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Section 3 **Wood Protecting Chemicals**

Resistance of borate-treated lumber to subterranean termites under protected, above-ground conditions

Kunio Tsunoda[1], Akio Adachi[1], Tsuyoshi Yoshimura[1], Tony Byrne[2], Paul I. Morris[2], and J. Kenneth Grace[3]

1 Wood Research Institute, 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 Entomology, University of Hawaii at Manoa, 3050 Maile Way, Honolulu, Hawaii 96822-2271, USA

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ABSTRACT

An experiment to simulate the dodai (sill plate) of the Japanese houses was conducted at the termite field test site of Wood Research Institute in Kagoshima, 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] in a dimension of 105 x 105 x 400 mm were placed on concrete blocks 19 cm above 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 visually inspected for termite attack and decay and rated according to AWPA standards. After 4 years' exposure, borate-treated samples (2% BAE shell, 3% BAE shell, 2% BAE through and 3 % BAE through treatments) were free from termite attack, while one replicate each of 2% BAE with DDAC (didecyldimethylammonium chloride) and CCA 4.0 kg/m^3 treatments, the latter included as a reference preservative, were slightly attacked. Untreated hem-fir and hinoki (*Chamaecyparis obtusa* Endl.) controls were slightly to heavily attacked during the same test period. No sign of decay was found on any sample, although moisture contents were well above fiber saturation points in some samples.

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

1.INTRODUCTION

Sodium borate is a diffusible preservative and easily leaches out of treated wood when exposed to liquid water. Consequently soluble borates can not the meet performance requirements demanded by laboratory tests which involve severe leaching cycles, and by standard ground contact field tests. However, sodium borate seems applicable to such end-uses where treated products are situated above ground and are protected from the weather. The dodai (sill plate) of conventional Japanese houses might exemplify this situation.

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

2.MATERIALS AND METHODS

Sound unseasoned hem-fir samples (105 x 105 x 1300 mm) were cut from 3500 mm long lumber so that 400 mm long 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 were produced 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.

Additional samples were also treated with chromated copper arsenate (CCA) at a retention of 4.0 kg/m^3 for comparison. 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 of these 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 block. Feeder stakes were driven into the soil to encourage initial termite attack and these stakes were replaced after 3 years' service. The installed samples were placed in clusters of eight, one each of 8 treatments (Table 1) and each cluster was covered with a PVC box. The replication of 10 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). A similar rating 0-10 was given for decay.

3.RESULTS AND DISCUSSION

Progressive termite attack is shown in Table 1. The first annual inspection showed that termites had started attacking untreated wood samples in 7 of the 10 boxes. Seven untreated hem-fir and 6 untreated hinoki sustained slight to moderate attack, while all treated samples were free from termite attack.

At the end of the second season termite attack was visible in 8 boxes and one replicate of treatment 5 (2% BAE shell with DOT/DDAC) had been slightly attacked. The number of boxes with termite attack increased with time and after three years every box showed some termite attack on the untreated controls. The first slight termite attack on CCA-treated sample was found at the fourth inspection on December 16, 1999.

Wood samples, treated with DOT only regardless of borate distribution in the wood (shell or through treatment) or of preservative retention, showed no termite attack by the end of fourth season. Recent reviews indicate that the effectiveness of sodium borates to subterranean termites in above-ground situations varies with test methods and termite species (Drysdale, 1994; Grace, 1997; Tsunoda, 1999). However, borate retentions ranging from 0.5% to 2.5% BAE protected wood products from any subterranean termite including that of *Coptotermes formosanus* (Preston et al., 1985 and 1996; Grace and Yamamoto, 1993 and 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 the former findings. Experimental design is clearly an important factor in the effectiveness of non-fixed preservatives such as DOT which must be used under protected above-ground conditions which prevent serious leaching. Therefore, the loss of a test preservative during the test period must be determined chemically to confirm the suitability of the test method. Unfortunately, chemical analytical data was not given for the previously reported investigations. Instances where sodium borate has been not protected against termites could thus be attributed 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 ability of DOT to control decay has been well established in literature (Drysdale, 1994) and the low natural durability of hem-fir to decay has also been reported (Panshin and De Zeeuw, 1970; Highley, 1995).Over the last 4 years' exposure in the field symptoms of decay were not observed, even on untreated wood samples, despite the fact that moisture contents were suitable for growth of wood-decaying fungi. It is unclear why decay is not present. The test will be run for several years and it is possible that longer exposure might result in its development so that the ability of DOT to control decay can be confirmed in the field.

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Table 1 Resistance of borate-treated lumber to subterranean termites in the 4-year field aboveground test

	Treatment							
	2% BAE shell	3% BAE shell	2% BAE through	3% BAE through	2% through with DDAC	CCA 4 kg/m^3	Untreated hem-fir	Untreated hinoki
Box 1	EE 10-10-10-10	BK 10-10-10-10	HI 10-10-10-10	EE 10-10-10-10	EJ 10-10-10-10	9F 10-10-10-10	F1 9 – 7 - 7 - 7	1 9 - 7 - 7 - 7
Box 2	AU 10-10-10-10	AS 10-10-10-10	CS 10-10-10-10	AU 10-10-10-10	HC 10-10-10-10	19F 10-10-10-10	F5 10 – 7 - 7 - 7	2 7 - 4 - 4 - 4
Box 3	BC 10-10-10-10	AY 10-10-10-10	EP 10-10-10-10	BC 10-10-10-10	HJ 10-10-10-10	11F 10-10-10- 9	F4 7 – 7 - 7 - 7	3 9 - 7 - 7 - 7
Box 4	AC 10-10-10-10	AW 10-10-10-10	EF 10-10-10-10	AC 10-10-10-10	DT 10-10-10-10	10F 10-10-10-10	F3 9 – 7 - 4 - 4	4 9 - 7 - 7 - 7
Box 5	AG 10-10-10-10	EG 10-10-10-10	dR 10-10-10-10	AG 10-10-10-10	EL 10-10-10-10	8F 10-10-10-10	F2 9 – 7 - 7 - 7	5 9 - 7 - 7 - 7
Box 6	BN 10-10-10-10	CG 10-10-10-10	FZ 10-10-10-10	BN 10-10-10-10	CH 10-10-10-10	6H 10-10-10-10	H4 9 – 7 - 7 - 7	6 9 - 7 - 7 - 7
Box 7	BQ 10-10-10-10	AI 10-10-10-10	GA 10-10-10-10	BQ 10-10-10-10	EM 10-10-10-10	18H 10-10-10-10	H5 9 – 7 - 7 - 7	7 10 - 9 - 9 - 9
Box 8	BJ 10-10-10-10	CB 10-10-10-10	FM 10-10-10-10	BJ 10-10-10-10	ES 10 - 9 - 9 - 9	22H 10-10-10-10	H1 9 – 7 - 7 - 7	8 10-10-10 - 9
Box 9	CE 10-10-10-10	AH 10-10-10-10	FS 10-10-10-10	CE 10-10-10-10	HG 10-10-10-10	15H 10-10-10-10	H3 10-10 - 9 - 7	9 10-10 - 9 - 7
Box 10	CJ 10-10-10-10	BR 10-10-10-10	GI 10-10-10-10	CJ 10-10-10-10	dO 10-10-10-10	5H 10-10-10-10	H2 10-10-10-10	10 10-10 - 4 - 4
Mean	10-10-10-10	10-10-10-10	10-10-10-10	10-10-10-10	10-9.9-9.9-9.9	10-10-10-9.9	9.1-7.6-7.2-7.0	9.2-7.8-7.1-6.8

Four annual inspection ratings of each sample are shown together with sample number in each column.