CWPA Proceedings, 2004, pp 19-32

TREATED FRAMING IN HAWAII

Mark J. Manning

U.S. Borax Inc.
26877 Tourney Road
Valencia, California

Summary

This paper provides a brief history on the use of preservative-treated framing lumber as a building material for residential construction in the State of Hawaii. Like many idyllic destinations, Hawaii offers a paradise-like environment that attracts visitors who travel there to enjoy the year-round warmth and tropical surroundings. Unfortunately, the environment in Hawaii challenges wood products with one of the more demanding exposure hazards found anywhere in the world. The same conditions that prove so enticing to both local residents and the several million annual tourists, also provide a near-perfect environment for the Formosan subterranean termite (FST - *Coptotermes formosanus*), a non-native pest that has wreaked havoc on wooden structures in Hawaii for over 100 years. Because of the threat afforded by the FST, local building codes have mandated the use of strategies aimed at protecting wooden structures from damage caused by the formidable Formosan. One of most important and widely used strategies has involved the use of wooden building materials that have been treated with preservatives to provide protection against wood destroying organisms such as decay fungi and the FST. The use of treated framing lumber in Hawaii has allowed wood to continue being utilized as a building material for residential construction, capable of competing with alternative materials such as steel and concrete.

1. Introduction

The Hawaiian Islands are a beautiful travel destination and an idyllic place to live, yet they offer one of the most severe exposure hazards anywhere in the world for the use of wooden building products. Year-round warm temperatures and significant precipitation provide the necessary conditions for both fungal decay and, more recently, comfortable surroundings for the Formosan subterranean termite (FST). The FST is extensively established on the Island of Oahu and, to a lesser degree, on the outer islands where it is still most closely aligned with port communities, having been ‘imported’ from Oahu.

These environmental conditions are so ideal for wood destroying organisms that it has been postulated that above-ground exposures in Hawaii are at least as severe as many ground-contact exposures on the North American mainland (Wilcox, 1984). Providing some semblance of an objective foundation for evaluating the aggressive climate in

Hawaii is the Scheffer Index which provides a tool for quantifying climatic exposure conditions for wood used in above-ground exposures and is based on a mathematical operation involving the average annual temperature and the number of days per month with measurable precipitation (Scheffer, 1971). In short, areas that are cool and dry are at one end of the continuum, while locations that are warm and wet are at the other. For example, the town of Hilo on the big island of Hawaii receives in excess of 150” inches (~3800 mm) of average annual precipitation and experiences mild temperatures year-round, yielding a Scheffer Index of over 300. This is in marked contrast to a Scheffer Index of less than 10 for Phoenix, Arizona, a desert community which receives less than 10” (~250 mm) of average annual precipitation. The local environment in Hilo is one of the more aggressive for wood products and this is exemplified by the large amount of field testing on wood preservatives that is carried out there in an effort to get a more rapid evaluation of performance. Untreated wood exposed above-ground in Hilo can exhibit significant signs of fungal decay in less than one year (Figure 1). Field tests on untreated Wood Plastic Composites (WPCs) in unprotected, above-ground exposures have exhibited fruiting bodies (indicative of fungal decay) after less than 18 months exposure in Hilo (Figure 2).

2. Discussion

The State of Hawaii is the most recent addition to the United States and this relative ‘newcomer’ is still only a few decades removed from near total domination by the sugar plantation owners – locally known as the Big Five (Wilcox, 1984). This oligarchy of the Big Five *decided and provided* nearly all of the goods that would be available in Hawaii. With regard to forest products – and more specifically lumber and plywood – this meant a commercial conduit of Douglas-fir streaming in from the Pacific Northwest. To this day, Douglas-fir is the overwhelming choice of builders and architects when it comes to wood materials for residential construction (Reinhardt, 2004).

Douglas-fir lumber and plywood is a popular building material along the west coast of North America and is often the preferred choice of builders. While it may be the overwhelming choice amongst those who construct dwellings out of wood in the western U.S., one would be hard pressed to find similar support in the pressure treatment community. Douglas-fir is a refractory wood species and presents significant challenges from a treatment perspective – even if the material is incised prior to treatment. In spite of these challenges, the Hawaiian market has historically chosen *unincised* Douglas-fir as the preferred material (Reinhardt, 2004). Several efforts to introduce alternative (more treatable) species have been unsuccessful.

So, in this most challenging of environments for forest products, the building industry in Hawaii has chosen to utilize a wood species that presents significant treatment challenges. Historically this has meant the use of Copper Chromated Arsenate (CCA) to pressure treat unincised Douglas-fir. The Uniform Building Code (UBC) has had a long-standing requirement for a preservative treated sill plate and this provided the initial impetus for local builders to begin using CCA treated lumber. In the late 1960's, the Hawaiian wood treaters (working with the local building department) developed a process based (prescriptive) 'Standard' for the pressure-treatment of unincised Douglas-fir lumber: a minimum 8 hour press cycle with a 2-4% CCA solution. This later developed into the "Hawaii Use Only" (HUO) Standard and was used successfully as part of a program administered by the now-defunct American Wood Preservers' Bureau (AWPB) (Keefe, 1996).

The HUO program involved other prescriptive measures including: a requirement that all structural lumber be treated and all end-cuts and drill holes be field treated, and that the soil beneath the house be treated with an approved soil termiticide. In 1976, the 'Standard' was formalized by the AWPB and the program officially commenced on January 1, 1977 for above-ground use only with a minimum retention requirement of 0.25 pcf (4.0 kg/m^3) CCA in an outer 0.2"(5 mm) assay zone and no minimum requirement for heartwood penetration. This represented a dramatic departure from the American Wood-Preservers' Association (AWPA) Commodity Standard, AWPA C2-02, (AWPA, 2004) for Douglas-fir lumber which included a requirement for incising and a preservative penetration requirement of 0.4" (10 mm) in 80% of the borings. The AWPA Standard recognizes the treatment challenges afforded by Douglas-fir and includes the following footnote: "… it is generally recognized that most sawn products from Coastal Douglas-fir are extremely difficult to treat with the preservatives ACC and CCA to the penetration and retention requirements of this Standard and related Commodity Standards for sawn products, even when incised".

As shown in Figure 3, well-treated CCA material exhibits excellent efficacy against the FST. The data shown here is from long-term testing carried out by researchers at Michigan Technological University and shows that low levels of CCA (0.03 pcf (0.48 kg/m^3) – well below the AWPA above-ground retention of 0.25 pcf) can provide protection against the FST (Laks, 2004). Of significant importance here is the fact that this test was run on samples of Southern Yellow Pine sapwood which was pressure treated with CCA; it is reasonable to assume that the entire sample was homogeneously treated with the target retention of CCA. As described above, the refractory nature of Douglas-fir heartwood would not yield a similar preservative distribution with CCA, particularly without a requirement for incising. The image in Figure 4 illustrates the potential downside with CCA-treated Douglas-fir heartwood and the envelope treatment that typically results. This sample of CCA-treated Douglas-fir was cut after treatment and was not end-coated with a field-cut preservative; the sample was exposed in a covered, above-ground test for one year. The FST was able to successfully excavate the significant zone of untreated material, leaving the preservative-treated 'shell' intact.

The local industry of wood-treaters and home builders continued participating in the HUO program. At the time, it was generally felt that with rigorous enforcement of the requirements, it was possible to construct a home that could withstand the FST. From a commercial standpoint, there was enough confidence for the chemical suppliers to offer a limited warranty on the treated lumber, providing all aspects of the HUO program (and any additional warranty requirements) were followed. Compliance with the HUO program was the norm until the mid-1980s when a number of different factors began to initiate the process of change.

From the late 1960s until 1985, the requirement to use wood treated to the HUO Standard was informally required by the Honolulu Building Department. As described above, the Hawaiian treaters participated in the HUO program which was monitored by the AWPB. In 1985, the Honolulu Building Department changed the treated wood requirement from an 'informal' requirement to an official requirement, notifying the home building community (builders, wood treaters, lumber yards and architects) with an official letter. This requirement became part of the Honolulu Building Code with amendments to the 1985 Uniform Building Code – adopted by the Honolulu City Council in 1987. Treatment with preservatives other than CCA (*eg*., ACA and Penta) was allowed but was extremely uncommon. (Reinhardt, 2004).

During the latter part of the 1980s there were two events which had an impact on the treated wood industry in Hawaii. In 1988, commercial use of the extremely effective class of insecticides known as organochlorine compounds (*eg*., *Chlordane*, *Aldrin* and *Heptachlor*) was phased out in the U.S. by the Environmental Protection Agency. These compounds had been extensively used as soil termiticides and were extremely long-lasting; in fact, it was concern over human health effects caused by this environmental persistence that led to the cancellation of commercial use. Unfortunately, the next-generation of soil termiticides was not as effective nor as long-lasting. – homes built after 1988 did not have the same level of protection afforded by the earlier soil termiticides. Instead of a protective barrier lasting decades, the replacement termiticides had significantly shorter lifetimes, in some cases lasting only a few years.

In 1989 an additional spotlight was cast on the termite protection arena when a ~$30 million settlement was awarded to residents of condominium project that had been severely damaged by the FST. The Crosspointe condominium project was built in the early 1980s using HUO treatment for the first floor only – there was no preservative treatment utilized in construction of the second floor. Ultimately the builder was found negligent in that they had followed neither UBC nor HUO.

The aforementioned events helped to provide an opportunity for 'CCA alternatives' to enter the Hawaiian market as a building material for residential construction. One of the first alternatives to emerge was Ammoniacal Zinc Copper Arsenate (ACZA, marketed as *Chemonite*) which was introduced into the Hawaiian market with a requirement for incising. This product was shown to be extremely effective at providing protection against the FST, but never developed into a commercial success – most likely due to the added costs (relative to HUO CCA) brought on by the incising and ammoniacal treatment.

Another alternative chemical emerged on the scene in 1992 when borate wood preservatives were commercially introduced into the Hawaiian market. Borate wood preservatives were first used in Australia in the late 1930s and later became widely used in New Zealand to treat timber framing to provide protection against borer attack

(Vinden, 1990). Because of their water soluble nature (they are not chemically fixed to the wood like CCA), borate-treated wood is only recommended for end-uses where the wood is protected and above-ground – hence the use for treated framing in New Zealand (Barnes, 1989, Manning, 1997 and Lloyd, 1997). Their history of use as a safe, effective and economical preservative for wood in protected, above-ground applications helped to support their introduction into the Hawaiian framing market.

Borates are members of a class of waterborne chemical preservatives which are diffusible in wood. Using the available moisture in unseasoned wood, the chemical redistributes itself after the treatment – diffusing from areas of high concentration (of chemical) to areas of lower concentration. The water-soluble chemical equilibrates in such a way as to remove the concentration gradient. This capability for the chemical to diffuse after treatment makes it possible to completely penetrate unseasoned wood, thereby allowing effective treatment of refractory species like Douglas-fir. Borates have broad-spectrum activity against wood-destroying organisms such as decay fungi, borers and termites (Drysdale, 1994). The efficacy of borates against the FST was first evaluated in the mid-1980s by Preston *et al.* at the Michigan Technological University field site in Hilo, Hawaii (Preston, 1985). Additional work was reported by researchers from the University of Hawaii (Grace, 1997). This positive efficacy data was used to support the initial adoption of borate-treated wood by the Honolulu Building Department.

Initial treatments were carried out exclusively at Honolulu Wood Treatment in Ewa Beach on the leeward side of the island of Oahu. Douglas-fir lumber and plywood was pressure-treated with the water-soluble chemical *Tim-bor*® Industrial (registered trademark of U.S. Borax Inc.) which is equivalent to Disodium Octaborate Tetrahydrate. Because of the diffusible nature of the borates, there was not a requirement for incising the lumber prior to treatment. The Douglas-fir lumber and plywood that was pressure treated with *Tim-bor* Industrial and met the minimum retention and penetration requirement was marketed under the name *Hi-bor*®(registered trademark of STN Holdings). *Hi-bor* lumber and plywood was rapidly accepted by the marketplace; by 1994, four additional treaters were producing *Hi-bor* lumber and plywood for a total of five: four in Hawaii and one on the U.S. mainland. By 1995, >90% of the wood used in residential construction in Hawaii was borate-treated.

With the rapid acceptance by the building community there was, unfortunately, some commercially inspired backlash by certain competitive interests. In December 1995, a lawsuit was filed by a wood treating company on the West Coast against the Superintendent of the Honolulu Building Department. The lawsuit challenged the efficacy of borates against the FST and the approval process that the Building Department used when first approving borate-treated lumber and plywood. After a brief hearing in January 1996, the lawsuit was thrown out – however, the Judge did rule that the normal approval process had not been followed and required that the Building Department hold a public hearing to consider the matter. A public hearing was held on March 6, 1996 with the result that Inorganic Boron was approved by the Honolulu Building Department at a minimum retention of 0.28 pcf (4.48 kg/m^3) as B_2O_3 with no requirement for incising and a minimum penetration requirement of 0.4" (10 mm) (Tsukazaki, 1996).

The efficacy of borate-treated lumber against the FST continues to be evaluated by researchers around the world. Field tests evaluating borate-treated Hem-fir lumber against the FST in a covered, above-ground exposure have been carried out by researchers in Hawaii, Canada and Japan (Grace, 2004). This test is still on-going with end-matched samples exposed to active FST colonies: one piece evaluated in Hawaii while the 'sister' piece is exposed to an FST colony in Japan. It is tentatively planned to carry out the test for a total of 10 years at each location. After six years in Hawaii and seven years in Japan, the borate-treated samples are exhibiting performance equivalent to that of the 0.25 pcf CCA (Copper Chrome Arsenate) which is being evaluated as a comparison control in the same test. The six-year results from the test in Hawaii are displayed in Figure 5. Results from these tests were instrumental in helping to establish an AWPA borate retention for exposure to the FST: 0.28 pcf B_2O_3 – the same retention approved by the Honolulu Building Department.

Additional tests are ongoing which are evaluating a variety of wood species (Douglas-fir, Southern Yellow Pine, Spruce-Pine-Fir, Hem-fir and Ponderosa Pine) treated to different borate retentions. In this test, the wood samples have been assembled into small 'house-like' structures (~ 1 m^3 in size) with sloped, plastic roofs, such that the test specimens are placed in protected, above-ground exposures. This equates to AWPA Use Category 2, which is the exposure for framing lumber used in residential construction. In this test (and the others previously discussed), it should be noted that the termite hazard is exceptionally severe in that untreated feeder stakes are driven into the ground with the upper surface placed in contact with the borate-treated sample; this is done in an ongoing effort to bring the FST up into the test unit and in contact with the treated specimens. In typical residential construction the exact opposite occurs - the builder and subsequent homeowner do everything possible to inhibit future termite pressure (*eg*., soil treatment, minimal use of wood in ground contact, regular inspections by pest control operators, etc.) (Morris, 2000).

In 2004, borate-treated lumber and plywood is still the leading treatment in the State of Hawaii. There have been over 3500 *Hi-bor* warranties issued and, to date, there are still no claims on wood that has been properly treated and used correctly (AWPA Use Category 2). Borates are now offered throughout North America by the leading preservative suppliers: Osmose (Timber Specialties in Canada), Arch and CSI. The 'Hawaiian Model' is now being successfully exported to the Southeastern United States where there is also a significant threat to wooden structures from the FST (Manning, 2003). The concept of treated framing in this region is not mandated like it is in Hawaii, yet there have been recent successes in the commercialization of what is becoming known as TSS –Treated Structural Systems (Simonian, 2004). The TSS concept is being applied to single-family residential structures and, more recently, to military and multi-family housing where the issue of durability is becoming more important to the long-term owners of these structures. A future candidate for the TSS concept is Japan, where there is extensive use of wood in residential construction and there is an emerging issue with the durability of Japanese homes.

As part of an effort to continue looking at strategies to control the FST, in 1998 the Honolulu Building Department convened a 'Blue Ribbon Panel' to help develop standards specific for Hawaii. This led to subsequent approvals for wood and wood-composite products that would provide protection against the FST : ACQ for lumber and plywood, Zinc Borate for OSB and Laminated Strand Lumber (LSL) and solvent-borne IPBC/Chlorpyrifos for Glu-Lam and I-Joists (Person, 2004).

As the 1990s came to a close, the biggest threat to wood products came not from the FST, but from a competitive building material – steel framing. In February 2000, the stated goal of the North American Steel Framing Alliance (NASFA) was to "Achieve market share shipments of light gauge steel framing products equal to 25% of the total residential market, in tons, by 2004" (NASFA, 2000). The State of Hawaii provided the perfect launching pad for this endeavor – the FST pressure was the most severe in North America and the aforementioned lawsuit created a short-term negative perception on the use of treated wood in Hawaii. In 1999, over 70% of the residential framing in Oahu was done in steel (Lew, 2000). This decrease in the use of treated framing is illustrated in Figure 6 which gives historical production data for the largest treating plant in Hawaii – note the drop in volume in the years following the lawsuit which was filed in December 1995 (Person, 2004); exacerbating this effect was the successful introduction of steel framing to the islands.

The North American forest products industry has begun to fight back and for the last few years there have been extensive promotional/educational campaigns aimed at extolling the positive attributes of wood for residential construction (as compared to steel framing and concrete block). Wood is the single major renewable building material and possesses significant positive environmental attributes throughout its life cycle, as compared with steel and concrete. This effort has been led by groups such as the Canadian Wood Council (CWC, information available at www.cwc.ca) and the Wood Promotion Network (WPN, information available at www.beconstructive.com). In Hawaii these efforts have been promoted by the Hawaii Lumber Products Association (HLPA, information available at www.hawaiilumber.com). In 2004, treated framing in Hawaii has begun to recapture market share from steel framing and large-scale building projects are turning away from steel and back to treated wood for the first time in several years (Person, 2004). The long-term durability of treated framing against the FST is a critical component of this turnaround. Macroeconomic factors have also played a role and helped to give treated wood the opportunity to reclaim market share. The actual and forecasted steel prices from January 2004 – July 2005 ($/ton) are shown in Figure 7; for the first six months of 2004 steel prices increased by over 50%, leading to a concomitant rise in the cost of steel framing. This has been facilitated by recent, favorable pricing for wood products. It is hoped that the wood industry in general, and the treated wood industry in particular, can continue to work together to promote the long term durability of Mother Nature's truly renewable building material.

3. Conclusions

Wood is a cost effective and environmentally desirable material for construction. However, wood destroying organisms such as termites, carpenter ants, and decay fungi can challenge the durability and sustainability of wood framed structures. In Hawaii, this threat is more severe than almost anywhere else in the world, driven primarily by the widespread presence of the Formosan subterranean termite. Pressure treated framing has been successfully used in Hawaii for upwards of 40 years. Since its introduction in 1992, borate-treated lumber and plywood (sold locally as *Hi-bor*) has become the market leader in treated framing – providing a safe, effective and economical option for the residential home builder. This Hawaiian model has recently been transplanted to the Southeastern U.S. and similar opportunities exist in Japan. Competition from steel framing has recently emerged, taking significant market share. In 2004, preservative treated wood products have begun making a comeback, helped by an effective promotional/educational campaign and recent increases in steel prices.

4. Acknowledgements

The author gratefully acknowledges the contributions of Jim Reinhardt (Architectural Diagnostics; Honolulu, HI) and Hap Person (Honolulu Wood Treating; Ewa Beach, HI) who provided significant amounts of local knowledge and perspective on the topic of treated framing in Hawaii.

5. References

American Wood-Preservers' Association (AWPA). 2004. Standard C2-02. Lumber, Timber, Bridge Ties and Mine Ties – Treatment by Pressure Processes. AWPA Book of Standards. AWPA, Selma, Alabama. pp. 105 - 116.

Barnes, H.M., Amburgey, T.L., Williams, L.H. and J.J. Morrell. 1989. Borates as wood preserving compounds: The status of research in the United States. Document No. IRG/WP/3542. International Research Group on Wood Preservation. Stockholm, Sweden.

Drysdale, J.A. 1994. Boron Treatments for the Preservation of Wood – A Review of Efficacy Data for Fungi and Termites. Document No. IRG/WP 94-30037. International Research Group on Wood Preservation, Stockholm, Sweden.

Grace, J.K. 1997. Review of recent research on the use of borates for termite prevention. *In*: Proc. The Second International Conference on Wood Protection with Diffusible Preservatives and Pesticides. Forest Products Society. Madison, WI. pp. 85-92.

Grace, J.K., Byrne, A., Morris, P.I. and K. Tsunoda. 2004. Six-year Report on the Performance of Borate-treated Lumber in an Above-ground Termite Field Test in Hawaii. Document No. IRG/WP 04-30343. International Group on Wood Preservation, Stockholm, Sweden.

Keefe, D. 1996. Personal Communication.

Laks, P. 2004. Personal communication.

Lew, V.T. 2000. Personal Communication.

Lloyd, J.D. 1997. International Status of Borate Preservative Systems. *In:* Proc. The Second International Conference on Wood Protection with Diffusible Preservatives and Pesticides. Forest Products Society. Madison, WI. pp. 45-54.

Manning, M.J. and T.K. Bhatia. 2003. Update on Borate Preservative Systems. *Proceedings of the 2002 Annual Meeting of the Canadian Wood Preservation Association*.

Manning, M.J., Lloyd, J.D. and M.W. Schoeman, 1997. The Future of Diffusible Preservative and Pesticide Systems. *In:* Proc. The Second International Conference on Wood Protection with Diffusible Preservatives and Pesticides. Forest Products Society. Madison, WI. pp. 157-168.

Morris, P.I. 2000. Integrated Control of Subterranean Termites: the Six S Approach. *In*: Proc. of the American Wood-Preservers' Association, 96. pp. 93-106.

North American Steel Framing Alliance. 2000. Promotional brochure.

Person, H. 2004. Personal communication.

Preston, A.F., McKaig, P.A. and P.J. Walcheski. 1985. Termite resistance of treated wood in an above ground field test. Document No. IRG/WP/2241. International Group on Wood Preservation, Stockholm, Sweden. 6 pp.

Reinhardt, J. 2004. Personal communication.

Scheffer, T.C. 1971 A Climate Index for Estimating Potential for Decay in Wood Structures Above Ground. *Forest Products Journal*, **21** (10), 25 – 31.

Simonian, C.S. 2004. Personal communication.

Tsukazaki, M. 1996. Personal communication.

Vinden, P. 1990. Treatment with Boron in the 1990's. *In:* Proceedings of the First International Conference on Wood Protection with Diffusible Preservatives. Forest Products Research Society. Madison, WI. pp. 22-25.

Wilcox, W.W. 1984. Observations on structural use of treated wood in Hawaii. *Forest Products Journal*, **34** (6), 39 – 42.

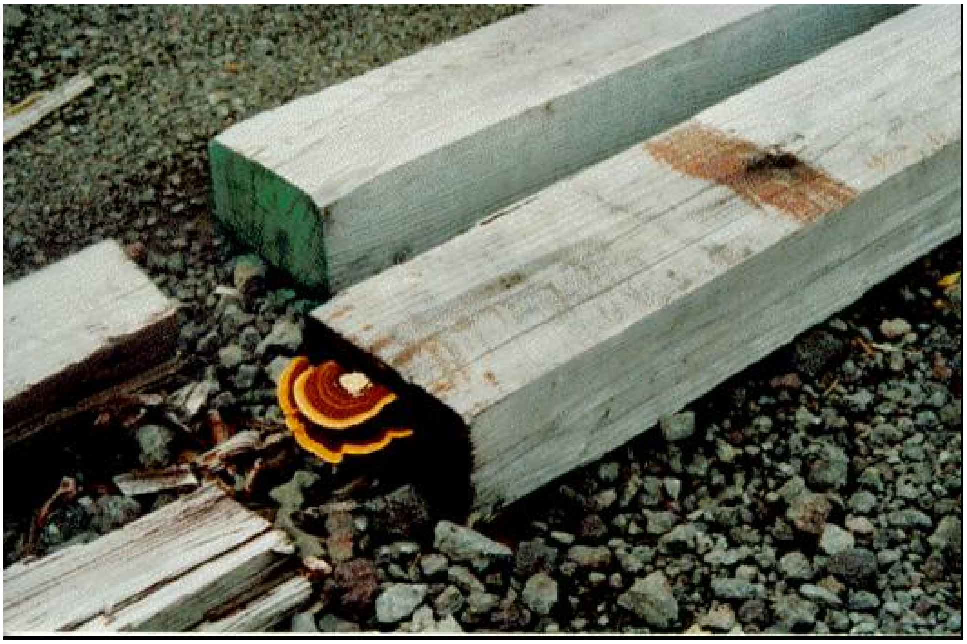

Figure 1. Fruiting bodies on untreated lumber exposed above-ground in Hilo, Hawaii for one year.

Figure 2. Fruiting body on the surface of an untreated Wood Plastic Composite (WPC) after 18 months exposure in Hilo, Hawaii.

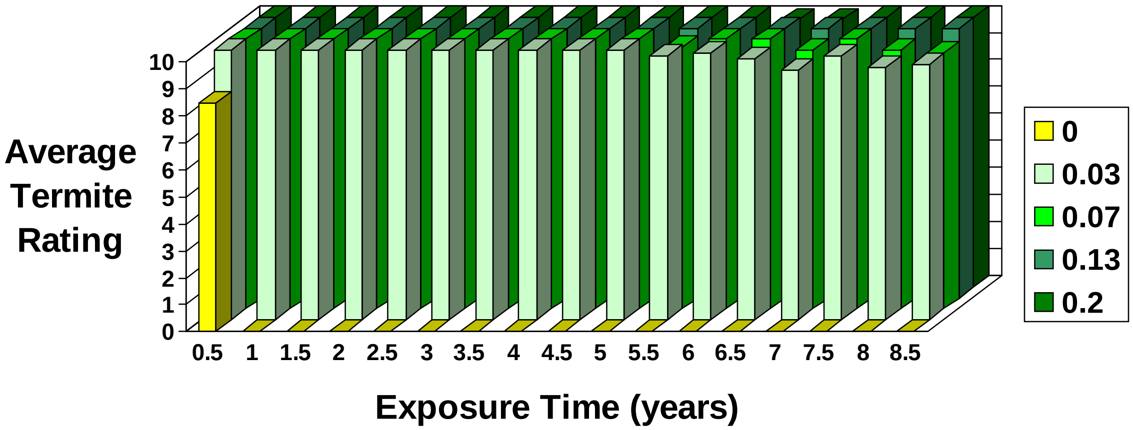

Figure 3. **Covered, Above Ground Exposure to the FST - MTU Test Site – Hilo, HI. CCA-C Treated Southern Pine Sapwood.**

Figure 4. Shell Treatment Susceptibility to the FST. Sample of CCA-treated Douglas-fir exposed to the FST in Hilo, HI for one year in a covered, above-ground test.

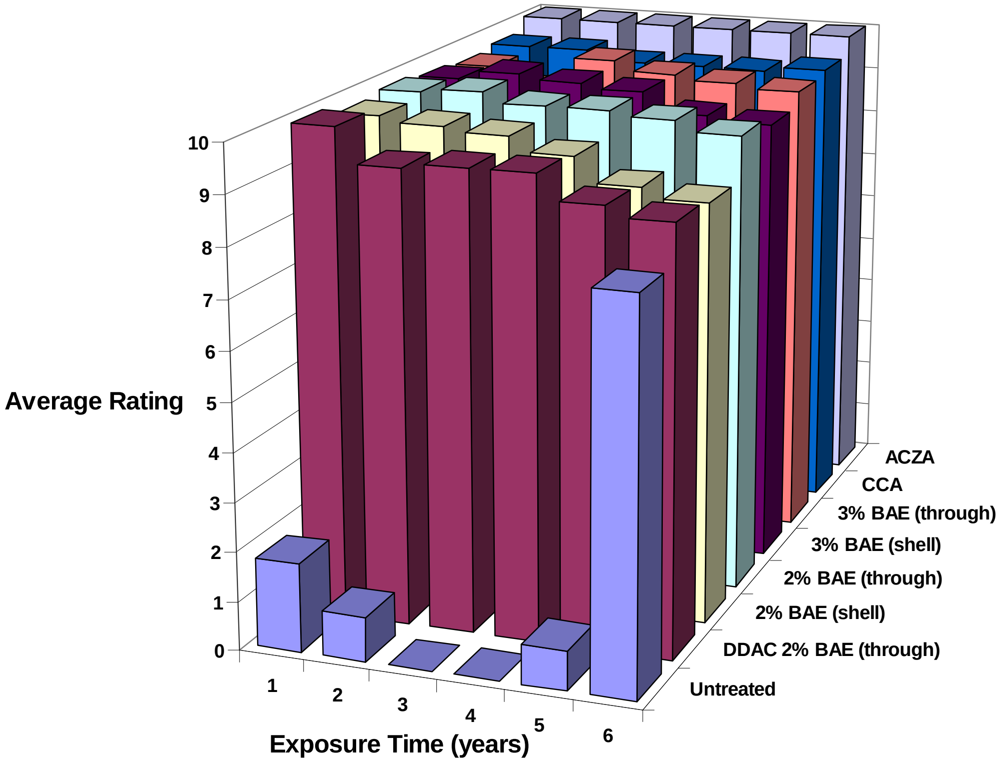

Figure 5. UofH / Forintek / Kyoto U. - 6 year data from Hem-fir Dodai samples exposed to the FST in a covered, above-ground test. Average visual ratings are on a 0 to 10 scale; rating of 10 indicates no attack while a rating of 0 indicates that the sample has been completely destroyed.

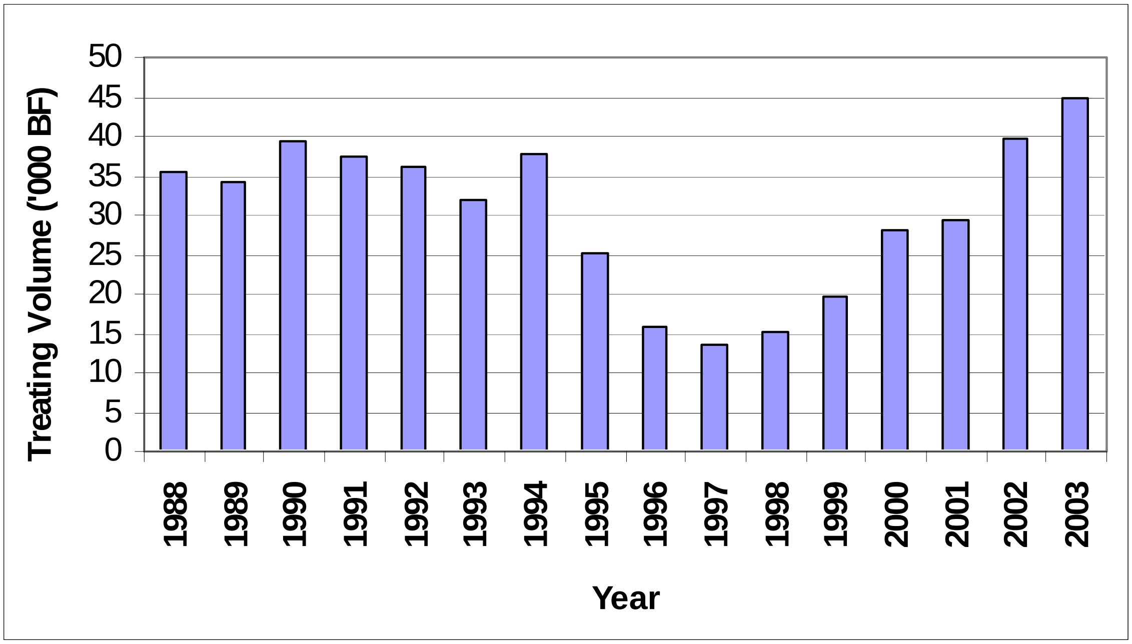

Figure 6. Historical Production Data for Preservative Treatment from a treating plant on Oahu.

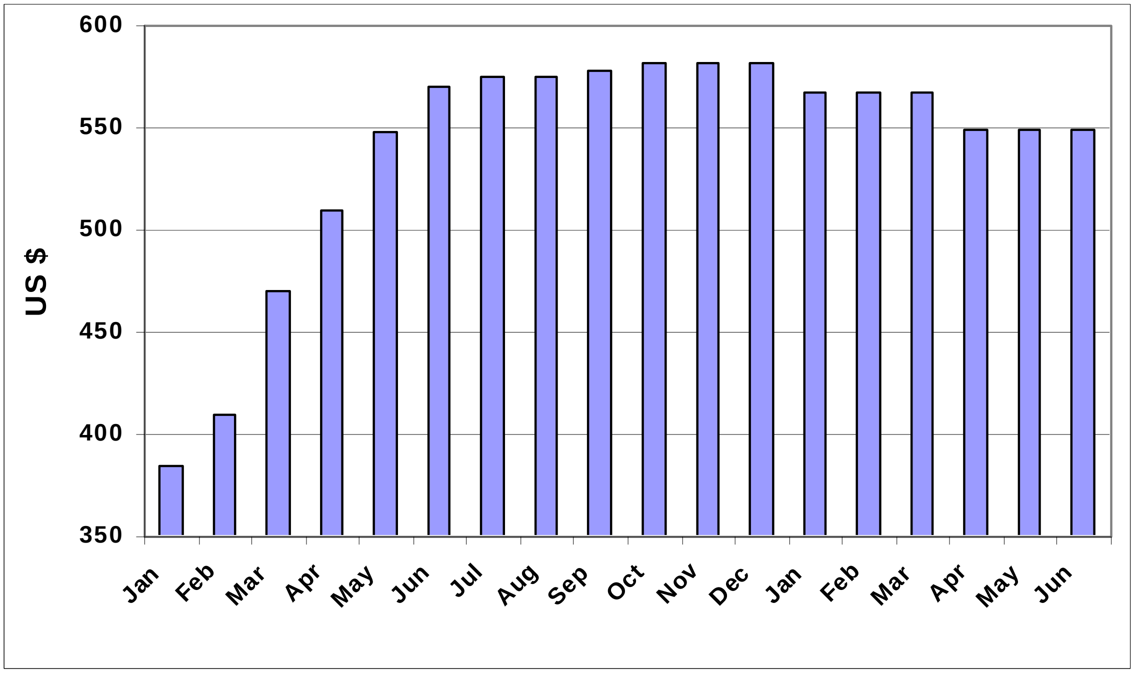

Figure 7. Steel Prices, Actual & Forecast (2004 – 2005, $ / ton). (Consline AG, 2004).