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Termite Resistance of Borate-treated Lumber in a Three-year Above-ground Field Test in Hawaii

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Abstract

A protected above-ground field test simulating the sill plate (dodai) used in conventional Japanese housing construction was established in both Hawaii and Japan to examine the efficacy of disodium octaborate tetrahydrate (DOT, 2% and 3% shell and through) wood treatments. In Hawaii, chromated copper arsenate (CCA, 4 kg/m^3) and ammoniacal copper zinc arsenate (ACZA, 4 kg/m^3) were included in the test, along with untreated western hemlock and Pacific silver fir controls. Both field sites support active Formosan subterranean termites, *Coptotermes formosanus* Shiraki, although termite pressure is greater in Hawaii probably due to the uniformly favorable environmental conditions. After three years, minor damage (visual rating of 7) has been noted to four individual treatment dodai (out of a total of 10 boards per treatment) as follows: 2% BAE shell treatment (1 board), 2% BAE + DDAC through treatment (2 boards), and CCA treatment (1 board). These same individual boards had been also rated 7 in the second year of the study; and, although at Year 3 ternutes are still present on the boards in each case, there has been no further visible deterioration. This supports an hypothesis of delayed deterrence from termite exposure to these nonrepellent treatments. In contrast, untreated control boards in Hawaii were completely destroyed within one to two years. Overall, all treatments have provided very good protection from termite attack over the three years of the study, with 9.3 representing the lowest mean rating. These results support the use of DOT, CCA or ACZA treatments to protect dodai from termite attack.
Key Words: *Coptotermes formosanus*, disodium octaborate tetrahydrate, sill plate, dodai

Introduction

As described by Grace *et al.* (1995), a protected above-ground field test was devised to evaluate the efficacy against Formosan subterranean termite (*Coptotermes formosanus* Shiraki) attack of disodium octaborate tetrahydrate (DOT) wood treatments of hem-fir intended for use as sill plates (dodai) in conventional Japanese building construction. With only minor variations, this test is replicated in Waimanalo (Island of Oahu), Hawaii, and in Kagoshima Prefecture (Island of Kyushu), Japan. Both test sites support active Formosan subterranean termite populations.

Grace *et al.* (1995) and Tsunoda *et al.* (1998) have described the test design and preliminary results from Hawaii and Japan, respectively. In addition to 2% and 3% BAE borate shell and through treatments, each test plot also includes chromated copper arsenate (CCA, 4.0 kg/m^3), untreated

control samples of both western hemlock (*Tsuga heterophylla*) and Pacific silver fir (*Abies amabilis*) (commercially sold as hem-fir, a mixture of these two species), and a locally-used timber considered to be termite resistant. In Japan, this locally-used wood is untreated hinoki (*Chamaecyparis obtusa*), a naturally durable softwood representative of the greater reliance on natural durability in Japanese construction (Grace 1999, 2000; while in Hawaii it is Douglas-fir (*Pseudotsuga menziesii*), incised and treated with ammoniacal copper zinc arsenate (ACZA, 4.0 kg/m^3).

The results of four years of field exposure in Japan are reported by Tsunoda *et al.* (2000). In the present paper, we report the results of three years of field exposure in Hawaii.

Materials and Methods

As described by Grace *et al.* (1995), test samples ca. 10 by 10 by 40 cm in size (ca. 2 kg) were each placed on a concrete building block 19 cm above soil grade. Untreated softwood feeder stakes within the block hollows extend into the soil. Each replication of 8 wood samples (complete block design) is covered with an untreated plywood box. Design of the concurrent test in Japan is essentially the same, except that plastic covers are used rather than plywood. In Hawaii, the plywood covers are replaced as necessary due to termite damage and weathering.

Treatments included in the field study in Hawaii are ACZA (Douglas-fir, 4.0 kg/m^3, incised); CCA (hem-fir, 4.0 kg/m^3, incised); and DOT (hem-fir, disodium octaborate tetrahydrate) at 2% boric acid equivalent (BAE) shell treatment, 2% BAE through treatment, 2% BAE + DDAC (didecyldimethylammonium chloride) through treatment, 3% BAE shell treatment, and 3% BAE through treatment. Each of the 10 test units also contains an untreated western hemlock or Pacific silver fir control board.

Annual inspections are non-destructive, utilizing a visual rating scale: 10 (sound), 9, 7, 4, 0 (complete failure). In Hawaii, untreated control boards must be replaced at 1-2 year intervals when they evidence complete failure, in order to ensure that an acceptable control is present in each replicate to monitor termite activity. In the present report, control boards were replaced after Year 2 when all had failed completely. For the sake of consistency, we have carried over the ratings of 0 for the original controls to the third year. However, many of the newly-placed control boards were completely destroyed by the Year 3 inspection, and the mean rating was 3.0, after only 10 months of field exposure.

Results and Discussion

Results of the 3-year inspection in February 2000 are presented in Table 1. Due to the size of the wood pieces (ca. 2 kg), it should be pointed out that a visual rating of 7 (significant attack, 5 or more deep penetrations) likely represents a very small mass loss due (perhaps ca. 1-5%).

During the first two years of the study, termites were active in all test units except #5. Since there was no attack on the untreated control in this unit, nor any evidence of termite exploration, this unit was not included in calculating the average visual damage ratings during these first two years. However, termites discovered and attacked the wood in this test unit during the third year of the test to the point where the control was rated 0, and ratings for unit #5 are included in the Year 3 averages. On the other hand, termites unexpectedly vacated test unit #2 between the Year 2 and Year 3 inspections. In this case, we have included ratings of the treated wood samples in this unit in the Year 3 average ratings, since they were previously attacked and it is likely that termites will return to this unit. Unlike wood decay fungi, termites are mobile and appear capricious in their foraging behavior, factors that must be taken into consideration in designing and evaluating field tests (Grace 1995).

On the average, all wood treatments protected the sill plates over the three-year period, with mean ratings ranging from 9.3 to 10. This is in sharp contrast to the complete failure (rating of 0) of five of the ten control boards within the first year of the test, and subsequent rapid failure of the remaining controls. The lowest individual board rating in Year 3 was 7, occurring with the 2% BAE shell treatment (1 board), 2% BAE + DDAC through treatment (2 boards), and CCA treatment (1 board). These same individual boards were also rated 7 in the second year of the study; and, although termites are still present on the boards in each case, there has been no further visible deterioration. As noted in previous work (Grace & Yamamoto 1994, Grace 1998), neither DOT nor CCA are repellent to termites, and minor damage is not unexpected. In the case of DOT, the lack of progression of attack beyond a rating of 7 after the second year of field exposure, despite the location of each of these samples within the test array immediately adjacent to untreated controls that were completely destroyed within a single year, is consistent with the "delayed deterrence" hypothesized from other studies (Grace 1997).

Results of this field test concur with those obtained in Japan (Tsunoda *et al.* 2000), where minor surface damage (rating of 9) has been noted with a single board each in the 2% BAE + DDAC through treatment and the CCA treatment. As would be expected, termite activity is at least 3-fold greater in Waimanalo, Hawaii, than in Kagoshima Prefecture. The uniformly high temperatures and high humidity found in Hawaii facilitate year-round foraging and growth of the colonies, in contrast to the seasonality found in Kagoshima. Since Formosan subterranean termites are firmly established in both locations, surviving very well, and represent the major structural problem in both locations, the potential for broader distribution of this damaging species is clear and emphasizes the need for effective treatment of lumber to be used in wood-frame construction. Results to date of both the 4-year field exposure in Japan and 3-year exposure in Hawaii support the use DOT, CCA, or ACZA wood treatments to protect otherwise susceptible sill plates (dodai) from termite attack.

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TABLE 1. Visual damage ratings on the AWPA 10 -0 scale of ca. 10 x 10 x 40 cm boards exposed to Formosan subterranean termite attack for two years in a protected above-ground field test in Waimanalo, Hawaii.[a]

Test Box	DOT 2% BAE, shell	DOT 3% BAE, shell	DOT 2% BAE, through	DOT 3% BAE, through	DOT + DDAC 2% BAE, through	CCA 4 kg/m^3	Untreated Hem-Fir[b]	ACZA 4 kg/m^3
#1	9-7-7	10-10-10	10-10-10	10-10-10	10-10-10	F 9-10-9	F 0-0-0	10-10-10
#2[c]	9-10-10	10-10-10	10-10-10	9-9-10	9-9-9	F 10-10-10	F 4-0-0	10-10-10
#3	10-10-10	9-10-10	10-10-9	10-10-10	9-10-10	F 10-10-10	F 0-0-0	10-10-10
#4	10-9-9	10-10-10	10-10-10	10-10-9	10-10-10	F 10-10-10	F 0-0-0	10-10-10
#5[d]	na-na-9	na-na-9	na-na-9	na-na-10	na-na-10	F na-na-10	F na-na-0	na-na-10
#6	9-10-10	10-10-10	10-10-9	10-10-10	10-7-7	H 9-7-7	H 4-0-0	10-10-10[e]
#7	10-10-10	10-10-9	9-10-10	9-10-10	9-7-7	H 10-10-10	H 0-0-0	10-10-10
#8	10-10-10	10-10-10	9-9-10	10-10-10	9-10-10	H 10-10-10	H 0-0-0	10-10-10
#9	10-10-10	10-10-10	10-10-10	9-10-10	10-10-10	H 9-10-9	H 4-4-0	10-10-10
#10	10-10-10	10-10-10	10-10-10	10-10-10	10-10-10	H 10-10-10	H 4-4-0	10-10-10
AVERAGE	9.7-9.6-9.5	9.7-9.9-9.8	9.8-9.9-9.7	9.6-9.2-9.9	9.9-9.2-9.3	9.7-9.7-9.5	1.8-0.9-0.0	10-10-10

[a] All boards except ACZA treatment (Douglas-fir) are hem-fir. CCA and ACZA treatments are incised as per AWPA recommendations. Rated on the AWPA visual rating scale of 10 (sound), 9, 7, 4, 0 (failure).
[b] Fir (F) and hemlock (H) controls were replaced after complete failure during Year 2-3. New controls in Year 3 had a mean rating of 3.0 after only 10 months.
[c] Termites present in test unit #2 in Years 1-2, but no termites present in Year 3 (as indicated by absence of feeding on control).
[d] There was no evidence of past or present termite exploration or attack in test unit #5 during Years 1-2, so this unit is not included in average for those years.
[e] Minor surface etching noted on underside of ACZA treatment in unit #6, ca. 1 mm deep by 3 mm wide by 20 mm long.