Oleh

JAMALUDIN KASIM

Ogos 1999

Pengerusi: **Jalaluddin Harun, Ph.D**

Fakulti: **Perhutanan**

Sifat fisikal buluh yang terdiri dari perepang, berat dan isipadu (kecuali tebal dinding buluh) didapati dipengaruhi oleh umur buluh. Kandungan lembapan didapati menurun dan ketumpatan meningkat dengan ketara mengikut peningkatan umur dan ketinggian batang buluh. Kandungan kelarutan air sejuk, air panas dan alkali dipengaruhi ($p < 0.05$) oleh umur buluh dan ketinggian batang manakala kandungan holosellulosa pula meningkat nyata ($p < 0.05$) dengan umur tapi tidak dengan ketinggian batang buluh.

Dalam penghasilan papan serpai urea formaldihid satu lapis kesemua sifat papan serpai didapati di pengaruhi ($p < 0.05$) oleh faktor; umur buluh, saiz partikel, kandungan perekat dan tambahan lilin. Untuk papan serpai tiga lapis, umur buluh, saiz partikel kor dan lilin (kecuali modulus kenyalan) menunjukkan kesan yang nyata keatas semua sifat papan serpai.

Papan serpai satu lapis melamin urea-formaldehid yang dihasilkan di semua peringkat umur buluh berbeza ($p < 0.05$) dalam semua sifat kekuatan mekanikal dan fisikal oleh kesan umur (kecuali kekuatan regangan), kandungan perekat, saiz partikel dan tambahan lilin. Untuk papan serpai tiga lapis, umur buluh menunjukkan kesan yang nyata keatas semua sifat papan (kecuali kekuatan kenyalan, modulus kenyalan dan pegangan skru di permukaan) manakala peningkatan saiz partikel kor dengan nyata mempengaruhi semua sifat papan serpai. Penambahan lilin dengan nyata meningkatkan kestabilan papan tetapi merosotkan sifat kekuatan mekanikal (kecuali modulus kenyalan).

Sifat papan komposit termoplastik berpartikel buluh berbeza dengan ketara bersamaan dengan perbezaan umur buluh, saiz partikel, tambahan penambat dan tambahan polipropilena anhidrid termaleat. Ketumpatan dan sifat kimia buluh mempengaruhi sebahagian dari sifat papan serpai tetapi pengaruhnya keatas perekatan papan serpai adalah tidak nyata. Sifat papan komposit termoplastik berpartikel buluh didapati tidak dipengaruhi langsung oleh perbezaan sifat kimia buluh. Tanpa mengira peringkat umur, partikel buluh didapati sesuai sebagai bahan mentah untuk penghasilan papan serpai dan komposit termoplastik.

CHAPTER I

INTRODUCTION

Bamboo is a replenishable raw material and is probably the most versatile forest product. Its potential can be harnessed to serve the rural community as well as the urban dwellers. In its adaptability to human needs, bamboo has few peers in the plant kingdom. Bamboo is in fact, one of the forest resources used by mankind since time immemorial for a variety of purposes. Bamboo is used for building houses, roof construction, foot bridges, fencing, rafts, baskets, furniture, tool handles, musical instrument and many other articles.

Bamboo is a perennial giant woody grass belonging to the subfamily *Bambusoidae* of the family *Graminae*. They are found growing in areas from sea level up to 3,000 m in altitude in all continents except Europe. It is estimated that there are about 1,200 to 1,500 bamboo species globally (Wong, 1995). Bamboo, which is said to be the fastest growing plant with a high cellulose content known so far (Farrelly, 1984), deserves greater attention as we enter into the era of decreasing forest acreage and increasing demands on timber supplies. It can provide up to six times as much cellulose per acre as compared to a pine forest. In China the annual production of bamboo forest is about two ton per hectare and can reach up to 10 to 12 tons with more intensive management (Wu and Ma, 1985). In Malaysia, with its abundant sunlight, the production shall be better. Furthermore, the harvesting of

bamboo does not disturb the soil surface which is a distinct advantage for harvesting in a hillside area to maintain soil fertility. Its foliage structure helps to conserve moisture while the fallen leaves build humus layer. Instead of interfering with the growth of the main timber species, bamboo can in fact, perform a remarkable role in its regeneration (Singh, 1969), deforestation and soil loss conservation programs (Farrelly, 1984). Therefore, bamboo a fast-growing plant, is potentially a good source of lignocellulosics material for composite board production, and at the same time, is useful in reafforestation, soil conservation and erosion control.

In Peninsular Malaysia, Wong (1995) reported the presence of 59 bamboo species representing 14 genera of which 34 of them are indigenous and the other 25 species are introduced or only known in cultivation. Peninsular Malaysian bamboo was categorized by Holttum (1958) as either village or cultivated bamboo's and native or forest bamboo. These bamboo species are found in abundance but are widely scattered in about 9.5% of the total forest reserve area in Peninsular Malaysia (Lockman et al., 1994) and are commonly found growing gregariously in areas that have been disturbed such as logged-over forest, degraded land, land fringing the forest, along river banks, on hillsides, and ridge tops (Holttum, 1958; Wong, 1995). They also occur as secondary growth on abandoned clearings where shifting cultivation is practised (Burton, 1979). Aminuddin and Abd. Latif (1991) reported that, depending on the species, they thrive best on well-drained sandy-loam to clay-loam or alluvium soils from the underlying rocks with a pH of 5.0 - 6.5.

Malaysian bamboo is classified as a minor forest product and is traditionally considered as weed interfering with the normal regeneration, development and maintenance of the main timber species (Watson and Wyatt-Smith, 1961; Medway, 1973; Ng, 1980; Salleh and Wong, 1987). In the past, attempts were made to control its growth but now, due to the rapid expansion of bamboo-based industries, it has become the second most important non-timber product in Malaysia after rattan (Aminuddin and Abd. Latif, 1991). Bamboo played an important role in the lives of the local people particularly those in the rural areas and is usually being used for making basket-ware, cords and toys, furniture and houses.

The bamboo industry has developed into a multi-million dollar industry with its products enjoying very high demand domestically as well as internationally. However, in producing the various bamboo products a lot of wastes (28 to 47%) are generated (Abd. Latif et al., 1990a). In addition, the top portion of a bamboo culm is usually discarded during harvesting and transporting, and if no action is taken the bamboo industry may be losing millions in income yearly. Therefore, the optimum use of this resource lies in the production of reconstituted products such as particleboard or plastic composite boards.

A composite can be defined as any combination of two or more materials, in any form, and for any use (Bhagwan and Lawrence, 1984; Rowell, 1991; Brent et al., 1994). In the wood industry, the term composite or reconstituted wood is usually used to describe any wood product that is "glued" together. In the wood industry, it ranges from fiberboard to laminated beam and structural component. The development of