Development of Preservation Methods for Laminated Veneer Lumber

**Jeremy Christmas**
Manager-Wood Modification
Fibre-gen, Carter Holt Harvey
PO Box 2463
Rotorua, New Zealand

Jeremy Christmas has over 25 years experience in timber preservation and wood technology in New Zealand and Australia. He is currently involved in the commercialisation of several novel processes for preserving LVL and Plywood.

**Terry Smith**
Business Development Manager
Osmose New Zealand
PO Box 88-048
Auckland, New Zealand

Terry has been actively involved with the technical aspects of the timber preservation for 16 years. In this time he has been heavily involved with the development of new treatment processes and the application of new preservative systems.

**Dr Javier Romero**
Product Development Manager
Osmose Australia Pty Ltd
PO Box 1569
Maroochydore Qld, Australia

Javier completed his PhD at Melbourne University in 1998 where he specialised in novel wood preservation systems. Javier has been instrumental in laying the groundwork for the engineered wood preservation innovations in this paper.

Summary

This paper describes the joint projects undertaken by Carter Holt Harvey and Osmose New Zealand to develop novel techniques for the preservation of Laminated Veneer Lumber in Australia and New Zealand. The specific methods described include veneer pre-treatment, addition of insecticides to the glue, and surface treatments of the finished product.

1. **Keywords**
Laminated Veneer Lumber, ACQ, Bifenthrin, TimberSaver™

2. **Introduction**

New Zealand and Australia are producing increasing volumes of laminated veneer lumber (LVL), primarily manufactured from *Pinus radiata*. LVL is suited to construction applications as it is light weight, straight, dry and of controlled structural properties, however it is not inherently resistant to insect attack or fungal degrade, therefore in its untreated form it is limited to applications in covered, dry, non-termite areas.

By treating the LVL with fungicides and insecticides, the properties can be enhanced to make it resistant to insects and fungi, and thereby expand the potential market for this useful structural product. This can include uses in such hazard applications as H1.2 [1] (internal framing/low level decay hazard), H2 [2] (internal framing/termite areas) or H3 (above ground exposed to weather).

Some LVL is being treated in New Zealand and Australia by conventional means using water-borne vacuum-pressure treatment or solvent-borne low pressure treatment, yet these methods are not ideal for LVL, leading to issues such as distortion, twist, re-drying cost and degrade, solvent emissions, and incomplete penetration. In order to overcome these problems, Carter Holt Harvey initiated a
project to identify new treatment technologies that could be applied to LVL. This paper will discuss the joint development projects undertaken between Carter Holt Harvey and Osmose NZ.

Many of the above limitations could be overcome either through the application of water-borne preservatives to the individual veneers prior to drying and gluing (veneer pre-treatment), through the use of biocides added to the glueline (glueline treatment), or though application of biocides directly to the surface of the finished LVL beam (superficial treatment). These three approaches and the work undertaken to develop them will now be covered in more detail.

3. Treatment Methods

3.1 Veneer Pre-treatment

Most post-manufacture treatment of LVL products in New Zealand and Australia is currently undertaken utilising Light Organic Solvent Preservative (LOSP) treatments. These overcome the distortion and re-drying issues of water-borne products, but result in a wood product that contains high levels (up to 100L/m³) of volatile organic solvent because of the need to overcome the penetration resistance of glue lines and radial faced edges. The resulting solvent emissions can create a health concern for workers handling the timber product unless lengthy evaporation periods are used. There is also an environmental discharge concern, and at this time no Australasian LOSP plant has any solvent recovery capability. In both cases of post-manufacture treatment, the preservative cannot readily penetrate the whole product due to the phenol formaldehyde (PF) glue-lines acting as barriers, and the limited tangential penetration that is possible. This means that any subsequent cutting or drilling can expose untreated wood, unless in-situ preservative coatings occur. In-service splitting or checking can also breach any treatment envelope.

The initial trials sought to establish the compatibility between the phenol formaldehyde resin adhesive and the treated veneer, using small (400mm) samples. These initial trials included CCA oxide, ACQ and Copper azole (plus an untreated control), all treated in a freshly peeled state to an H3 (above ground, exposed) retention using conventional vacuum pressure impregnation. After drying, the veneers were laminated with PF resin to form 5-ply. The bonds in the completed products were then subjected to assessment by chisel test, in a dry state, after vacuum pressure impregnation with water and after 72-hour boiling.

The results [3] showed a clear preference for the use of ACQ as a preservative system, with mean bond scores of 8 (out of a possible score of 10) when tested using a vacuum pressure impregnation then chiselled. (10 equals 100% wood failure, 8 equals 80% wood failure). The lower performance for the other two preservative systems, and the additional disposal issues created by the use of CCA, meant that only ACQ was further pursued. Based on the small scale trials, a larger trial was undertaken to produce a small commercial quantity of full-sized plywood 2400 x 1200 mm in size. This trial in 2001 was also an opportunity to assess any effects on air quality or handling that the introduction of ACQ preservative may have. Approximately 7m³ of 3mm sapwood veneer was treated at a commercial ACQ treatment plant near Auckland. Treatment was by vacuum pressure impregnation of the 1m-high block-stacked veneer packs, with absorption of 160L/m³. After treatment, the packs were partially disassembled to assess chemical penetration; this was largely complete and uniform, although some lighter colour patches suggested lower uptakes where heartwood was present.

The veneer was dried in a commercial veneer dryer with an initial temperature of 210°C. Odour from the ACQ chemical (namely the monoethanolamine) was apparent adjacent to the first dryer zone, but not noticeable after this. Air monitoring at the dryer exit and grading stations confirmed that there were no hazardous vapours concentrations present due to the addition of ACQ preservative [4]. The dried veneer was flat and an even brown colour somewhat different to
untreated veneer. This material was subsequently assembled into 5-ply using normal (untreated) glue-spreads and pressing conditions. The finished plywood was an even colour and flat. Bond results were comparable with normal untreated veneer [5]

Given the success of this small commercial trial, further research was undertaken to gain a better understanding of the factors involved in achieving high quality bonds. These included veneer drying conditions (temperature), moisture content and gluespread. The conclusion from this work was that decreased veneer dryer temperatures could improve bond quality, however this also limited the throughput of the dryer, and so an appropriate temperature was selected as a compromise. Further work is now required to optimise drying schedules of ACQ treated veneers for specific driers.

A further 7m³ commercial trial was conducted to confirm earlier results. Air monitoring was conducted during the pressing operation, and monoethanolamine was only detected at the hot press at 0.26 ppm, far below the 3 ppm TWA limit. The completed plywood had excellent bond qualities with an average score of 8.05 (dry), 6.7 (Vacuum Pressure), and 7.7 (72-hour boil) [6].

Based on these results for plywood, the decision was taken to progress to a larger scale trial to manufacture LVL using the continuous press at Marsden Point near Whangarei, New Zealand. Marsden Point is a large facility utilising a microwave pre-heater prior to a Dieffenbacher continuous press.

50m³ of green sapwood veneer was treated using vacuum pressure impregnation at a commercial ACQ treatment plant. This material was then dried at the Marsden Point facility, whilst air monitoring was conducted. Monoethanolamine was detected at 0.13ppm at the dryer in-feed; however concentrations were below the detection limit at all other locations [7]

The dried veneer was then scarfed and re-graded and then used for the assembly of 39mm thick LVL. Air monitoring around the lay-up line, press and trim saw areas did not detect monoethanolamine above the detection limit. Bond quality in this commercial trial was equal or better than that normally obtained with untreated veneer.

The manufacture of treated LVL using a continuous press process and ACQ treated veneer has been proven to be commercially and technically viable, and trial batches have been manufactured for customer acceptance, with initial feedback being very positive.

3.2 Glue line Treatments

Termites are the cause of over $80 million damage each year in Australia and with the increasing use of LVL in termite-prone areas of Australia there has been a need to develop a low cost treatment that can be incorporated into the LVL at time of manufacture. Traditional pressure treatments are difficult with large dimension LVL beams.

The solution to this dilemma is to introduce an effective termiticide into the adhesive prior to LVL manufacture. There are however several requirements of the termiticide for it to be successful as a glueline additive. The additive needs to be:

- Stable in the glue system. PF glue is strongly alkaline (pH 12) and readily hydrolyses some very effective termiticides as permethrin and deltamethrin.
- Able to withstand pressure temperatures of in excess of 160°C without breaking down and therefore losing efficacy.
- Able to withstand microwave preheat energy
- Compatible with the glueline system to ensure glue viscosity and bond strength are not effected
- A strong repellent as well as an effective contact insecticide
- Extractible from the glue system by analytical chemistry methods to ensure treatment loadings can be accurately measured
- An insecticide that does not pose a threat to people or the environment during manufacture, and application.

The addition of insecticides to the adhesive of LVL is not new in Australia. Formulations containing such chemicals as chlordane and dieldrin have been used in the past however these formulations are no longer registered for timber treatment in Australia due to environmental and health reasons. The Australian / New Zealand Standard for preservative treatment of LVL [8] currently allows for the addition of Arsenic or Deltamethrin. Arsenic is now not being used as a glueline additive in Australia, for the above reasons, and may follow the fate of chlordane and dieldrin. Deltamethrin however is being used as an effective protection against termites although it is not very stable in the PF glue mixes, nor is it stable under the heat and pressure of the LVL curing process. It also causes paraesthesia or stinging sensations of the skin of some production staff [9]. There was therefore a need to find a more effective insecticide for this application.

Bifenthrin is a synthetic pyrethroid which is a contact insecticide with strong repelling properties. This molecule is widely used in cropping as a miticide and insecticide. It is currently one of two chemicals registered as chemical termite barriers in Australia as organochlorines were banned for environmental and health reasons. (The other approved chemical is chlorpyrifos, an organophosphate).

Work begin in this chemical application when Creffield and Watson [10,11] conducted laboratory bioassays and field trials using bifenthrin impregnated *Pinus radiata* blocks and plywood samples using PF resin containing bifenthrin. From their work they concluded that bifenthrin was relatively stable and highly active at low concentrations, demonstrating good efficacy against the economically important termite species, *Coptotermes acinaciformis*. Further work was carried out by Kennedy, Collins and Vella [12] which demonstrated that bifenthrin was stable in the PF glue mix. Kennedy et al. then developed an analytical chemistry method of extracting the bifenthrin from the PF glue system [13].

This initial work encouraged Carter Holt Harvey and Osmose to conduct a series of commercial trials to determine whether the introduction of bifenthrin into the glue line would affect the integrity of the glue bond or create any air emission issues that may impact on production staff or the environment.

The initial commercial trial was conducted at Nangwarry LVL mill in March 2002 using a bifenthrin-based glueline additive, Bistar 80SC. 15m$^3$ of LVL was made using 3.75 litres of a 10% bifenthrin formulation with 20% citronella added as a deodoriser. During this trial workplace exposure monitoring was conducted for Volatile Organic Compounds (VOC), pinenes and Bifenthrin and an odour survey was also conducted.

The workplace exposure monitoring showed VOC’s were well below the Worksafe guidelines are were predominantly pinenes. The bifenthrin levels were also below detection levels. A further trial was then conducted at Tokoroa Plywood mill in July 2002 using Bistar 80SC without citronella. Again air monitoring was conducted and no emissions were detected [14]. A further odour survey was conducted but no odours were noted. Bond tests were also conducted using dry chisel, vacuum pressure and steam (72 hour boil equivalent) and there were no negative impacts from the addition of bifenthrin to the production process or to the bond quality [15].

In July 2003 a commercial trial was carried out at Marsden Point LVL. Bistar 80SC was applied at 25g a.i. per m$^3$ with a 5g a.i. per m$^3$ surface spray and some 38m$^3$ of 90mm thick LVL was
manufactured. Air monitoring was again conducted and no emissions were detected [16]. Wood samples were independently tested by Queensland Forestry and found to exceed the AS/NZS 1604.4:2003 H2 requirements [17].

In late 2003 the National Registration Authority of Australia approved the use of bifenthrin in LVL glue-lines. In December 2003 Carter Holt Harvey commenced production of bifenthrin glueline treated LVL products. To date the demand for this product has been strong and we are expecting the demand to grow.

### 3.3 Surface Treatments

New Zealand has recently suffered from an increasing incidence of decay in house framing. The causes of this are numerous and include poor cladding and flashing installation, complex house design with numerous difficult joints, and unforgiving cladding systems that prevent or restrict ventilation or drying ability of the underlying frame. As a result of the high public profile of these issues, the NZ Government has introduced revisions to building standards and codes to reduce the risk to home-owning consumers. This has included the development of a specification for decay-resistant treatments for structural timbers in the external wall frames, where they are protected from direct wetting but may be accidentally exposed to elevated moisture contents due to building envelope failures; this is referred to in NZS3640:2003 as Hazard Class H1.2. This standard does not however provide for an H1.2 treatment level for LVL, so work has commenced to develop an LVL equivalent.

All LVL treatment in New Zealand is currently undertaken using organic solvent treatments to an H3 level, which is both costly and utilises high quantities of solvent. As a simple alternative method of producing a decay resistant LVL beam for internal use, surface-applied TimberSaver™ treated LVL has been installed in an accelerated test at Forest research in September 2003. This product that can be applied by a simple linear spray to a finished LVL beam, so TimberSaver™ promises to be a cheap, efficient and clean technology for LVL preservation.

TimberSaver™ is a boron-based, surface-applied wood preservative that has delivered excellent protection for solid wood in simulated wall framing trials at NZ Forest Research [18].

The performance of this material is uncertain in LVL, as the glue-lines may act as a barrier to diffusion of the preservative; hence the outcome of this trial is awaited with some interest. Logically however, the glue-lines will also act as a barrier to moisture penetration, so the expectation is that this treatment system will deliver the desired protection for LVL.

### 3.4 General

The specific schedules and preservative loadings are very much dependent on the specific equipment used in the LVL manufacturing process, such as driers and presses. The successful application of each of the above preservatives therefore needs to be specifically tailored to individual production facilities.

### 4. Conclusion

LVL is a relatively new construction material in New Zealand and Australia, and the product is experiencing rapid growth into traditional solid wood markets. There is a real need to develop improved preservation methods to enable the product to be more fully utilised under a wider range of conditions. The three preservative systems discussed provide cost-effective and practical methods to achieve these objectives. Glueline insecticide treatments using bifenthrin are now fully commercialised and ACQ veneer treatments are undergoing commercial trials, so the future of preservative treated LVL looks to be very promising.
5. References


[10] Creffield J.W. and Watson K., ‘Correlation between a laboratory bioassay and field trail conducted to determine the termiticidal effectiveness of bifenthrin’, IRG/WP 02-20248, 2002


