UNIVERSITI PUTRA MALAYSIA

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By

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Chairman : Associate Professor Zaidon Ashaari, PhD

Faculty : Forestry

Bamboo can be an alternative for wood as raw material for laminated products. Like wood, bamboo is non-durable. It is susceptible to fungal and termite attacks. Hence, there is a need to treat bamboo to enhance their resistance towards fungal and termite attacks. Chemical treatment is one of the effective ways to preserve bamboo and the choice of preservatives and its concentrations would determine the success of the treatment. The objective of this study was to evaluate the efficacy of some preservatives on bamboo (*Gigantochloa scortechinii*) strips and laminates in terms of their resistance towards fungal and termite attacks. Other properties such as strength and gluing quality of the strips were also determined. The preservatives used in this study were pyrethroid compounds, i.e., light organic solvent preservatives (LOSP) (a.i tributyltin naphthenate (3.5%), permethrin (0.2%)), water based preservatives (WBP) (a.i disodium octaborate (10%), benzalkonium chloride (2%), permethrin (0.2%), tributyltin-oxide (TBTO, 1%) and borax (5% w/v). Bamboo strips without epidermis, 150 mm x 20 mm x 4 mm were prepared and vacuum-preassure treated with the treating solutions.

Untreated and water-boiled strips were served as controls. A batch of the treated and untreated strips were evaluated for colour changes, strength properties (static bending) and resistance towards white rot (*Pycnophorous sanguineus* Wulfex Fries) and termite (*Coptotermus curvignathus* Holmgren) attacks. Another batch of the treated and untreated strips were fabricated into laminates using phenol formaldehyde (PF) as binder. The laminates were then tested for their bonding quality which includes buffering capacity, contact angle, shear strength and percentage of wood failure. The laminates were also subjected to white rot and termite tests.

All treatments changed the bamboo strips into lighter colour with the colour changes index (ΔE) value ranging from 2.68 to 11.7 and whitish (W) value 0.67 – 8.46%. TBTO-treated strips had the highest ΔE while WBP-treated strips had the highest whitish values, i.e., 9.29 and whitish value of 8.46%.

The resistance of bamboo strips and laminates against white rot and termite attacks were evaluated based on their weight loss after exposure to those biodeteriorating agents. The results showed that all preservative treatments increased the resistance of bamboo strips and laminates towards white rot from the original value of 17.6%, i.e., weight loss of untreated strips and 22.9% (untreated laminates). However, boiling in water for 30 minutes was decreased the resistance of the strips against white rot attacks. The weight loss value for this strip was 21.8% while 22.4% for the laminates. TBTO was found to be the best preservative to protect both bamboo strips (10.7%) and laminates (9.71%) against the fungus.

The results also revealed that bamboo laminate was more durable than bamboo strips when exposed to termite. The increment in resistance for these materials were 62.5% and 72.9%, respectively. All preservative-treated materials had significantly lower weight loss values compared to untreated and water-boiled bamboo materials. Among the preservatives, WBP gave the best protection against termite and borax-treated materials had the least efficacy in protecting the strips. For the laminates, TBTO gave the best protection while borax gave the least protection against termite.

A study on the strength properties of treated bamboo strips revealed that the chemical treatments slightly reduced the modulus of rupture (MOR) and modulus of elasticity (MOE) in static bending. The reduction of MOR for the treated strips was in the range of 1.22% to 19.6% whilst the reduction in MOE ranging from 1.3% to 18.2%. Strips treated with LOSP gave the most effect on the MOE and MOR properties. The strength and stiffness of bamboo strips were markedly reduced when treated with LOSP while for boiled treatment, the properties were slightly reduced.

The shear strength and bamboo failure of the laminates were evaluated in dry and wet conditions. For wet condition test, the laminates were exposed to cyclic boil test. In dry test, with the exception of borax treatment, the shear strength and bamboo failure of the

treated laminates were significantly reduced. The shear strength values for the treated laminates were in the range of 0.64 Nmm^{-2} to 2.04 Nmm^{-2} compared to 2.66 Nmm^{-2} for the untreated laminates. The same trend was observed when tested in wet condition. The shear strength of the laminates was reduced for all treatments which the shear strength ranged from 0.48 Nmm^{-2} to 0.65 Nmm^{-2} compared to 0.79 Nmm^{-2} for untreated laminates. The wood failure of the treated material did not differ significantly to untreated bamboo laminates. The wood failures ranged from 8 % to 28 % in dry condition test and 2 to 4% in wet condition. The results also showed the bamboo laminates surpass the requirement of the British Standard: Part 8: Specification for Bond Performance of Veneer Plywood.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

KEBERKESANAN BAHAN PENGAWETAN PILIHAN TERHADAP BILAH DAN LAMINASI BULUH SEMANTAN *(Gigantochloa scortechinii)*

Oleh

ROZIELA HANIM ALAMJURI

Mei 2008

Pengerusi : Profesor Madya Zaidon Ashaari, PhD

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Buluh boleh menjadi bahan mentah alternative selain kayu untuk produk laminasi. Seperti kayu, buluh tidak mempunyai ketahanan yang tinggi terhadap serangan kulat serta anai-anai. Oleh yang demikian, adalah perlu merawat buluh untuk meningkatkan tahap ketahanan terhadap kulat serta anai-anai. Rawatan kimia adalah kaedah yang efektif dalam merawat buluh dan pemilihan bahan awet dan kadar kepekatan bahan awet akan pengaruhi keberkesanan rawatan. Tujuan kajian ini adalah untuk menilai keberkesanan bahan awet dan ke atas bilah dan laminasi buluh (*Gigantochloa scortechinii)* terhadap serangan kulat dan anai-anai. Ciri kekuatan dan kualiti rekatan laminasi turut dikaji. Bahan awet yang diguna dalam ujikaji ini adalah campuran pyrethroid didalan bahan awet beasaskan larutan organik ringan (LOSP) (a.i tributyltin naphthenate (3.5%), permethrin (0.2%)), pengawet berasaskan air (WBP) (a.i disodium octaborate (10%), benzalkonium chloride (2%), permethrin (0.2%), tributyltin-oxide (TBTO, 1%) dan borax (5% w/v). Bilah buluh, 150 mm x 20 mm x 4 mm tanpa epidermis dirawat menggunakan kaedah tekanan vakum. Bilah buluh tanpa rawatan serta rawatan merebus didalam air digunakan sebagai kawalan. Bilah buluh yang telah dirawat diuji untuk melihat perubahan warna selepas rawatan, ciri kekuatan (lenturan) dan ketahanan terhadap serangan kulat pereput putih (*Pycnophorous sanguineus* Wulfex Fries) dan anai-anai (*Coptotermus curvignathus* Holmgren). Untuk laminasi buluh phenol formaldehyde (PF) digunakan sebagai perekat. Laminasi buluh diuji untuk melihat

kualiti rekatan termasuk kemampuan menampan alkali dan asid, sudut persentuhan, kekuatan ricih dan kegagalan kayu. Ketahanan laminasi buluh juga di uji terhadap serangan kulat pereput putih dan anai-anai.

Semua rawatan didapati mengubah warna bilah buluh menjadi lebih cerah dimana index perubahan warna (ΔE) adalah pada kadar 2.68 to 11.7 dan kadar keputihan (W) adalah 0.67% – 8.46%. Bilah buluh yang dirawat menggunakan TBTO menpunyai index perubahan warna (ΔE) (9.29) manakala rawatan menggunakan WBP memberikan kadar keputihan (8.46%) tertinggi.

Ketahanan bilah dan laminasi buluh terhadap serangan kulat pereput putih dan anai-anai dinilai berdasarkan kehilangan berat selepas didedahkan kepada agen perosak. Keputusan menunjukkan semuan rawatan menggunakan bahan awet meningkatkan kadar tahap ketahanan bilah dan laminasi buluh berbanding kekurangan berat bilah (17.6%) dan laminasi (22.9%) tanpa rawatan. Rawatan merebus didalam air selama 30 minit, mengurangkan tahap ketahanan terhadap serangan kulat pereput putih. Nilai kehilangan berat untuk bilah adalah 21.8% dan 22.4% untuk laminasi buluh. Rawatan menggunakan TBTO meningkatkan ketahanan 10.7% untuk bilah buluh dan 9.71% untuk laminasi buluh jika dibandingkan dengan bahan awet yang lain.

Keputusan juga menunjukkan laminasi buluh mempunyai ketahanan yang lebih tinggi dari bilah buluh selepas didedahkan terhadap anai-anai. Peningkatan tahap ketahanan untuk laminasi buluh adalah 62.5% dan 72.9% untuk bilah buluh. Semua rawatan kimia didapati mengurangkan kehilang berat jika dibandingkan dengan dengan buluh tanpa rawatan dan rawatan merebus didalam air. Diantara bahan awet, WBP memberikan ketahanan paling tinggi terhadap serangan anai-anai, manakala rawatan menggunakan borax memberikan ketahanan paling sedikit terhadap bilah buluh. Rawatan menggunakan TBTO pula memberikan ketahanan paling tinggi dan rawatan menggunakan borax pula memberikan ketahanan yang paling sedikit terhadap laminasi buluh.

Ujikaji terhadap kelenturan bilah buluh selepas rawatan menunjukkan nilai modulus kepecahan (MOR) dan nilai modulus kelenturan (MOE) sedikit berkurang. Pengurangan nilai MOR adalah berkadar 1.22% - 19.6% manakala dalam MOE adalah 1.3% - 18.2%. Bilah yang dirawat menggunakan LOSP memberikan kesan yang paling buruk terhadap MOE dan MOR. Kekuatan dan sifat kekakuan bilah buluh yang dirawat menggunakan LOSP dan merebus nyata berkurangan selepas bilah dirawat.

Sifat kekuatan ricih dan kegagalan kayu laminasi buluh dinilai menggunakan ujian kering (DT) dan basah (CBR). Dalam keadaan ujian basah, laminasi buluh didedahkan dengan merebus serta merendam blok ujikaji didalam air sejuk secara berulang. Dalam keadaan ujian kering, kecuali rawatan menggunakan borax, kekuatan ricih bagi kesemua rawatan adalah menurun. Kekuatan ricih adalah berkadar 0.64 Nmm^{-2} - 2.04 Nmm^{-2} dibandingkan dengan 2.66 Nmm^{-2} bagi laminasi tanpa rawatan. Situasi yang sama berlaku dalam ujian keadaan basah. Kekuatan ricih laminasi buluh menurun untuk semua rawatan dan berkadar 0.48 Nmm^{-2} – 0.65 Nmm^{-2} jika dibandingkan 0.78 Nmm^{-2} bagi laminasi tanpa rawatan. Kegagalan kayu tidak memberi kesan yang bererti jika dibandingkan dengan bilah yang tidak dirawat. Peratus kegagalan kayu berkadar 8 % - 28 % dalam ujian keadaan kering dan 2 – 4% untuk ujian dalam keadan basah. Secara keseluruhan, laminasi buluh ini adalah menepati piawaian dalam British Standard:Bahagian 8: Spesifikasi untuk kekuatan lekatan papan lapis.

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I certify that the Examination Committee met on 5 May 2008 to conduct the final examination of **Roziela Hanim bt. Alamjuri** on her **Master of Science** thesis entitiled **" Efficacy of Some Preservatives on Bamboo (*Gigantochloa scortechinii*) Strips and Laminates"** in accordance with Universiti Putra Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relavent degree. Member of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follow:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quatations and citations, which have been duty acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other instituitions.

ROZIELA HANIM BT. ALAMJURI

Date:

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CHAPTER 1

INTRODUCTION

Bamboo is a fast growing monocotyledon plant belonging to the Graminae family and Bambusiodae subfamily. It consists about 700 species and are found in Asia (Liese, 1985). In contrast, other estimates bamboo diversity vary from about 45 – 50 genera with 300 – 750 species (Dransfield and Uchimura, 1980). In Malaysia, Wong (1995) reported that there are 59 bamboo species representing 14 genera. Out of these, 34 species are indigenous and the others are introduced or only known through cultivation.

Due to its fast growing ability and availability, attractive and unique appearances, bamboo species such as *Gigantochloa scortechinii* and *G. wrayi* was intensively used in the cottage industry for making products like poultry cage, vegetable basket, handicraft items, joss paper, incense stick, skewer and chopsticks (Azmy and Razak, 1991; Aminuddin, 1995). In Indonesia, bamboo were converted into a form of sheet by weaving bamboo into mat, which then can be served as a part of hut compartments such as wall, ceiling and ground coverings (Larasati, 1999).

Anwar *et al*. (2005), reported that bamboo such as *G. scortechinii* are suitable for composite materials, laminated boards and plywood. The properties of plywood made from *G. scortechinii* are extremely high in modulus of rupture, bending strength and modulus of elasticity. The ply-bamboo strength ranks as the highest among all the structural boards and even as good as the solid wood of high-density commercial timber (Chen *et al.*, 1985).

At present, rubberwood is the most abundant material for particleboard manufactured in Malaysia (Jalil, 2002). However, due to the scarcity of these resources, development of other materials such as bamboo should be explored to overcome this problem. Bamboo, as a fast growing renewable material with a simple production process, is expected to be a sustainable alternative for more conventional materials like concrete, steel and timber (Lugt *et. al*, 2003). In fact, Anonymous (2002), Kries (2000) recognized bamboo as a very sustainable material.

Gigantochloa scortechinii, known as Buluh Semantan is well known and established in the Malaysian community. It was widely used for traditional uses such as water pipes, poles, flooring, and handicrafts. In the 1980's, due to the dwindling supply of wood in the tropics the interest in bamboo as wood material has been getting greater attention. It emerged as the most potential non timber forest product to substitute wood as a raw material. Besides, bamboo composites have gained popularity in Japan and China (Tang, 1996) and it is widely recognized in panel form and ideal compared to wood.

Bamboo has similar morphological properties with wood and one of the fastest growing species (Ray, 2005). Its growth rate depends on species and generally matures quickly (Aminuddin and Abd. Latif, 1991). Bamboo is a highly renewable resource which may have 40 – 50 stems in one clump, which adds up to 10 to 20 culms yearly. However, the low durability of bamboo makes it render highly susceptible to fungi, insect and other deterioration agents. According to durability classification (Anonymous, 1982), bamboos fall in class III (non-durable category) with little variation in durability among different species. The starch content in bamboo plays an important role in its durability and service life. Abd. Latif *et. al,* (1993) found that the durability of bamboo against deterioration agents is strongly associated with the chemical composition.

Fresh felled bamboo must be treated, although the development of stain can be avoided by rapid drying (Richardson, 1993). In fact, even in kiln drying there is a threat that stain will develop before the moisture content is significantly reduced. Bamboo can be treated either by non-chemical or chemical methods. Non–chemical methods include soaking, smoking and boiling (Zaidon *et al.*, 2000). Chemical treatment which includes brushing, spraying, butt-treatment, sap displacement method, vacuum, hot and cold bath, and by full or empty cell