IRG/WP 02-30278

THE INTERNATIONAL RESEARCH GROUP ON WOOD PRESERVATION

Section 3 **Wood Protecting Chemicals**

Performance of borate-treated sill plates (dodai) in a protected, above-ground field test in Japan

Kunio Tsunoda[1], Akio Adachi[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 Plant & Environmental Protection Sciences, University of Hawaii at Manoa, 3050 Maile Way, Honolulu, Hawaii 96822-2271, USA

Paper prepared for the 33rd Annual Meeting
Cardiff, Wales, United Kingdom
May 12-17, 2002

IRG Secretariat
SE-100 44 Stockholm
Sweden

Performance of borate-treated sill plates (dodai) in a protected, above-ground field test in Japan

Kunio Tsunoda[1], Akio Adachi[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 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 (IRG/WP 2000-30239).
An experiment to simulate the dodai (sill plate) of the Japanese houses was conducted at the termite field test site of the 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]- 105 x 105 x 400 mm in size were placed on concrete blocks 19 cm the 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 annually inspected for termite attack and decay and visually rated according to AWPA standards since installation on December 21, 1995. After 6 years' exposure, one or two samples from each group of borate treatments (2% BAE shell, 3% BAE shell, 2% BAE through and 3 % BAE through treatments) were very slightly attacked by termites, though these treatments were free from termite attack for the first 5 years. Over the same period, slight termite attack was observed on the samples of 2% BAE plus DDAC (didecyldimethylammonium chloride) and CCA 4.0 kg/m^3 treatments, the latter included as a reference preservative. Untreated hem-fir and hinoki (*Chamaecyparis obtusa* Endl.) controls showed progressive termite attack starting in the first year and were moderately to heavily attacked after 6 years' exposure. Incipient decay was first found on 7 untreated hem-fir and sapwood portion of two untreated hinoki during the 5th year of exposure. Decay on the untreated controls progressed in the 6th year as expected.

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 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 previously developed for evaluating the 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 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 in a protected, above-ground test in Japan. Similar test has been conducted in Hawaii where termite pressure is much higher than in Kagoshima, Japanese test site, and the results obtained from both test sites will be compared in details elsewhere.

2.MATERIALS AND METHODS

Sound, unseasoned hem-fir samples (105 x 105 x 1300 mm) were cut from lumber so that 400 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) at 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 block. 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 (Table 1) 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.

3.RESULTS AND DISCUSSION

Table 1 shows the progression of termite attack and decay on each test sample. 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 a CCA-treated sample was found at the fourth inspection. No decay was found on any sample regardless of treatment. 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 first 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.

During the fifth year no progress in termite attack and decay was found on the treated samples. However, signs of incipient decay were first found on 7 untreated hem-fir controls and on the sapwood portion of two untreated hinoki controls during the fifth year.

Decay on the untreated controls progressed in the sixth year as expected. One or two borate-treated samples first sustained slight termite attack, and one and two of the treatments 5 (2% BAE shell with DOT/DDAC) and 6 (CCA 4.0 kg/m^3) respectively sustained new termite attack.

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 fifth 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 these 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 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. Instances where sodium borate has not been 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) .

References

American Wood Preservers' Association (2001) Book of Standards. Standard E7-01. Standard method of evaluating wood preservatives by field tests with stakes. Granbury, Texas, USA, 409-418.

Archer, K. J., D. A. Fowlie, A. F. Preston and P. J. Walcheski (1991) A termite field test with diffusion treated lumber. The Int. Res. Group on Wood Preserv. Document No. IRG/WP/3648.

Drysdale, J. A. (1994) Boron treatments for the preservation of wood - A review of efficacy data for fungi and termites. The Int. Res. Group on Wood Preserv. Document No. IRG/WP 94-30037.

Gay, F. J., K. M. Harrow and A. H. Wetherly (1958) Laboratory studies of termite resistance . III. A comparative study of the anti-termite value of boric acid, zinc chloride, and "Tanalith U". CSIRO, Australia. Division of Entomology Technical Paper No. 1.

Grace, J. K. (1997) Review of recent research on the use of borates for termite prevention. [In] Proc. 2nd Int. Conf. on Wood Protection with Diffusible Preservatives and Pesticides. For. Prod. Soc/, Madison, Wisconsin, 85-92.

Grace, J. K., K. Tsunoda, A. Byrne and P. I. Morris (1995) Field evaluation of borate-treated lumber under conditions of high termite hazard. [In] Proc. Wood Preservation in the '90s and Beyond. For. Prod. Soc., Madison, Wisconsin, 240.

Grace, J. K., R. T. Yamamoto (1993) Sequential exposure of borate treated Douglas-fir to multiple Formosan subterranean termite colonies in a 40-week field test. The Int. Res. Group on Wood Preserv. Document No. IRG/WP 93-10006.

Grace, J. K., R. T. Yamamoto (1994) Repeated exposure of borate-treated Douglas-fir lumber to Formosan subterranean termites in an accelerated field test. For. Prod. J. 44(1), 65-67.

Highley, T. L. (1995) Comparative durability of untreated wood in use above ground. Int. Biodeterioration and Biodegradation 35(4), 409-421.

Kennedy, M. J., J. W. Creffield, R. H. Eldridge and B. C. Peters (1996) Field evaluation of the above-ground susceptibility of *Pinus* heartwood and untreated or treated sapwood to two species of Australian subterranean termites. The Int. Res. Group on Wood Preserv. Document No. IRG/WP/ 96-10147.

Moffat, A. R. and B. C. Peters (1993) Chemical evaluation of borate treated pine sapwood attacked by the subterranean termite *Coptotermes acinaciformis*. The Int. Res. Group on Wood Preserv. Document No. IRG/WP 93-20003.

Panshin, A. J. and C. De Zeeuw (1970) V1. Structure, identification, uses and properties of the commercial woods of the United States and Canada. Textbook of Wood Technology. 3rd ed. McGraw-Hill, New York. p. 705.

Peters, B. C. and P. J. Allen (1993) Borate protection of hoop pine (*Araucaria cunninghamii*) sapwood from attack by subterranean termites (*Coptotermes* spp., Isoptera: Rhinotermitidae). Aust. For. 56(3), 249-256.

Peters, B. C. and C. J. Fitzgerald (1998) Field exposure of borate-treated softwood to subterranean termites (Isoptera: Rhinotermitidae, Mastotermitidae). Mat. u. Org. 32(1), 41-66.

Preston, A. F., L. Jin and K. J. Archer (1996) Testing treated wood for protection against termite attack in buildings. Proc. AWPA 92, 205-220.

Preston, A. F., P. A. McKaig and P. J. Walcheski (1985) Termite resistance of treated wood in an above ground field test. The Int. Res. group on Wood Preserv. Document No. IRG/WP/ 2241.

Tsunoda, K. (1999) Application of borates to wood preservation (2) Field evaluation and applicability to the preservative treatment of composites. Mokuzai Hozon (Wood Presrvation) 25(6), 251-262 (in Japanese)

Tsunoda, K., A. Adachi, T. Yoshimura, A. Byrne, P. I. Morris and J. K. Grace (1998) Resistance of borate-treated lumber to subterranean termites in the field. The Int. Res. Group on Wood Preserv. Document No. IRG/WP 98-10255.

Table 1　Inspection results (1995～2001)

	Treatment							
	1	2	3	4	5	6	7	8
Box 1	EE10/10/10/10/10/10	BK10/10/10/10/10/10	HI10/10/10/10/10/10	HE10/10/10/10/10/09	EJ10/10/10/10/10/09	9F10/10/10/10/10/10	F1 09/07/07/07/07/07 10/10/10/10/10/10	1 09/07/07/07/07/07 10/10/10/10/10/10
Box 2	AU10/10/10/10/10/10	AS10/10/10/10/10/10	CS10/10/10/10/10/09	dN10/10/10/10/10/10	HC10/10/10/10/10	19F10/10/10/10/10/10	F5 10/07/07/07/07/04 10/10/10/10/09/07	2 07/04/04/04/04/04 10/10/10/10/1010
Box 3	BC10/10/10/10/10/10	AY10/10/10/10/10/09	EP10/10/10/10/10/10	dV10/10/10/10/10/10	HJ10/10/10/10/10	11F10/10/10/09/09/09	F4 07/07/07/07/07/04 10/10/10/10/09/09	3 09/07/07/07/07/07 10/10/10/10/10/10
Box 4	AC10/10/10/10/10/10	AW10/10/10/10/10/10	EF10/10/10/10/10/10	Ed10/10/10/10/1010	dT10/10/10/10/10	10F10/10/10/10/10/10	F3 09/07/04/04/04/04 10/10/10/10/09/09	4 09/07/07/07/07/04 10/10/10/10/10/10
Box 5	AG10/10/10/10/10/09	EG10/10/10/10/10/10	dR10/10/10/10/10/09	GM10/10/10/10/10/09	EL10/10/10/10/10	8F10/10/10/10/10/09	F2 09/07/07/07/07/04 10/10/10/10/09/09	5 09/07/07/0707/04 10/10/10/10/10/10
Box 6	BN10/10/10/10/10/10	CG10/10/10/10/10/09	FZ10/10/10/10/10/10	GE10/10/10/10/10/10	CH10/10/10/10/10	6H10/10/10/10/10/10	H4 09/07/07/07/04/04 10/10/10/10/09/09	6 09/07/07/07/04/04 10/10/10/10/09/09
Box 7	BQ10/10/10/10/10/10	AI10/10/10/10/10/10	GA10/10/10/10/10/10	Gd10/10/10/10/10/10	EM10/10/10/10/10/07	18H10/10/10/10/10/09	H5 09/07/07/07/04/04 10/10/10/10/09/09	7 10/09/09/09/09/07 10/10/10/10/10/10
Box 8	BJ10/10/10/10/10/10	CB10/10/10/10/10/10	FM10/10/10/10/10/10	FX10/10/10/10/10/10	ES10/09/09/09/09/09	22H10/10/10/10/10/10	H1 09/07/07/07/07/04 10/10/10/10/10/10	8 10/10/10/09/07/07 10/10/10/10/10/10
Box 9	CE10/10/10/10/10/10	AH10/10/10/10/10/10	FS10/10/10/10/10/10	FP10/10/10/10/10/10	HG10/10/10/10/10	15H10/10/10/10/10/10	H3 10/10/09/07/04/04 10/10/10/10/09/07	9 10/10/09/07/07/04 10/10/10/10/09/07
Box 10	CJ10/10/10/10/10/10	BR10/10/10/10/10/10	GI10/10/10/10/10/10	GN10/10/10/10/1010	dO10/10/10/10/10	5H10/10/10/10/10/10	H2 10/10/10/10/07/07 10/10/10/10/10/09	10 10/10/04/04/04/04 10/10/10/10/10/10
Mean	10/10/10/10/10/9.9 10/10/10/10/10/10	10/10/10/10/10/9.8 10/10/10/10/10/10	10/10/10/10/10/9.8 10/10/10/10/10/10	10/10/10/10/10/9.8 10/10/10/10/10/10	10/9.9/9.9/9.9/9.9/9.5 10/10/10/10/10/10	10/10/10/9.9/9.9/9.7 10/10//10/10/10/10	9.1/7.6/7.2/7.0/5.8/4.6 10/10/10/10/9.3/8.8	9.2/7.8/7.1/6.8/6.3/5.2 10/10/10/10/9.8/9.6

Treatment:1=2% shell, 2=3% shell, 3=2% through, 4=3% through, 5=2%-DDAC shell, 6=CCA 4 kg.m^3, 7=untreated hemlock and fir,

8=untreated hinoki

Upper figures for termite ratings and lower ones for decay ratings in each box of treatments 7 and 8 and in the Mean boxes of all treatments.