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Performance of borate-treated lumber after 10 years in a protected, above-ground field test in Japan (Final report)

Kunio Tsunoda[1], Anthony Byrne[2], Paul I. Morris[2], and J. Kenneth Grace[3]

[1] Research Institute for Sustainable Humanosphere, Kyoto University, Uji, Kyoto 611-0011, Japan
[2] Forintek Canada Corp., Western Laboratory, 2665 East Mall, Vancouver, British Columbia V6T 1W5, Canada
[3] Department of Plant & Environmental Protection Sciences, University of Hawaii at Manoa, 3050 Maile Way, Honolulu, Hawaii 96822-2271, USA

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Kunio Tsunoda[1], Anthony Byrne[2], Paul I. Morris[2], and J. Kenneth Grace[3]

[1] Research Institute for Sustainable Humanosphere, Kyoto University, Uji, Kyoto 611-0011, Japan
[2] Forintek Canada Corp., Western Laboratory, 2665 East Mall, Vancouver, British Columbia V6T 1W5, Canada
[3] Department of Plant & Environmental Protection Sciences, University of Hawaii at Manoa, 3050 Maile Way, Honolulu, Hawaii 96822-2271, USA

ABSTRACT

This document is supplemental to the previous IRG document (Tsunoda *et al*. 2004). An experiment to simulate the sill plate (dodai) of the Japanese houses was conducted at the termite field test site of the Research Institute for Sustainable Humanosphere of Kyoto University in Kagoshima Pref., Japan where two economically important subterranean termite species [*Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe)] are established. DOT(disodium octaborate tetrahydrate)-treated hem-fir samples [*Tsuga heterophylla* (Raf.) Sarg. and *Abies amabilis* (Dougl.) Forbes]- 105 x 105 x 500 mm in size were placed on concrete blocks 19 cm above the ground surface. The test samples were prepared from sound wood samples pressure treated to supply 10 replicates of shell-treated materials at target levels of 2% BAE and 3% BAE. The subsequent diffusion storage produced another set of through-treated samples at the same target levels. Feeder stakes within the block hollows extended into the soil to facilitate the access of the termites to the wood samples. The assembled sets were covered with plastic boxes to protect the samples from the weather. Samples were annually inspected for termite attack and decay and visually rated according to AWPA standard since installation on December 21, 1995.

All treated samples still remained free from decay after 10 years' exposure. In contrast, slight progress in termite attack was observed on a few treated samples within the last two years. Four samples with target retention of CCA 4 kg/m^3 were slightly attacked with mean rating of 9.6 against termite attack after 10 years. This meant that the extent of termite attack did not develop after the first attack. Through treatment at 3% BAE performed as well as CCA 4 kg/m^3 after 10 years with mean rating of 9.5. Although mean ratings of termite attack on the treated samples ranged from 8.8 to 9.6, statistical analysis showed no significant differences among all treatments. Untreated hem-fir and hinoki (*Chamaecyparis obtusa* Endl.) controls showed progressive termite attack starting in the first year and were heavily attacked after 10 years' exposure. Decay was found on 9 and 6 untreated hem-fir and hinoki, respectively.

Keywords: Borate-treatment, disodium octaborate tetrahydrate (DOT), subterranean termites, sill plate (dodai), above-ground use, field test

1. INTRODUCTION

Sodium borate is a diffusible preservative and unfixed in wood. These properties do not allow treatment with water-soluble borates to meet performance requirements after severe leaching and evaporation cycles. The recently revised Japanese standard (JIS K 1571 2004) established the mild evaporation method (60 for 7 days) for dry above-ground use without any risk of wetting. However, this weathering method is not always applied to evaluation of preservatives for treating wood in use class 2 above-ground conditions.

A test design to simulate the sill plate (dodai)-use was previously developed for evaluating the effectiveness of preservatives against subterranean termites (Grace *et al*., 1995; Tsunoda *et al*., 1998; Morris *et al*., 2003) over a long period of field exposure under protected above-ground conditions. The test method is also applicable to the evaluation of biological resistance of other wood materials without modification (Tsunoda 2003, 2005). The objective of the current investigation was to determine whether borate-treatments could provide wood products with resistance against both subterranean termites and decay fungi in an above-ground protected test in Japan.

2. MATERIALS AND METHODS

Sound, unseasoned hem-fir samples (105 x 105 x 1300 mm) were cut from lumber so that 500 mm long end-matched samples, free of large knots and checks, were obtained following treatments. The wood samples were pressure treated with aqueous solutions of disodium octaborate tetrahydrate (DOT) or DOT with didecyldimethylammonium chloride (DDAC). Ten replicates were produced of both shell- and through-treated cross sections treated to target retentions of 2% and 3% boric acid equivalent (BAE). Retentions of shell treated samples were determined by chemical analyses of the surface 16 mm zones.

For comparison to a standard preservative additional samples were also treated with chromated copper arsenate (CCA) to a retention of 4.0 kg/m^3. For each treatment half of the hem-fir samples were western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] and half were Pacific silver fir [*Abies amabilis* (Dougl.) Forbes]. Untreated samples of both species and of hinoki [*Chamaecyparis obtusa* (Endl.)] a naturally durable softwood, were included in the field test.

After determining the air-dried weight of each wood sample, the samples were installed at the termite field test site in Kagoshima Prefecture, Japan on December 12, 1995. Each sample was placed on a concrete block with pine sapwood feeder stakes in the hollows of the concrete blocks. The feeder stakes were driven into the soil to encourage initial termite attack and these stakes were replaced after 3 and 5 years' service. The installed samples were placed in clusters of eight, one each of 8 treatments* and each cluster was covered with a PVC box. The replication of 10 per treatment resulted in 10 boxes being installed. Annual visual inspection was conducted and the degree of termite attack was rated according to AWPA field stake test procedure [10: sound (no attack), 9: trace to slight attack (surface nibbling or shallow excavation), 7: moderate attack (obvious penetration), 4: heavy attack (deep penetration), and 0: failure (sample largely disintegrated) (American Wood Preservers' Association 2001). A similar rating 0-10 was given for decay.

Inspection results were statistically analyzed by Tukey's test (p: <0.01) (inerSTAT-a v1.3) (Vargas 1999) to compare the performance among treatments after 10 years' exposure.

* 2% BAE shell, 3% BAE shell, 2% BAE through, 3% BAE through, 2% BAE +DDAC shell, CCA 4 kg/m^3, untreated hem-fir and untreated hinoki.

3. RESULTS AND DISCUSSION

3.1 Inspection results up to 8 years' exposure

We have already reported the inspection results for the first 8 years (Tsunoda *et al.* 2004) but, briefly summarize them here.

All treated samples were found free from decay. Slow progress in termite attack was recorded on the samples of 5 treatments, except 3% BAE through treatment of which only two samples sustained very slight termite attack. In contrast, both termite attack and decay on the untreated control developed as expected, and mean termite rating went down to 4.0 (severe damage) (Fig. 1).

3.2 Inspection results after 10 years

The treated samples outperformed untreated samples without any exception. All treated samples still remained free from decay after 10 years' exposure, although slight progress in termite attack was observed on a few treated samples in the 9^{th} and 10^{th} years. Four samples with target retention of CCA 4 kg/m^3 were slightly attacked with mean rating of 9.6 against termite attack. This meant that the extent of termite attack did not develop after the occurrence of first attack. Through treatment at 3% BAE performed similarly to the treatment of CCA 4 kg/m^3 with mean rating of 9.5. After 10 years' exposure, 5-6 samples from each group of borate treatments (2% BAE shell, 3% BAE shell, 2% BAE through and 3 % BAE through treatments) were slightly attacked by termites. The number of borate-treated samples, which sustained termite attack, increased within the last two years. It should be noted that Tuckey's test ($p: <0.01$) showed no significant differences among all treatments.

Untreated hem-fir and hinoki (*Chamaecyparis obtusa* Endl.) controls showed progressive termite attack starting in the first year and were heavily attacked, and mean rating of each wood species went down to 4.0. Incipient decay was first found on 7 untreated hem-fir and sapwood portion of two untreated hinoki during the 5^{th} year of exposure, whereas 9 and 6 sustained slight to heavy decay after 10 years' exposure, respectively.

3.3 General discussion

The ability of DOT to control decay has been well established in literature (Drysdale1994) and the low natural durability of hem-fir to decay has also been reported (Panshinn and De Zeeuw 1970; Highley 1995). Recent reviews indicate that the effectiveness of sodium borates to subterranean termites in above-ground situations varies with test methods and termite species (Drysdale1994; Grace 1997; Tsunoda 1999). However, borate retentions ranging from 0.5% to 2.5% BAE protect wood products from subterranean termites, including *Coptotermes* species (Preston *et al*. 1985, 1996; Grace and Yamamoto 1993, 1994; Moffat and Peters 1993; Peters and Allen 1993; Peters and Fitzgerald 1998) with a few exceptions (Archer *et al*. 1991; Kennedy *et al*. 1996). The present results seem to fit with these findings.

Experimental design is clearly an important factor in the efficacy of unfixed preservatives such as DOT that must be used under protected above-ground conditions to prevent serious leaching. Therefore, the retention of a test preservative during the test period must be determined chemically in order to confirm that the method is suitable for testing leachable preservatives. Unfortunately, chemical analytical data was not given for the previously reported investigations where borate treatment failed against termites. Such failure could thus be attributable to low levels of borate, resulting from low initial retentions or from leaching of the preservative, or to the presence of borate-tolerant termites such as *Mastotermes* sp. (Peters and Fitzgerald,1998) and

Nasutitermes sp. (Gay *et al*., 1958).

The test samples were recovered after 10 years' exposure to determine the distribution of DOT and to chemically analyze the DOT retention of each treated sample. The obtained data will be compared with those from Hawaii and Canada for better understand of the performance of borate-treated lumber under protected, above-ground conditions.

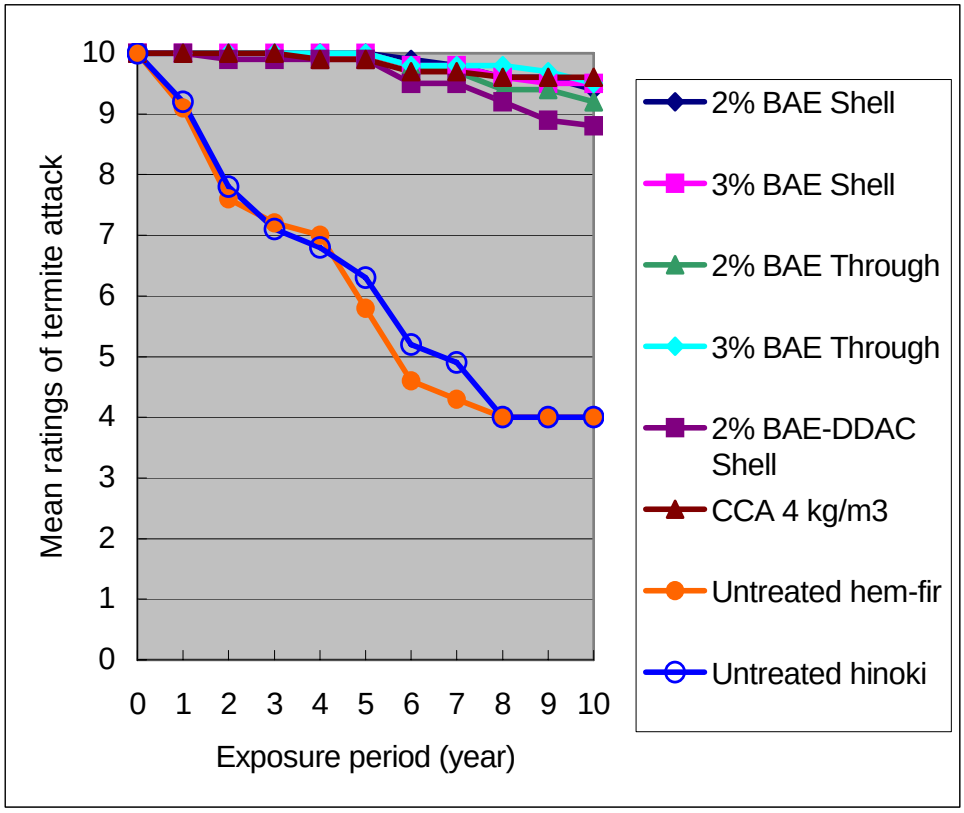

Fig. 1 Progress in termite attack on treated and untreated lumber

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