Technical Note

Resistance of Selected Wood-Based Materials to Fungal and Termite Attack in Non–Soil Contact Exposures

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Abstract

The resistance of three naturally durable heartwood species and a stranded giant bamboo product to fungal and termite (*Coptotermes formosanus*) attack was evaluated at a test site located near Hilo, Hawaii. Merbau (*Intsia bijuga* or *I. palembanica*) and ipe (*Tabebuia* spp.) were both exceptionally resistant to fungal and termite attack, while western juniper (*Juniperus occidentalis*) heartwood was slightly less resistant to degradation. The presence of heartwood on western juniper samples had no noticeable effect on the performance of adjacent sapwood. The bamboo decking proved to the least durable of the materials and experienced substantial termite and fungal attack over the 32-month test period.

Wood represents one of the most important renewable construction materials. Wood is easily shaped, requires little energy for processing, and has exceptional structural properties; however, one of its most important negative attributes is its susceptibility to biological degradation under the proper conditions. The risk of degradation varies with environmental conditions, with the highest risk occurring with direct soil contact or marine exposures. Degradation can be controlled in two ways. The first involves taking advantage of the presence of compounds naturally produced in the heartwood of some species. These compounds can provide resistance to attack by fungi, insects, and marine borers (Scheffer and Cowling 1966). Two excellent examples of naturally durable materials are ipe (*Tabebuia* spp.) and merbau (*Intsia bijuga* or *I. palembanica*), which have well-deserved reputations for durability and are used in a variety of exterior applications (Yamamoto and Hong 1989, 1994; Tsunoda 1990; Scheffer and Morrell 1998; Miller et al. 2003; Ngee et al. 2004; Wang et al. 2005; Arango et al. 2006; Tanikawa 2006; Flaete et al. 2009). The domestic softwood western juniper (*Juniperus occidentalis*) has a similar reputation for durability in soil contact (Morrell et al. 1999).

The other approach for improving durability is to artificially impregnate the material with biocides that limit the risk of biological attack. While a variety of nondurable materials are impregnated to improve their durability, bamboo-based materials have attracted increased interest. Bamboo is typically considered to be nondurable (Liese and Kumar 2003), but there has been interest on the part of producers for exterior applications such as decking. Evaluating the durability of these materials can occur in a number of ways, depending on the intended application. Historically, durability against terrestrial biodeterioration has most often been assessed by exposing wood stakes to direct soil contact. In many cases, however, the wood will not be in contact with soil, and the soil exposure assessment may unfairly rule out products that might perform well in aboveground exposures. Fortunately, there are a number of standards for evaluating the risk of decay out of soil contact. Two of the most commonly used methods for evaluating aboveground durability are the ground proximity procedures for fungal or termite exposures (American Wood Protection Association [AWPA] 2006a, 2006b). Both methods place the wood on concrete blocks to avoid direct soil contact, but differ in the extent to which specimens can be wetted. The fungal exposure places shade cloth over the blocks, allowing rainfall to enter, but limiting drying, while the termite procedures cover the blocks to prevent wetting. These two procedures provide reasonable approaches for assessing products intended for decking applications. Unfortunately, these methods have most often been applied for evaluating preservative-treated wood, and there are few data assessing naturally durable woods.

This report describes field evaluations of three naturally durable woods and a stranded bamboo composite.

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Materials and Methods

Merbau, ipe, and western juniper lumber was obtained from commercial sources. A stranded composite giant bamboo product (most likely *Bambusa atrovirens*) was also included in the test. The materials were cut into 19 by 50 by 125-mm-long specimens. The merbau and ipe materials contained only heartwood. The western juniper was a mixture of sapwood and heartwood. While sapwood is generally considered to have little inherent durability, there are claims that juniper sapwood adjacent to heartwood is protected. For this reason, juniper samples were cut with all sapwood, all heartwood, and a mixture of the two. A total of 40 specimens were prepared for the merbau, ipe, and bamboo samples. Thirty samples were prepared from juniper heartwood or sapwood, while only 10 samples could be fabricated from the heartwood–sapwood mixture.

Half of the samples for each material were exposed to termites, while the other half of the samples were exposed to fungal attack. The termite exposure followed the procedures described in AWPA Standard E21 (AWPA 2006b). Briefly, hollow concrete blocks were placed on the ground and then untreated southern pine sapwood stakes (19 by 19 by 200 mm long) were driven into the ground to create pathways for termites to explore upward onto the concrete. Test specimens were placed on the blocks in a pattern in which each piece was surrounded by 19 by 19-mm untreated pine sapwood. The resulting assembly was then covered with a wood box that prevented overhead wetting. The assembly was evaluated at approximately 6-month intervals. The specimens were scraped clean of materials deposited by the termites and then visually rated on a scale from 10 (no evidence of termite attack) to 0 (completely destroyed; ratings: 10, 9, 7, 4, or 0). Additional untreated pine sapwood stakes were driven into the ground, and the test blocks were placed on the concrete blocks along with untreated pine sapwood controls, again surrounded by 19 by 19-mm untreated pine sapwood. The site, located in Hilo, Hawaii, has a tropical climate and is characterized by an extremely aggressive attack by *Coptotermes formosansus*.

Fungal exposure followed procedures described in AWPA Standard E18 in which solid concrete blocks were placed on the ground and then the test specimens were placed on the blocks (AWPA 2006a). The blocks were then covered with a frame containing greenhouse shade cloth. The samples were exposed to approximately 5 m of annual rainfall and average daily temperatures between 24°C and 30°C. The site, located outside Hilo, Hawaii, has an average Scheffer Climate index above 400 (Scheffer 1971). Each sample's condition was visually assessed at approximately 6-month intervals using a visual scale from 10 (completely sound, no evidence of damage) to 0 (completely destroyed; ratings: 10, 9.5, 9.0, 8.0, 7.0, 4.0, or 0).

The samples were exposed for 32 months.

Results and Discussion

Termite exposure

Untreated pine sapwood was completely destroyed at each evaluation point, indicating that conditions were suitable for aggressive Formosan termite attack (Table 1). Termite workers tended to cover merbau and ipe samples with soil and fecal matter, but there was no evidence of substantial termite attack. One ipe block contained a single exploratory tunnel, which was not extended in subsequent exposures. The juniper sapwood blocks experienced substantial termite attack after the first 6-month exposure. The damage continued to progress over the next 26 months, and the samples were nearly destroyed at that point. Juniper heartwood samples were free of termite damage for the first 12 months of exposure and then experienced slight damage after 20 and 32 months. The results indicate that both ipe and merbau would be considered highly resistant to Formosan termite attack, while the juniper heartwood was slightly less resistant. Juniper sapwood had little resistance to termite attack.

Samples with a mixture of juniper sapwood and heartwood were also attacked within 6 months of exposure, but the attack was primarily confined to the sapwood portions of the blocks. Termite attack continued to increase on these specimens over the additional exposure period, but the damage was relatively slight. The results indicate that adjacent heartwood does not markedly affect termite resistance of the sapwood.

Bamboo composite samples also experienced attack within 6 months of Formosan termite exposure. Although the silicate in bamboo may make it slightly resistant to termite attack, bamboo has little natural resistance to degradation (Liese and Kumar 2003). This attack was confined to specific strands in the composite. Termite attack continued to progress with continued exposure and samples had an average rating of 4.5 after 32 months of exposure. The attack continued to be confined to specific strands, suggesting that workers were exploring the material and selectively attacking strands. The reasons for this selective attack are unclear, but the results clearly show that the material is unsuitable for situations in which Formosan termites are present.

Table 1.—Decay and termite ratings of selected wood samples after 32 months of exposure in Hilo, Hawaii.[a]

Species	Termite rating				Decay rating			
	6 mo	12 mo	20 mo	32 mo	6 mo	12 mo	20 mo	32 mo
Merbau	10.0	10.0	10.0	10.0	10.0	10.0	9.9 (0.3)	9.7 (0.5)
Ipe	10.0	10.0	10.0	9.95 (0.2)	10.0	10.0	9.95 (0.2)	10.0
Bamboo	8.0 (0.0)	5.4 (2.4)	4.0 (0.0)	4.9 (1.4)	9.6 (0.2)	9.0 (0.1)	7.1 (0.4)	5.6 (2.0)
Juniper sapwood	5.8 (1.6)	3.2 (1.8)	3.2 (1.8)	2.6 (1.9)	9.7 (0.2)	9.3 (0.4)	7.8 (1.1)	2.2 (3.2)
Juniper heartwood	10.0	10.0	9.2 (1.7)	9.7 (0.5)	10.0	10.0	9.2 (1.0)	8.0 (2.1)
Juniper heartwood–sapwood	7.7 (1.0)	6.7 (2.6)	6.3 (1.8)	6.1 (2.5)	9.8 (0.1)	9.8 (0.2)	7.9 (1.1)	4.5 (3.9)
Pine	0	0	0	0	10.0	—[b]	8.0 (2.7)	3.0 (3.0)

[a] Values represent means of 20 samples per species for each exposure (termite or decay) for merbau, ipe, and bamboo, 15 samples each for juniper heartwood and heartwood–sapwood mixtures, and 5 samples for juniper sapwood. Figures in parentheses represent one standard deviation.

[b] Missing data.

Fungal exposure

Untreated pine sapwood samples began to fail within 18 months of exposure in the ground proximity test. These results indicated that conditions were suitable for aggressive fungal attack. Merbau and ipe heartwood samples had no evidence of fungal attack for the first 12 months of exposure (Table 1). Slight evidence of fungal damage was noted on specimens of both species after 20 months, but this damage was very slight. Both species have excellent reputations for decay resistance, and these results support those assessments. Bamboo samples were visibly discolored after 6 months of exposure and the damage progressed with continued exposure. Most of the bamboo samples had ratings of 4 after 32 months of exposure, suggesting that they were nearing the end of their effective service life. The stranded bamboo composite appears to be unsuitable for exterior exposure without some type of supplemental treatment.

Juniper sapwood samples experienced slight decay after 6 months, and this damage continued to progress. The condition of the sapwood samples declined to an average rating of 2.2 after 32 months. Juniper heartwood samples were free of fungal attack for the first 12 months of exposure. Samples experienced slight fungal attack after 20 months of exposure and had an average rating of 8 after 32 months of exposure. As with the termite exposures, juniper heartwood was durable, but provided slightly lower decay resistance than either merbau or ipe. Samples composed of mixtures of juniper sapwood and heartwood tended to be only slightly less resistant to fungal attack than samples composed of only heartwood. These results differed from those found with mixed samples exposed to termite attack. While the mixed samples had slightly higher ratings than the sapwood samples after 32 months, this appeared to be more a function of decay resistance of the heartwood component than any effect of the heartwood on adjacent sapwood.

Conclusions

Merbau and ipe heartwood were exceptionally resistant to termite and fungal attack in non–soil contact, while juniper heartwood was slightly less resistant to attack. The presence of heartwood had no effect on durability of adjacent sapwood. The stranded bamboo was more resistant to fungal and termite attack than untreated pine sapwood, but still experienced substantial damage and would not be suitable for exterior, non–soil contact exposure.

Literature Cited

American Wood Protection Association (AWPA). 2006a. Standard field test for evaluation of wood preservatives intended for Use Category 3B applications exposed, out of ground contact, uncoated ground proximity decay method. Standard E18-06. *In:* AWPA Annual Book of Standards. AWPA, Birmingham, Alabama.

American Wood Protection Association (AWPA). 2006b. Standard test method for evaluation of preservative treatments for lumber and timber against subterranean termites in above ground, protected applications (UC1 and UC2). Standard E21-06. *In:* AWPA Annual Book of Standards. AWPA, Birmingham, Alabama.

Arango, R. A., F. Green III, K. Hintz, P. K. Lebow, and R. B. Miller. 2006. Natural durability of tropical and native woods against termite damage by *Reticulotermes flavipes* (Kollar). *Int. Biodeterior. Biodegrad*. 57:146–150.

Flaete, B. O., F. G. Evans, and G. Alfredson. 2009. Natural durability of different wood species—Results after five years testing in ground contact. *In:* Proceedings of the 5th Meeting, The Nordic Network in Wood Material Science and Engineering, Forest and Landscape Papers, 43/2009, A. Bergstedt (Ed.), October 1–2, 2009, Copenhagen, Denmark; Faculty of Life Sciences, University of Copenhagen, Copenhagen. pp. 65–70.

Liese, W. and S. Kumar. 2003. Bamboo preservation compendium. Technical Report 1 (INBAR Technical Report 22). Centre for Indian Bamboo Resource and Technology, New Delhi. 231 pp.

Miller, R. B., A. C. Wiedenhoeft, R. S. Williams, W. Stockman, and F. Green III. 2003. Characteristics of ten tropical hardwoods from certified forests in Bolivia. Part II. Natural durability to decay fungi. *Wood Fiber Sci*. 35(3):429–433.

Morrell, J. J., D. J. Miller, and P. F. Schneider. 1999. Service life of treated and untreated fence posts. 1996 post-farm report. Research Contribution 26. Forest Research Laboratory, Oregon State University, Corvallis. 24 pp.

Ngee, P.-S., A. Tashiro, T. Yoshimura, Z. Jaal, and C.-Y. Lee. 2004. Wood preferences of selected Malaysian subterranean termites (Isoptera: Rhinotermitidae, Termitidae). *Sociobiology* 43(3): 535–550.

Scheffer, T. C. 1971. A climate index for estimating potential for decay in wood structures above ground. *Forest Prod. J*. 21(10): 25–31.

Scheffer, T. C. and E. B. Cowling. 1966. Natural decay resistance of wood to microbial deterioration. *Annu. Rev. Phytopathol*. 4: 147–170.

Scheffer, T. C. and J. J. Morrell. 1998. Natural durability of wood: A worldwide checklist of species. Research Contribution 22. Forest Research Laboratory, Oregon State University, Corvallis. 58 pp.

Tanikawa, M. 2006. Durability evaluation of natural durable wood species by a fungus cellar test. *Wood Preserv*. 32(2):51–59.

Tsunoda, K. 1990. The natural resistance of tropical woods against biodeterioration. *Wood Res*. 77:18–27.

Wang, A. H. H., Y. S. Kim, A. P. Singh, and W. C. Ling. 2005. Natural durability of tropical species with emphasis on Malaysian hardwoods—Variations and prospects. Document No. IRG/WP/05-10568. International Research Group on Wood Preservation, Stockholm. 34 pp.

Yamamoto, K. and L. T. Hong. 1989. Location of extractives and decay resistance in some Malaysian hardwood species. *J. Trop. Forest Sci*. 2(1):61–70.

Yamamoto, K. and L. T. Hong. 1994. A laboratory method for predicting the durability of tropical hardwoods. *Jpn. Agric. Res. Q*. 28:268–275.