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Performance of Borate-Treated Wood Against *Reticulitermes flavipes* in Above-Ground Protected Conditions

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ABSTRACT

Termites cause economically significant damage in Canada only in a few localized areas. However, one of those is in Canada's largest city, Toronto, Ontario. In 1996, a test was set up of borate-treated lumber above ground, protected from rain but exposed to subterranean termites (*Reticulitermes flavipes*)in Kincardine Ontario. The material included western hemlock and amabilis fir lumber treated with borate and chromated copper arsenate (CCA). After 6 years exposure, the treated material was generally performing well, with some pieces showing residual signs of earlier superficial feeding or cosmetic damage. Performance of borate-treated and CCA-treated samples were equivalent. Attack was moderate on untreated controls.

KEYWORDS: Borate treatment, subterranean termites, sill plate, above ground, field test

1 INTRODUCTION

To maintain and expand markets for Canadian wood products in termite-infested areas, it is critical that wood frame construction uses multiple lines of defense against termite attack (Morris 2000). The last line of defense before damage occurs is the use of treated wood. It is therefore important to demonstrate that Canadian treated wood can provide adequate termite resistance. disodium octaborate tetrahydrate (DOT) is particularly effective at penetrating deeply into the relatively impermeable Canadian Wood species. However, DOT is not fixed in wood and is eventually leached out in ground-contact. The major commercial application for this preservative is therefore above ground, protected from liquid water.

A test method was therefore designed simulating sill plates on concrete foundations protected from the weather, but exposed to termites (Grace *et al.* 1995). Experiments are underway, using traditional Japanese sill plates (dodai), in Hawaii (Grace *et al.* 2001) and Japan (Tsunoda *et al.* 2002,) where the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, presents an extreme hazard. This termite has in the past few years become established in the southern United States, particularly Louisiana where property losses have amounted to billions of dollars.

In Canada, the western subterranean termite, *Reticulitermes hesperus* Banks causes some economic impact in the Okanagan and Georgia Basin regions of British Columbia and the Eastern subterranean termite, *Reticulitermes flavipes* (Kollar), causes substantial economic impact in parts of southwestern Ontario. The latter problem receives considerable attention because it affects Toronto, Canada's largest city. Although pressure treatment with wood preservatives is known to confer protection against termites, there has been very little data generated on the performance of treated Canadian wood species.

With the assistance of the town of Kincardine, Ontario, Forintek set up a ground-contact termite test site in 1988 (Doyle 1990). This town represents the northerly limit of known infestations of termites in Ontario. In late 1996, the test was expanded to include material out of ground contact, using samples that failed to meet the target retention for trials of borate treated wood being set up in Hawaii and Japan, but met the requirements for use in Canada (CSA O80.1997a). This report summarizes performance of the above ground test material after six years of exposure.

2 METHODS

Test specimens, 100 x 100 x 400 mm, were prepared from western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), Pacific silver fir (*Abies amabilis* (Dougl.) Forbes), and western red cedar (*Thuja plicata* D. Donn.). Ten western hemlock pieces were selected to achieve a mean retention of 3.3 kg/m^3 B_2O_3 (1.4% Boric acid Equivalent - BAE) in a 25-mm shell treatment from a larger number of specimens pressure-treated with an aqueous solution of DOT. This met the requirements of CSA O80.34 for borate-treated lumber used out of ground contact (Canadian Standards Association 1997a). Ten fir replicates through-treated to a mean of 2.5 kg/m^3 B_2O_3 (1.3% BAE) in the full cross-section were also selected. This material would have just failed the CSA O80.34 retention requirement of 2.7 kg/m^3 B_2O_3. Ten hem-fir pieces were treated to a mean of 3.2 kg/m^3 B_2O_3 (1.4% BAE) in a 25-mm shell with DOT solution to which 0.5% of didecyldimethylammonium chloride (DDAC) had been added to improve penetration.

To compare the performance of borate to another preservative, five each of hemlock and fir samples were prepared from incised lumber pressure-treated with chromated copper arsenate (CCA-C) to retentions of 4.0 and 5.0 kg/m^3, respectively, and preservative penetrations of 10 mm or more. These CCA-treated samples met the retention and penetration requirements of CSA O80.2 for lumber exposed above ground (Canadian Standards Association 1997b). The cut end of each CCA-treated piece of lumber was given a coating of commercial copper naphthenate field-cut preservative. Borate retentions were determined by mannitol titration (Winters ca. 1965), and CCA was analysed by energy dispersive X-ray spectrometry (American Wood Preservers' Association 1997). Ten untreated samples of western red cedar, a naturally durable species were also included, along with five each of untreated hemlock and fir controls.

The test method (Grace *et al.* 1995) was designed such that the wood samples would rest on top of concrete blocks standing on the soil surface and the whole assembly covered with a box to protect from rain and to maintain high humidity (Figure 1). There was no direct contact between the samples and the soil, other than that brought by the termites to construct shelter tubes. The covering boxes were constructed from CCA-treated plywood, 600 mm wide x 350 mm high x 1000 mm long with an open bottom. The exterior and interior were painted with exterior primer and two coats of white paint to reduce build-up of heat in direct sun. Within each box, six hollow concrete blocks purchased from a local lumberyard were placed directly onto the leveled soil in a 3 x 2 array, 50 mm apart.

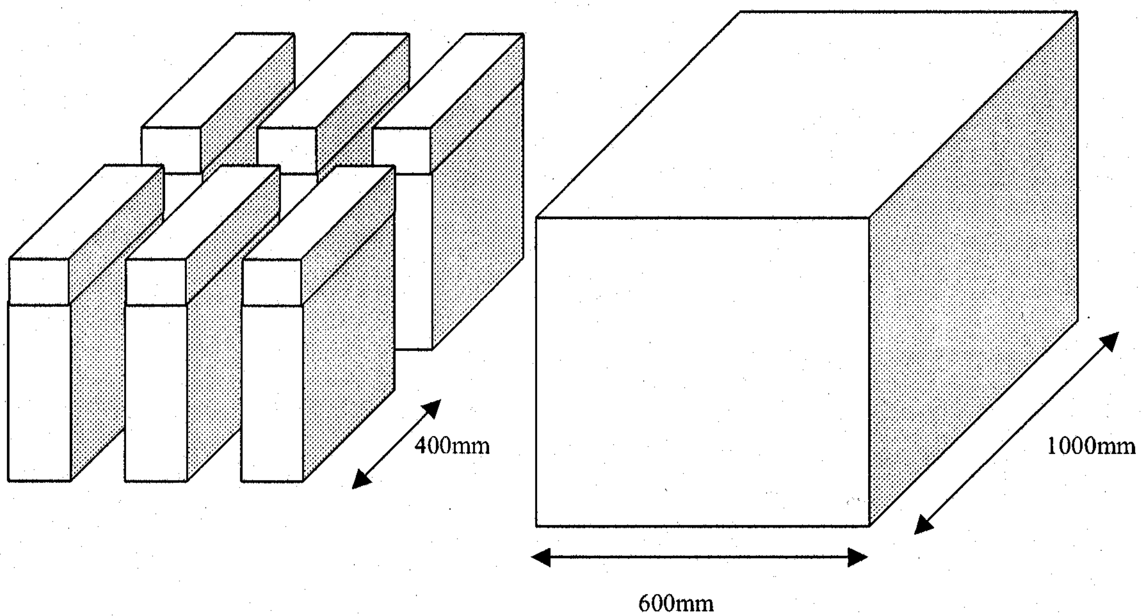

Figure 1: Collection of test assemblies with cover box removed

Through the two perforations in each block, 25 x 25 x 300 mm pine heartwood feeder stakes were hammered into the ground so that the top of the stake was within 2–5 mm of the top of the concrete block (Figure 2). The feeder stakes were prepared from moderately durable heartwood to remain free from decay and mould long enough to be discovered by a foraging population of termites. In November 1996, one replicate from each treatment plus two of the untreated controls — a total of six samples — were placed in each of ten test boxes. The test samples were situated one per block such that they covered the holes in the block but were not in direct contact with the feeder stake. This was to prevent direct tunneling from the untreated wood stakes into the test samples. The position of each piece of test material was recorded and a database was prepared.

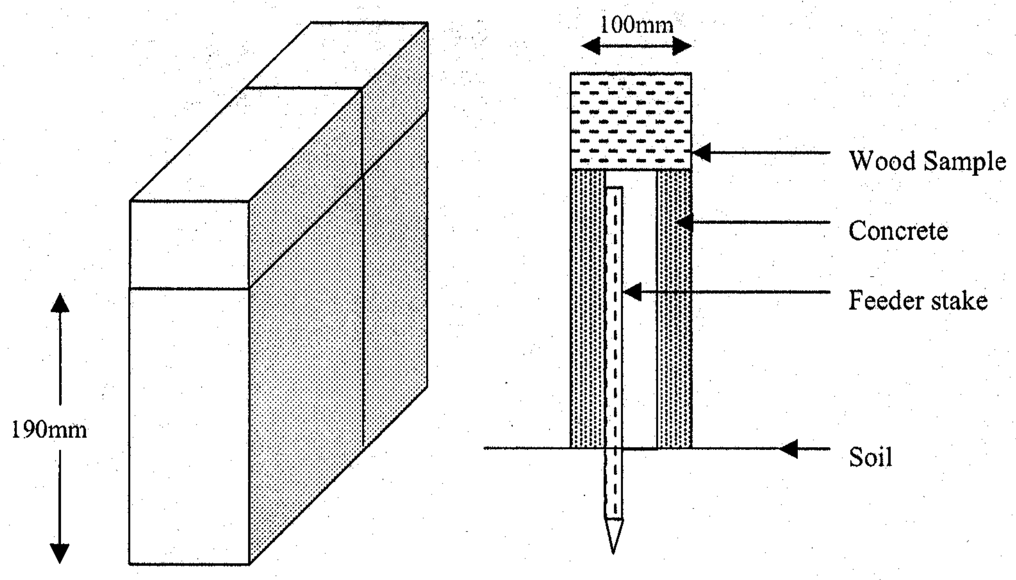

Figure 2: Cross-section of test assembly

To encourage even distribution of termite attack throughout the test plot, feeder strips were installed in November 1998, linking the ten individual test boxes. To accomplish this, the concrete support blocks were lifted, leaving the feeder stakes in place. Small trenches, 25 mm deep, were dug to join the feeder stakes of one test unit to the feeder stakes of adjacent test units and to bait stations or termite nests. Pine heartwood feeder strips, 10 x 10 mm in size, were installed end-to-end in the trenches, which were then filled in with soil. After that, the support blocks, samples, and shelter boxes were replaced.

To monitor conditions inside the test assemblies, a HOBO data logger, programmed to record temperature and humidity once per hour, was installed on the interior north wall of one of the boxes in August 1999 and removed a year later. Temperature and relative humidity data monitored during that time were downloaded into a program designed to summarize these data.

Test material was rated annually by visual examination for signs of termite attack. Each sample was carefully removed, examined and assigned a rating using a 0–10 scale (Table 1), and then replaced in the same location. All ratings were subsequently entered into the database.

Table 1: Termite attack grading system

AWPA Rating	Description
10	Sound. Surface grazing (nibbling) is permitted, but such cosmetic damage must be noted in the report.
9	Trace of attack. For example, surface erosion up to 5 mm deep, or up to two termite penetrations of up to 10 mm deep.
7	Moderate attack. For example, surface erosion over 5 mm. Penetrations over 10 mm deep or ramifying tunnels present.
4	Heavy attack. For example, extensive tunneling of up to 50–75% of the cross- section.
0	Failure due to termite attack.

3 RESULTS AND DISCUSSION

After 6 years, the level of termite activity was relatively even among the ten test boxes and attack on the untreated controls was well established. Mean ratings for untreated wood ranged from 8.8 for the naturally durable western red cedar, to 7.1 for hem-fir (Table 2). The differences between hemlock and amabilis fir were negligible. Figure 3 shows linear fits to the depreciation data over 6 years, but longer-term exposure may indicate that a linear model is inappropriate.

No preservative-treated sample received a rating less than 9 at the six-year evaluation. Borate treatments were performing as well as CCA treatments with mean ratings of 9.0 or higher (Table 2). As with borate treatments, the CCA data for hemlock and amabilis fir were combined, averaging the CCA retention as 4.5 kg/m^3. At this stage, there was no discernable difference between through and shell treatments with borate or from the addition of DDAC.

Evaluations between years 2 and 4 overestimated the level of damage to treated material based on exploratory tunneling that appeared to penetrate the surface particularly at incisions on CCA-treated samples. Continued evaluations and probing with stiff wire revealed that these tunnels were shorter than the depth of preservative penetration and did not increase in depth with time.

Figure 4 illustrates that the relative humidity inside the boxes remained close to 100% virtually all year. As a result, condensation formed on the lid of some boxes and dripped onto the samples. This might be creating a leaching hazard for the borate-treated samples, although no detrimental effects are apparent at this stage.

Table 2: Performance of above-ground samples at the Kincardine termite test plot after 6 years exposure

Species	Treatment	Mean AWPA Rating	Standard Deviation
hem-fir	None	7.1	1.4
western red cedar	None	8.8	0.6
hemlock	3.3 kg/m^3 B_2O_3 shell	10.0	0.0
amabilis fir	2.5 kg/m^3 B_2O_3 through	9.7	0.5
hem-fir	3.2 kg/m^3 B_2O_3 + DDAC shell	9.6	0.5
hem-fir	4.5 kg/m^3 CCA shell	9.0	0.0

4 CONCLUSIONS

- Peformance of borate-treated and CCA-treated lumber was equivalent after 6 years exposure to termites above ground protected from rain in Kincardine Ontario.

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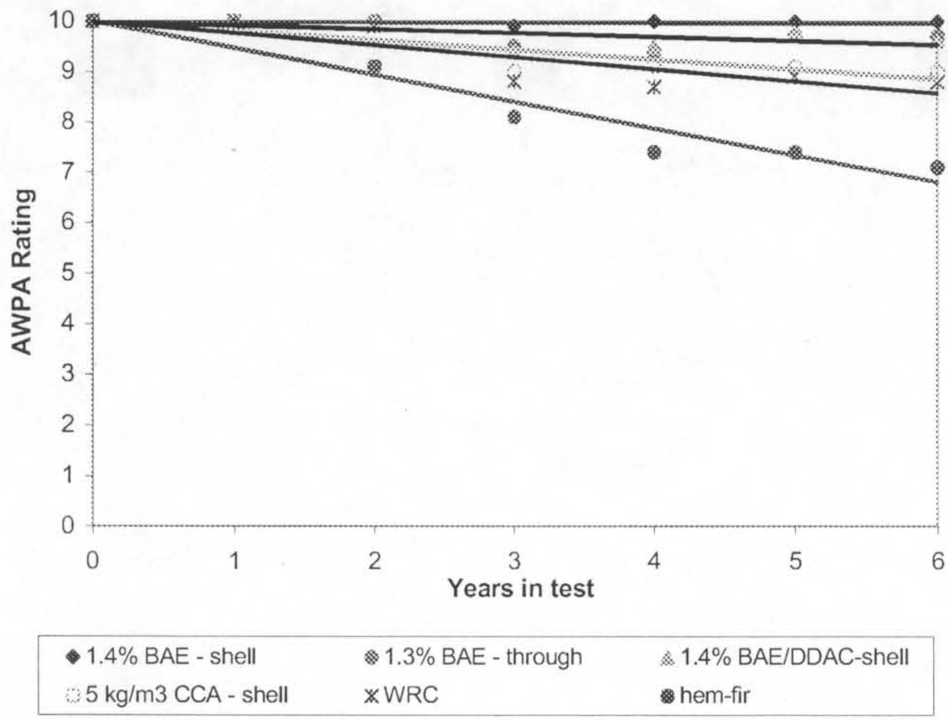

Figure 3: Performance of above-ground samples at the Kincardine termite test plot after six years exposure

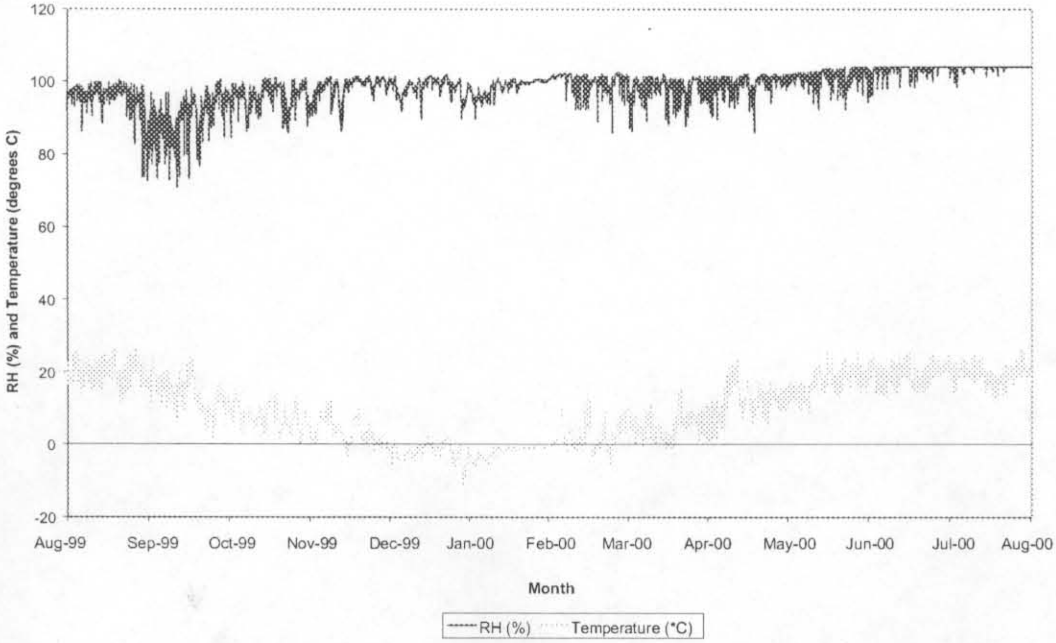

Figure 4: Conditions inside Kincardine test box during 1999-2000