Termite Resistant Wood Products

by

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ABSTRACT

Use of either naturally-resistant woods, preservative treatments, or engineered wood products with enhanced insect/decay resistance represents a final line of defense in structural protection. Ideally, proper construction techniques, physical or chemical barriers, and baiting systems can be used to prevent termites from ever entering the structure. However, very few things in life work perfectly all of the time, so redundancy is valuable in termite prevention. If termites penetrate the outer defenses of the building, use of insect-resistant building materials ensures against structural collapse and allows sufficient time for the problem to be discovered and corrected. Laboratory and field tests against *Coptotermes formosanus* have demonstrated the preservative concentrations necessary for protection, and illustrate the different modes of action of different preservatives (toxicity vs. repellence). For example, borate and CCA (chromated copper arsenate) wood treatments are not repellent to termites, but a four-year field test in Hawaii indicates that only superficial cosmetic damage will occur even with long-term termite exposure and that the timbers remain structurally sound. In contrast, untreated timbers in this test were destroyed within a single year. Research on naturally-resistant woods indicates that these, too, are not immune to termite attack, but can be equivalent in resistance to preservative-treated wood. Steps must also be taken to protect engineered wood products, and viable approaches are incorporation of preservatives during manufacture or incorporation of wood or bark containing naturally-resistant extractives.

INTRODUCTION

The severity of the damages attributable to Formosan subterranean termite (*Coptotermes formosanus* Shiraki) attack strongly suggests that a multi-tactic (or integrated) approach to termite prevention is advisable. Although modern methods of termite management such as baiting systems can certainly be relied upon (Grace & Su 2001), common sense dictates that, in an imperfect world, a certain measure of redundancy is a very good idea. Thus, a sensible approach to termite prevention can

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include: (1) proper architectural design, including moisture management, elimination of any wood to soil contact, and efforts to insure that termite inspection is possible; (2) use of termite resistant building materials; (3) installation of physical or chemical barriers to prevent termite penetration of the structure in particularly susceptible locations; (4) and application of a baiting system, or a variation on this theme (e.g., a non-repellant liquid insecticide), around the structure to directly attack the local termite population.

Numerous publications are available dealing with application and efficacy of soil insecticides or baits for termite control. Proper architectural design and "termite proofing" the structure are discussed by Dost & Botsai (1990), Grace & Yates (1999), Verkerk (1990), and Yates *et al.* (1999), among other authors. With respect to physical barriers, recent papers by Yates *et al.* (2000, 2002) provide directions for use of a particle barrier (crushed basalt) to prevent termite penetration by *C. formosanus*, and a stainless-steel mesh is also a popular preventative barrier against this species (cf., Grace *et al.* 1996, Grace & Yates 1999).

Wood is still the most popular building material, although plastic has made rapid inroads in the residential fencing market, and steel has made the transition from an industrial building material to residential construction. In Hawaii, where lumber is relatively expensive and the threat of termite attack is very high, steel now commands nearly 70% of the residential framing market on the island of Oahu, according to various industry estimates (Grace, unpublished data).

Termite resistant wood products include naturally durable timbers, preservative-treated lumber and other solid wood products, and engineered (composite) materials. Variables that affect and may be modified to improve the durability of composite materials include use of a particular tree species or specific part of the tree in the product, selection of appropriate glues and binders, incorporation of plastics or cement, and substitution of wood fiber with various agricultural fibers.

NATURAL DURABILITY

Naturally-durable timbers offer an alternative to the use of wood preservatives. It is important to note, however, that only the heartwood contains extractives imparting insect and decay resistance; while the sapwood of most tree species is quite susceptible to attack. For example, heartwood of *Chamaecyparis nootkatensis* (yellow cypress, or Alaska cedar) and *Chamaecyparis obtusa* (hinoki) resists attack by the Formosan subterranean termite (Grace & Yamamoto 1994; Grace & A. Byrnes, unpublished), but the sapwood of both species is severally damaged (Grace 2000; Grace & A. Byrnes, unpublished). Extractive content in the heartwood (as well as the proportion of heartwood to sapwood in the tree) can also vary with age of the tree, and growth site. Teak from old-growth sites in Laos and Myanmar (Grace & Yamamoto 1994), for example, was more resistant to Formosan subterranean termite attack than heartwood samples from younger stands in Malaysia (Grace *et al.* 1999).

Variation also occurs in the response of different insects, and even different termite species in the same genus, to secondary plant compounds. The neem tree, *Azadirachta indica*, contains a wealth of biologically active chemicals, yet only compounds found in the bark and not the heartwood were found to deter subterranean termites (Delate & Grace 1995). Different species of *Coptotermes* have also been observed to respond differently to the heartwood of various tropical trees (Grace *et al.* 1998, 2000; Wong *et al.* 1998, 2001).

Where it is practical and economically viable to differentiate durable heartwood from susceptible sapwood, understanding the degree of natural durability of specific woods can open new export markets. Interest in using Indonesian bangkirai (*Shorea laevis*) for building construction in the Pacific region has increased in the past several years as a direct result of studies demonstrating termite resistance (Grace & Tome, unpublished). Natural termite-resistance also can be seen as a "value-added" property to encourage a local forestry industry (Grace *et al.* 1996), or cultivation of lesser-utilized tree species to replace depleted natural stands of tropical lumber species (Grace *et al.* 2000, Wong *et al.* 2001).

PRESERVATIVE TREATMENTS

Since most wood products are either not sufficiently resistant to termite attack, or contain a significant proportion of susceptible sapwood even though the heartwood may be durable, preservative treatment is the most important means of protecting these products against insects and decay. For residential construction, waterborne (e.g., CCA, ACZA, ACQ) and diffusible (disodium octaborate tetrahydrate) preservatives are most common, and are generally applied by pressure treatment. As a result of the high termite hazard in Hawaii, this state is unique in requiring that the entire structure be constructed of either treated or naturally-durable lumber.

Concerns in preservative treatment are (1) use of an adequate concentration of preservative for the target termite species, including a "safety factor" to account for both variation in the treatment and in lumber characteristics; (2) achieving either good preservative penetration of the lumber or such a perfect exterior (shell) treatment that termites cannot reach the susceptible interior wood; and (3) safe and appropriate use of the treated wood product.

Chromated copper arsenate (CCA) has been the most widely used waterborne preservative in North America, but is currently being phased out of use by agreement with the US Environmental Protection Agency. This preservative is certainly effective against the Formosan subterranean termite (Grace 1998, Grace *et al.* 2001, Tsunoda *et al.* 2001), but penetrates some commonly-used lumber species, such as Douglas-fir, very poorly. In Hawaii, where Douglas-fir is used extensively, disodium octaborate tetrahydrate (DOT) has become the most popular preservative. Current field tests in Hawaii and Japan (Grace *et al.* 2001, Tsunoda *et al.* 2002) have demonstrated that minor surface scarring by termites can occur on both DOT and CCA-treated timbers, but that this does not progress to the level of structural damage. In Hawaii, untreated hemlock and white fir control boards in this test are rapidly destroyed and must be replaced annually. Interestingly, boards treated with ammoniacal copper zinc arsenate (ACZA) in this same field test show much less evidence of surface exploration by termites than the CCA-treated boards, possibly due to some residual repellency associated with this treatment (Grace *et al.* 2001).

Although quite effective against both decay and insect attack (Grace 1997, and included citations; Grace *et al.* 2001, Tsunoda *et al.* 2002), the diffusible nature of DOT requires that it not be used in contact with the soil, or exposed to or running water or high rainfall (unless the surface is kept well sealed). A higher concentration of DOT is also required for exposure to the Formosan subterranean termite than with other termite species (Grace 1997, Su *et al.* 1994).

Thus, the treatment must be geared to the target termite species, and the treated wood must not be used inappropriately. In most of the United States, CCA has been the most popular treatment for wood used in exterior applications. As CCA is phased out these uses, ACQ (ammoniacal copper quat) is growing in use, at least in the southeastern USA. As with other new copper-based preservatives (e.g., copper azole, copper citrate), ACQ is more repellent than toxic to termites (Grace, unpublished) and appears to provide good protection in field use by this behaviorally-based mode of action (Preston *et al.* 1996). The longevity (long-term residual activity) of these newer repellent preservatives, in comparison to the more toxic preservatives, is not yet well-defined.

ENGINEERED WOOD PRODUCTS

Engineered wood products (composites) may be treated with a preservative either after manufacture, or by incorporation of a preservative such as zinc borate in the manufacturing process (Laks & Manning 1995, 1997). Incorporation of non-wood materials into composites will likely slow down any biological deterioration, but should not be relied upon to confer immunity from insects or decay. Fungal decay has been noted in plastic/wood lumber (Morris & Cooper 1998), and termites are capable of doing minor damage to cement/wood composites (Grace, unpublished data).

Naturally-durable woods are very rarely used in engineered wood products. However, Morris *et al.* (1999) demonstrated that the bark from western white spruce, essentially a waste product, could be used to manufacture composite boards with a high degree of resistance to both decay fungi and the Formosan subterranean termite. This approach to using natural durability (particularly if waste products from milling can be used) deserves attention.

Agricultural fibers are sometimes thought to have greater natural resistance to termite attack than wood fibers, although agricultural fields and stored grains are certainly subject to attack by other insects. However, boards made from sugar cane (bagasse) or industrial hemp fiber are attacked by Formosan subterranean termites (Grace 1996, and unpublished data). As with wood composites, incorporation of a preservative treatment appears necessary to protect agricultural fibers from termite attack.

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