Hawaiian Experience with Treated Building Components

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Abstract

Both termites and decay are significant problems in the tropical climate of the Hawaiian Islands. The Formosan subterranean termite, *Coptotermes formosanus*, is a severe pest in Hawaii, followed in importance by the drywood termite *Cryptotermes brevis*. Several other important pest termites have also been recently introduced to Hawaii, including *Coptotermes vastator*, a relative of *C. formosanus*. For over 2 decades, building codes in Hawaii have required use of a soil insecticide treatment or a physical barrier to subterranean termites and preservative treatment of all structural timbers. "Hawaii Use Only" chromated copper arsenate treatment of Douglas-fir, coupled with soil treatment, was the most popular building system for quite a few years. Subsequently, ACZA treatment made small inroads into the Hawaii market. In the past decade, disodium octaborate treatment at 0.42 pcf (Hi-Bor) has become the most commonly used framing treatment. An oil treatment of chlorpyrifos and IPBC (Tribucide) has commonly been used for exposed beams and other decorative timbers. Laboratory and field studies have demonstrated the efficacy of these preservatives when both penetration and an adequate retention are achieved. Although steel framing has taken a large market share in Hawaii, new wood treatments are currently being evaluated, particularly for composite materials. These studies demonstrate that composites require treatment in regions of high termite pressure, and that one cannot assume that inclusion of non-cellulosic materials in a product is sufficient to eliminate termite attack.

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Termites In Hawaii

Termites have been estimated to cost the residents of Hawaii approximately US$ 100 million each year. The Formosan subterranean termite, *Coptotermes formosanus*, is the most serious insect pest in Hawaii. This termite has been present for over 100 years and is found on all of the major islands (10,25,30) . Recently, a second subterranean termite, *Coptotermes vastator*, has also become established in Hawaii, although only on the island of Oahu (28). The discovery of *C. vastator* in Hawaii is significant, since it is the most serious termite pest in Guam and the Philippines (22, 27).

Other termites found in Hawaii are *Cryptotermes brevis, Cryptotermes cynocephalis, Incisitermes immigrans, Incisitermes minor, Neotermes connexus,* and *Zootermopsis angusticollis* (10, 30). Of these, *C. brevis* is the most common drywood termite pest occurring in buildings. *Incisitermes immigrans* occasionally infests structural lumber, and *C. cynocephalis* and *I. minor* are serious pests in other parts of the world that were only introduced to Hawaii during the past few years but have the potential to become serious problems there as well.

A thorough approach to termite prevention requires a combination of the following elements:

1. proper architectural design, including moisture management, elimination of any wood to soil contact, and efforts to ensure 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. 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; and
5. periodic inspections of the building.

Commercial use of physical barriers to termite penetration in building construction originated in Hawaii with the Basaltic Termite Barrier, invented at the University of Hawaii (24,31). This product consists of crushed basaltic rock, screened to a particle size that termites are unable to move with their mandibles. The rock is too hard for the termites to crush, and packs together too tightly for them to find spaces through which to move. Thus, it forms a non-chemical barrier to termite tunneling. This barrier is used in all State Government construction in Hawaii, and is also used by a number of architects in residential construction. A second physical barrier consisting of a marine-grade stainless steel screen, TermiMesh, is also common in new construction in Hawaii to prevent termite penetration (14,15). As described below, local building codes in Hawaii require that specific steps be taken in construction to prevent termite attack.

Wood Treatment in Hawaii

Wood is still used extensively in building construction in Hawaii, 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. Steel now commands nearly 70 percent of the residential framing market on the island of Oahu and as much as 40 percent statewide, according to various industry estimates (6).

As a result of the high termite hazard in Hawaii, local building codes are unique in requiring that wood-frame residential structures be entirely constructed of preservative-treated lumber. Honolulu Wood Treating Co., Ltd., was incorporated in Hawaii in 1955, and began locally treating lumber in 1956. Douglas-fir from the Pacific Northwest is the major lumber species used in Hawaii, and this refractory species is not recommended for treatment with chromated copper arsenate (CCA). However, pressure treatment with CCA was the only viable approach at that time. CCA has been the most widely used waterborne preservative in North America, although it will be phased out of use for treatment of construction lumber in 2003, by agreement with the U.S. Environmental Protection Agency (EPA). This preservative is certainly effective against the Formosan subterranean termite (4,7,26), but penetrates some commonly used lumber species, such as Douglas-fir, poorly.

In order to achieve some measure of quality control, the American Wood-Preservers' Bureau (AWPB) took the lead in the early 1960s, in drafting an "Hawaii Use Only" (HUO) standard for treating Douglas-fir for the Hawaii market. This standard required the accepted aboveground CCA retention of 0.25 pcf, but did not have a penetration requirement, nor require incising prior to treatment. Since there is very little penetration of preservative below the wood surface, it takes a rather lengthy and rigorous treatment cycle to achieve the required retention in the form of a thin, shell treatment of the lumber. Along with adoption of the HUO standard, Wolman introduced a 20-year, $5,000 replacement bond program in Hawaii that required on-site end-coating of cuts, pretreatment of the soil with a termiticide, and regular property inspections. Other CCA manufacturers followed suit, and these termite prevention measures became standard construction practice in Hawaii.

Although the multiple precautions (integrated pest management) required by the wood replacement warranties in Hawaii represented a reasonable and state-of-the-art approach to termite prevention, substandard treatments ("pressure painting") are sometimes applied to lumber sold at the retail consumer level, and homeowners and small contractors are generally not involved in warranty programs and are not always conscientious about end-coating and soil treatment. With the poor CCA penetration of Douglas-fir even with careful treatment, careless wood treatment or omission of any of the other on-site precautions means disaster when termites find there way into the untreated interior of the structural lumber. In Hawaii's tropical environment, fungal decay is also a significant problem that is promoted by poor treatment, failure to end-coat, and inappropriate architectural design (1,28).

In 1984, Wilcox (28) discussed the difficulty of obtaining any wood more treatable than Douglas-fir in Hawaii due to the long-standing trade relationships fostered by an island economy. He also emphasized the poor architectural decisions that contributed to termite and decay problems in Hawaii's structures. Subsequently, ammoniacal chromated zinc arsenate (ACZA) was introduced as a commercial wood treatment for Douglas-fir in Hawaii, with treatment following AWPA recommendations of 0.25 pcf and incising prior to treatment. The combination of incising and an ammoniacal treatment resulted in better penetration of the lumber and effective termite prevention (7,23), and this treatment was readily adopted by several large contractors. However, the dark-colored and incised wood surface had limited appeal to many architects, contractors, and consumers, who continued to favor CCA-treated lumber.

In the late 1980s, significant changes were made in the local amendments to the building code of the City and County of Honolulu, with other counties in Hawaii following suit. A provision allowing the practice, still common in the U.S. mainland, of incising and treating only the mudsill (bottom wall plate) in residential construction to the ground-contact retention of 0.40 pcf CCA and using untreated framing throughout the rest of the structure was removed. Up to this point, contractors had the option of either following this provision or treating all structural lumber to 0.25 pcf CCA in accordance with the HUO standard or ACZA treatment specifications. With this local amendment, the only option available was to have all structural lumber treated with CCA or ACZA. Treatment of the soil with a termiticide was also required by the code in addition to use of treated wood, and installation of a screened particle barrier such as the Basaltic Termite Barrier was incorporated into the code as an alternative to soil treatment. In the late 1990s, use of a marine-grade stainless steel mesh (TermiMesh) was also incorporated into the code as an additional option for creating a barrier to termite penetration of the structure.

In 1991, the diffusible preservative disodium octaborate tetrahydrate (DOT) was approved for use in Hawaii. A higher concentration of DOT is required for exposure to the Formosan subterranean termite than with other termite species (3,21), and a series of laboratory and field tests were performed to establish threshold requirements and commercial treatment retentions (12,13). Currently used in Hawaii at a recommended retention of 0.42 pcf, DOT is able to achieve significant penetration in Douglas-fir and rapidly displaced CCA for treatment of structural framing. Ongoing field tests in Hawaii and Japan (7,26) 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.

DOT is effective against both decay and insect attack (3), but its diffusible nature requires that it not be used in contact with the soil, or exposed to running water or high rainfall unless the surface is kept well sealed. Recently, ACQ (ammoniacal copper quat) was approved for use in Hawaii, and with the demise of CCA, ACQ and other new copper-based preservatives such as copper azole and copper citrate are likely to be adopted for these exterior applications. ACQ is more repellent than toxic to termites (6) and appears to provide good protection in field use by this behaviorally based mode of action (20). The longevity of these newer repellent preservatives, in comparison to the more toxic preservatives, is not yet well-defined.

For the past decade, DOT, under the trade name Hi-bor, has been the most widely used preservative for treatment of construction lumber in Hawaii. When an oil-based treatment is required, as for exposed woodwork or glulam beams, the preferred treatment has been a chlorpyrifos/IPBC formulation (Tribucide). Target chlorpyrifos retentions are 0.0175 pcf, which is approximately 35× the toxic threshold to Formosan subterranean termites (6). Recently, zinc borate has entered the marketplace as a treatment for composite products during manufacture, and field tests in Hawaii have demonstrated that this treatment is very effective against the Formosan subterranean termite (16,17).

Alternatives to Wood Treatment

Alternatives to preservative-treated solid lumber that have been suggested in Hawaii include naturally-durable timbers, steel, plastic, and composite products incorporating agricultural fibers, plastics, or cement. As previously mentioned, steel framing and plastic fencing have achieved large market shares in Hawaii, due both to their obvious resistance to termites and to the higher cost of wood in Hawaii in comparison to the U.S. mainland. Naturally durable timbers have been used in lieu of treated wood in some instances in Hawaii and are approved by the local building departments on a case-by-case basis. For example, Indonesian bangkirai, *Shorea laevis*, has been used to construct several buildings in Hawaii, and interest in expanded use of this species in the Pacific region has developed as a result of studies demonstrating its termite resistance (6). It is important to note, however, that only the heartwood of durable tree species contains extractives imparting insect and decay resistance; while the sapwood of most tree species is quite susceptible to attack. For example, heartwood of *Chamaecyparis* species (Hinoki and Alaska cedar) resists attack by the Formosan subterranean termite (11), but the sapwood is subject to attack (5). 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 (11), for example, was more resistant to Formosan subterranean termite attack than heartwood samples from younger stands in Malaysia (9).

Composite wood products are sometimes thought to be more resistant to termite attack than solid wood because of the addition of non-cellulosic materials or agricultural fibers. It is true that incorporation of non-cellulosic materials will likely slow down biological deterioration, but it does not confer immunity. For example, fungal decay has been noted in plastic/wood lumber (18), and termites are capable of doing minor damage to cement/wood composites (6). In the case of agricultural fibers, it is worth remembering that grains in the field and in storage are attacked by many insects and plant pathogens, and it is therefore unlikely that boards or panels containing such fibers would be insect-resistant. Boards made from sugar cane (bagasse) or industrial hemp fiber have been found to be attacked by Formosan subterranean termites (2,6).

An interesting approach to conferring durability to composites is the incorporation of either wood or extractives from naturally durable tree species. Morris and colleagues (19) 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.

In general, under the conditions of high termite hazard found in Hawaii, even naturally durable timbers require some level of preservative treatment unless they are truly all heartwood, and composites should either be treated during or after manufacture. In the past, Hawaii has been unique in requiring treatment of all structural lumber, and even after-manufacture treatment of composite building materials. However, with the expanding range of the Formosan subterranean termite in the southeastern United States, an increasing interest in value-added and branded lumber products on the part of major national manufacturers and distributors, and the development of in-line treatments such as zinc borate for composites, use of treated wood products for termite prevention is likely to spread far beyond the shores of Hawaii.

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