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Durability of light organic solvent preservative (LOSP) treatments for softwood glulam

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ABSTRACT

Treatment options for outdoor above-ground (H3) glulam of *Pinus radiata* and *P. elliottii* were examined. Beams were treated with azole LOSP to retentions of ~40 L/m^3 or ~70 L/m^3 either before or after gluing. TBTN-LOSP and CCA were included for comparison. Test specimens were exposed for four years outdoors in the wet tropics at Innisfail or in an accelerated field simulator (AFS) in horizontal or vertical orientation. Decay was 2.5 times faster at Innisfail than in the AFS. Glulam treated before gluing generally performed better than glulam treated after gluing, whether vertically or horizontally exposed. One exception was horizontally exposed specimens in the AFS, perhaps as treated wood is not lost upon dressing when treated in final form. Nevertheless, as glulam failure mostly occurs at ends, treatment before gluing provides better protection of individual laminates, especially important when beams are docked to size. End grain protection can be improved by resealing, and copper naphthenate was more effective than zinc naphthenate.

1. Introduction

Glulam allows the manufacture of timber beams that are stronger than can be made from solid (single piece) timber, and in a wider range of sizes (Bahadori-Jahromi et al., 2006). In Australia glulam is commonly produced from *Pinus radiata* and *Pinus elliottii*, and these products need preservative treatment for protection against decay fungi and termites if used outdoors. One of the main questions when preserving glulam is whether to treat before or after gluing (Selbo, 1957; Tascioglu et al., 2003). It is often more convenient to treat glulam in final form to meet 'just in time' production, less preservative treated wood waste will be generated, and the preservative will not interfere with the formation of the glue bond (Hunter, 1985; Vinden, 1985; Vick and Kuster, 1992; Frihart, 2003; Lisperguer and Becker, 2005; Lee et al., 2006; Lorenz and Frihart, 2006; Gaspar et al., 2010). Conversely, gluebonds block the penetration of preservatives (Vick and Kuster, 1992), so that grain orientation then greatly influences how deeply each laminate is treated. For example, the penetration of *P. radiata* glulam is restricted in the tangential direction irrespective of the severity of treatment, while this timber is very permeable in the radial and longitudinal directions (Vinden, 1985; Hunter, 1985).

Preservative characteristics also influence treatment method. Creosote and pentachlorophenol in heavy oil can be applied after gluing as the formulations do not distort or swell wood, and they limit checking during weathering so that the unpenetrated core is less likely to become exposed. These treatments have performed well in heavy engineering structures such as bridges (Selbo, 1957, 1964; Selbo et al., 1965; Reisdorff, 2010). Preservatives such as CCA, and more recently ACQ and copper azole, are more suitable for the domestic market. However, being waterborne preservatives they are rarely used in after-glue treatments as variations in seasoning rates along the beam can cause distortion and checking (Gaspar et al., 2010). Also, CCA-treated wood can suffer from checking during service (Selbo, 1964; Selbo et al., 1965) and open unpenetrated core. The alternative of treating before gluing is difficult as CCA interferes with the glue bond and glulam can delaminate in service (Vick and Kuster, 1992; Frihart, 2003; Lorenz and Frihart, 2006). This difficulty extends to laminates cut from recycled power poles (Piao et al., 2009). Researchers have sought to improve the gluability of water-borne treated laminates (Vick, 1995; Frihart, 2003; Tascioglu et al., 2003; Lee et al., 2006; Lorenz and Frihart, 2006; Gaspar et al., 2010), but success appears to require some in-house experience. These complications have limited production

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of glulam treated with CCA in the USA (Vick, 1995; Sellers and Miller, 1997); although in New Zealand, CCA-treated *P. radiata* laminates are often converted into glulam and have performed well, especially if coated to reduce the effects of weathering (Hunter, 1985; McIntosh, 1997). Glulam poles can also be produced from *Pinus sylvestris* that are CCA-treated before gluing and creosote-treated after gluing (Bergman and Jermer, 2010).

The light organic solvent preservatives (LOSPs) are widely used for glulam preservation in New Zealand (NZ) and Australia. In NZ these preservatives may be used in the milder H3.1 service category, and treated timber should be painted to boost durability (NZS 3640: 2003). For more structural H3.2 applications in NZ only water-bornes such as CCA, ACQ and copper azole are used. However, in Australia there is no subdivision of the H3 category and LOSP-treated glulam can be used in the full spectrum of outdoor above-ground applications and there are no coating requirements (AS/NZS 1604.5:2010). LOSP also provides the choice of treating before or after gluing. As the solvent is 'light' (white spirit, mineral spirits) and therefore more easily volatilised from wood, LOSP-treated laminates are relatively easy to glue, especially if wax is excluded (Hunter, 1985), although some loss of adhesion can still occur (Herzog et al., 2004).Alternatively, glulam can be treated in final form as LOSP does not swell wood. The effect of treatment method on durability has not been studied systematically. However, in Australia the author has been made aware of several examples of premature failure in glulam treated after gluing to the LOSP retention of 35 L/m^3-40 L/m^3. In some, the top end of glulam posts were docked to height after installation and simply painted, perhaps exposing unpenetrated sapwood and heartwood. These examples have raised concern about the level of preservative penetration that can be achieved in glulam that is LOSP treated after gluing, and whether it is an inferior product to glulam treated before the laminates are glued.

The aim of this trial was to compare the resistance to decay of LOSP azole-treated *P. elliottii* and *P. radiata* glulam, treated before or after gluing, and at two different preservative retentions. Other aspects were to examine the value of resealing ends cut after treatment with preservative, to calibrate decay rates between the field (Innisfail in the wet tropics) and a laboratory test facility called the Accelerated Field Simulator (AFS, Johnson and Syers, 1998; Cookson, 2012). Other variations were *P. elliottii* glulam treated with TBTN-LOSP, and *P. radiata* treated with CCA. The treatment, penetration, and two and three year inspections were described earlier (Cookson, 2011a,b). This article provides the final four year inspection results.

2. Materials and methods

2.1. Treatment and installation

P. radiata (radiata pine) and *P. elliottii* (slash pine) were treated either before gluing as loose laminates (70 mm × 30 mm profile) or after resorcinol gluing and dressing as glulam (260 mm × 65 mm profile, eight laminates per beam). Lengths that were 3.0 m or 3.6 m were treated with azole LOSP. Most treatments occurred at commercial treatment plants in Queensland, where each timber pack was weighed before and after treatment. The low retention loose laminates of *P. radiata* were treated (before gluing) in a pilot plant as 1.8 m lengths.

Proprietary treatment schedules were used at the commercial treatment plants and are not disclosed. The azole LOSP pilot plant treatment used a schedule of 1 min vacuum at −30 kPa, 10 min to introduce the treating solution while under vacuum, vacuum release and hold for 90 s. The LOSP was then drained from the treatment tray, and a final vacuum applied at −95 kPa for 10 min. The azole was 'ready to use' Vacsol Azure from Arch Wood Protection, and contained 4.5 g/L propiconazole, 4.5 g/L tebuconazole and 3.2 g/L permethrin. Two treatment levels were sought, ~40 L/m^3 and ~70 L/m^3, and both should meet the retention requirement of 0.06% m/m azoles.

While the main focus of the trial was for azole treatments, some additional TBTN and CCA treatments were conducted when spare untreated glulam was available, and test specimens were distributed according to the exposure space available at the test sites. The TBTN treatment was conducted in the pilot plant on *P. elliottii* glulam beams 1200 mm × 260 mm × 65 mm (treatment after gluing). The treatment solution was Osmose Lifewood H3 (235WR), and contained 50 g/L TBTN (12 g/L elemental tin), 20 g/L permethrin, >90 g/L white spirit and 50 g/L dichlofluanid. Additional TBTN concentrate and white spirit was added so that treatment would result in an appropriate H3 retention of 0.16% m/m elemental tin. The treatment schedule used was −25 kPa vacuum for 5 min, 80 kPa for 2.5 min, drain LOSP from treatment tray and apply a final vacuum of −95 kPa for 20 min.

A further comparison was the H3 CCA oxide (Tanalith O) treatment in the pilot plant of *P. radiata* 200 mm long × 260 mm × 65 mm (treatment after gluing) for exposure at Innisfail. The treatment schedule used to achieve a mean retention of 0.38% m/m total active elements was 30 min at −95 kPa, introduce CCA, 710 kPa pressure for 60 min, release pressure and leave the test specimens to soak for 15 min.

After LOSP treatment 200 mm long test specimens were cut from glulam beams. Test specimens were to be exposed horizontally (flat) or vertically (like posts). Those exposed horizontally had their cut ends resealed with three coats of epoxy (two part epoxy, Wattyl-Sigma Epinamel 202), so that decay should initiate through the original treated surface rather than the ends cut after treatment and glulam manufacture. The vertically exposed test specimens at Innisfail were painted on the sides in an effort to reduce splitting during exposure. The acrylic paints used were one coat of British Paints 'All in One' sealer primer undercoat, and two coats of Dulux Weathershield 'vivid white' low sheen. Similar vertical specimens in the AFS were not painted because they would not be exposed to outdoor weathering and were unlikely to split. Half of the vertically exposed test specimens at either site had no additional protection given to the ends cut after treatment (unsealed ends). The other half had the cut ends resealed with LOSP, using either a brush application of copper naphthenate (CuN) or a spray can application of zinc naphthenate (ZnN). The CuN formulation contained 1.2% m/m elemental copper in white spirit and 1.3% m/m permethrin. The ZnN formulation was 'Tanalised enseal clear', which contained 26% m/m zinc as zinc naphthenate and 1.3% m/m permethrin in liquid hydrocarbons. The preservatives were applied until all end grain was damp, after which they were left to air dry in a laboratory for more than one week. There were ten replicate test specimens of each variation at each test site, although the vertically exposed sealed specimens had five replicates sealed with CuN and five sealed with ZnN.

2.2. AFS and field exposure

The test specimens installed outdoors at Innisfail were placed upon two rows of untreated *P. radiata* 70 mm × 20 mm × frame length that would act as water traps and support fungal growth. The untreated *P. radiata* strips were nailed onto CCA-treated *P. radiata* bearers 70 mm × 35 mm × frame length (up to 2.4 m) (Fig. 1).

Other specimens were exposed indoors in an AFS, which is a large incubation room where conditions were 28 °C and 85% relative humidity. The test specimens were exposed in three empty stainless steel tanks 1770 mm long × 620 mm wide × 740 mm high (Fig. 2). The tanks were raised on wooden chocks so that a drainage system