OBSERVATIONS ON PLASTIC LUMBER AS A SUBSTITUTE FOR PRESERVATIVE-TREATED WOOD

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Abstract

Plastic lumber is being heavily promoted as a substitute for preservative-treated wood, particularly in public works applications. Parks and Recreation departments are attracted by the claims for environmental friendliness, minimal maintenance and long life. These positive attributes have been sufficient to overcome the numerous negative factors with these products. However, these claims are here called into question, based on a review of the literature and observations of material in service.

Introduction

Plastic lumber has been heavily promoted in trade journal articles (*inter alia* Anon 1996, Robbins 1996) as a more environmentally friendly alternative to preservative-treated wood with superior weather and decay resistance and virtually unlimited life.

Three main types of plastic lumber can be identified:

1. Engineered plastic materials, typically made from new vinyl or fibreglass.
2. Recycled plastic products, mostly polyethylene, some reinforced with fibreglass or steel.
3. Plastic/wood composites, with the plastic component being recycled polyethylene.

Compared to wood, engineered plastic materials have disadvantages in terms of weight, typically 3-4 times that of wood, and strength properties around one-half those of wood (Balatinecz 1996, Shaw 1997). Being made from new materials, they are more expensive than recycled plastic lumber.

Compared to engineered plastic materials, non-reinforced recycled plastic products have similar or lower strength properties, ranging from one-half to one-fifth that of wood, and similar or lower weight, ranging from 1.5 - 3 times that of wood (Balatinecz 1996, Shaw 1997). Their cost is typically 2 - 5 times that of wood (Lampo and Finney 1993, Smith 1995, Rosenblatt 1997). Due to the inherent properties of plastic and the low stiffness-to-weight ratio, they also exhibit creep, resulting in scenes like those illustrated in Figure 1. The fibreglass-rod and steel-reinforced products, though stiffer, are more difficult to cut and much more difficult to recycle.

Plastic/wood composites tend to have similar properties to the better recycled-plastic-only products (Balatinecz 1996, Shaw 1997). The wood fibre may just act as a filler but can provide some reinforcing function (Simonsen 1997, Boeglin, Triboulot and Masson 1997). Plastic/wood composites are easier to cut and drill than solid plastic, they have a lower thermal expansion and better surface traction. Their wood fibre content tends to range from 30 to 50% and it is claimed that the wood fibre is encapsulated by the plastic protecting it from wetting, weathering and decay. Field testing of some first-generation products has shown that this material is not weather resistant (Archer, Fox and Richards 1996). Until recently the claim of decay resistance had remained unchallenged. Laboratory tests of a 50:50 plastic/wood composite showed negligible decay after 12 weeks but the moisture content had slowly built up to levels which would support decay (Schmidt 1993). Naghipour (1996) did observe mass and strength losses in laboratory-made and commercial plastic/wood composites exposed under laboratory conditions for 16 weeks. The highest mass losses were observed for samples with more than 50% wood fibre content. Of the 50/50 formulations, the greatest mass loss (14.4% of the wood component) occurred with a commercial product. Morris and Cooper (1998) have shown that a commercial recycled plastic/wood composite can be attacked by bluestain, white-rot and brown-rot fungi after as little as four years in service.

The high density of all these products necessitates predrilling prior to nailing. This is a slow process because the heat from a drill at high revolutions can melt the plastic and bind the drill bit (Hollick 1997). Projects using these products typically cost 2-4 times those using treated wood due to the higher cost of the material and the higher labour cost to install (Rosenblatt 1997). Another concern is consistency of supply. Being proprietary products, they may be very difficult to replace if the original manufacturer goes out of business (Rosenblatt 1997). Some of these products come in a range of colours but plastic/wood composites typically weather to a grey colour (Archer *et al.* 1996, Shaw 1997). Although refinishing is not necessary, if desired, it can be very difficult, requiring intensive surface preparation (Hollick 1997).

A major barrier to the widespread acceptance of plastic lumber has been the lack of industry-recognised material specifications and design guidance although this is now being addressed (Anon 1997, Lampo and Finney 1993, Shaw 1997).

The presumed environmental friendliness of these products also needs to be questioned. The energy required for the manufacture and processing of recycled plastic lumber is about 3 - 4 times greater than that for wood (Smith 1995). Smith (1995) also points out that the raw material is a non-renewable resource. Not all plastics can be considered non-toxic. Commingled plastic lumber can contain pigments or dyes, plasticisers and antioxidants (Lampo and Finney 1993). These may or may not be as well fixed in the plastic as wood preservatives are in wood. Post-consumer recycled plastics can be contaminated with leftover product contained in bottles and with metals (Lampo and Finney 1993). Plastic wood is not immune to fire (Lampo and Finney 1993, Shaw 1997) and the resulting smoke may be cause for concern. PVC has come under attack as an "environmental poison" by Greenpeace because it releases chlorinated organic compounds when burned (Price 1994). Bearing all these issues in mind, it is instructive to determine whether the in-service performance of these materials bears out the manufacturers claims.

Observations on Plastic Lumber Products in Everglades National Park

Recycled plastic and plastic/wood composites have gained the highest level of public awareness partly because they have been extensively used by public authorities and parks (Figures 1-7). Such organisations are attracted by the claims of infinite life with no maintenance. It was therefore no surprise to find that the Everglades National Park in Florida had used such products to reconstruct boardwalks, park benches and other structures in the winter of 1992/93 after Hurricane Andrew. The supposed environmental benefits have been promoted in plaques attached to these structures (Figure 2). However, if one looks a little closer, these products do not appear quite so impressive.

Recycled plastic products (without wood fibre) are well known to require wood or metal substructures to provide stiffness and load-carrying capacity (Figures 2, and 3). Without such support these materials can barely hold up their own weight (Figure 1). Even plastic/wood composites, deck joists (typically preservative-treated wood) may have to be as close as 30 cm (one foot) on centre (Figure 4). The deck boards must be predrilled and screwed rather than nailed.

While these strength issues were anticipated, the observation of wood-rotting fungi growing on this material (Morris and Cooper 1998) came as something of a surprise. One fungus was *Gloeophyllum striatum* (Swartz:Fr.) Murrill (Figure 5), a brown-rot fungus (Gilbertson and Ryvarden 1986), and the other was *Pycnoporus sanguineus* (L.:Fr.) Murrill (Figure 6), a white-rot fungus (Nobles and Frew 1962). Furthermore dark stained patches on the surface of the plastic/wood composite (Figure 7) had the appearance of fungal stain. Microscopic examination confirmed extensive colonisation by a blue-stain fungus (Morris and Cooper 1998). Considering these findings, it is highly likely that, this material would also be susceptible to soft rot in ground contact. Soft rot is caused by fungi related to those that cause bluestain but have the capability to degrade lignocellulose somewhat like the brown-rot and white-rot fungi. Although Florida has the highest decay hazard in North America due to its climate, it is likely that similar decay problems would still occur in more temperate regions but at a slower rate.

The product in question was a 50:50 mixture of wood fibre, mostly hardwood, and recycled high-density polyethylene (Shaw 1997, Morris and Cooper 1998). The conditions were probably right for decay in much of this material. Swelling due to absorption of moisture was indicated by horizontal bowing of many boards which were restrained at both ends (Figure 8). Given this dimensional change and the growth of wood-inhabiting fungi on this material, it would appear that the wood fibres were not completely encapsulated by plastic.

It is possible that complete encapsulation might be accomplished with a higher plastic-to-wood ratio. These products are also believed to have undergone further development in the last four years to reduce moisture uptake and improve dimensional stability but it is not known if this has eliminated the decay problem. Eliminating the wood component altogether might be regarded as one solution to the decay problem but this does not help at all with the strength and weight problems (Figures 1, 2, 3 and 9).

At a time when sustainable development has become accepted as a common goal of most levels of public authority, their use of plastic lumber is not logical. Since plastics are made from a non-renewable resource, it would be more appropriate to recycle plastic bottles into more plastic bottles rather than trying to substitute for products made from a renewable resource. It is not the intent of this paper to support the suggestion implied by the plaque on the recycled plastic product illustrated in Figure 9.

Conclusion

The performance claims for plastic lumber should be carefully examined before making a judgement as to their ability to substitute for preservative-treated wood.

References

Anon. 1996. Plastic Lumber. Ready for prime time. Plastics Technology, August 1996. 34-39.

Anon. 1997. Test methods approved for plastic lumber. Environmental Building News 6(9):p4.

Archer, K.J., R.F. Fox and M.J. Richards. 1996. Performance Characteristics of recycled wood products: A comparison of "plastic wood" and treated lumber. Abstract of a technical forum presentation. Proc. American Wood Preservers' Assoc. 92:68.

Balatinecz, J. 1996. Plastic wood - Can it compete with the real stuff? Proc Cdn. Wood Preservation Assoc. 17:35-36.

Boeglin, N., P. Triboulot and D. Masson. 1997. A feasibility study on boards from wood and plastic waste: bending properties, dimensional stability and recycling of the board. Holz als Roh- und Werkstoff. 55 (1): 13-16.

Gilbertson, R.L. and L. Ryvarden. 1986. North American Polypores. Fungiflora, Oslo Norway.

Hollick, M. 1997. Personal communication - Pacific Wood Preservation Services.

Lampo, R. and D. Finney. 1993. From the garbage heap to your home. Recycled plastics are coming. ASTM Standardisation News August 1993. ASTM Philadelphia PA.

Morris, P.I. and P.Cooper, 1998. Recycled plastic/wood composite lumber attacked by fungi. For. Prod. J. 48. in press.

Naghipour, B. 1996. Effects of extreme environmental conditions and fungus exposure on the properties of wood- plastic composites. MSc thesis, Faculty of Forestry, University of Toronto.

Nobles, M.K. and B.P. Frew. 1962. Studies in wood inhabiting hymenomycetes V. The genus Pycnoporus Karst. Can. J. Bot. 40: 987-1016.

Price, W. 1994. Save PVC, use a tree. Timber Trades Journal 2 July 1994.

Robbins, A.E. 1996. Forecast Plastic. Building Products Digest, December 1996. p12.

Rosenblatt, M. 1997. Plastic decking lumber - Competitive analysis for wood treaters. Text of a presentation to the Osmose World Symposium 1997. Feb. 18-23 1997. Osmose Wood Preserving Division, Griffin GA.

Schmidt, E.L. 1993. Decay testing and moisture changes for a plastic-wood composite. Abstracts of the Research Symposium. Proc. American Wood Preservers' Assoc. 89: 108-109.

Shaw, C. 1997. Industry Update: Plastics as substitutes for treated wood products. Text of a presentation to the Osmose World Symposium 1997. Feb. 18-23 1997. Osmose Wood Preserving Division, Griffin GA.

Simonsen, J. 1997. Efficiency of reinforcing materials in filled polymer composites. For. Prod. J. 47 (1):74-81.

Smith, W.B. 1995. Characteristics of recycled plastic lumber. Abstract of a technical forum presentation. Proc American Wood Preservers' Assoc. 91: 90-91.

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Figure 1 Sagging recycled-plastic-lumber picnic table. The level tables in the background are pressure-treated wood.

Figure 2 Metal-supported recycled-plastic-lumber picnic table

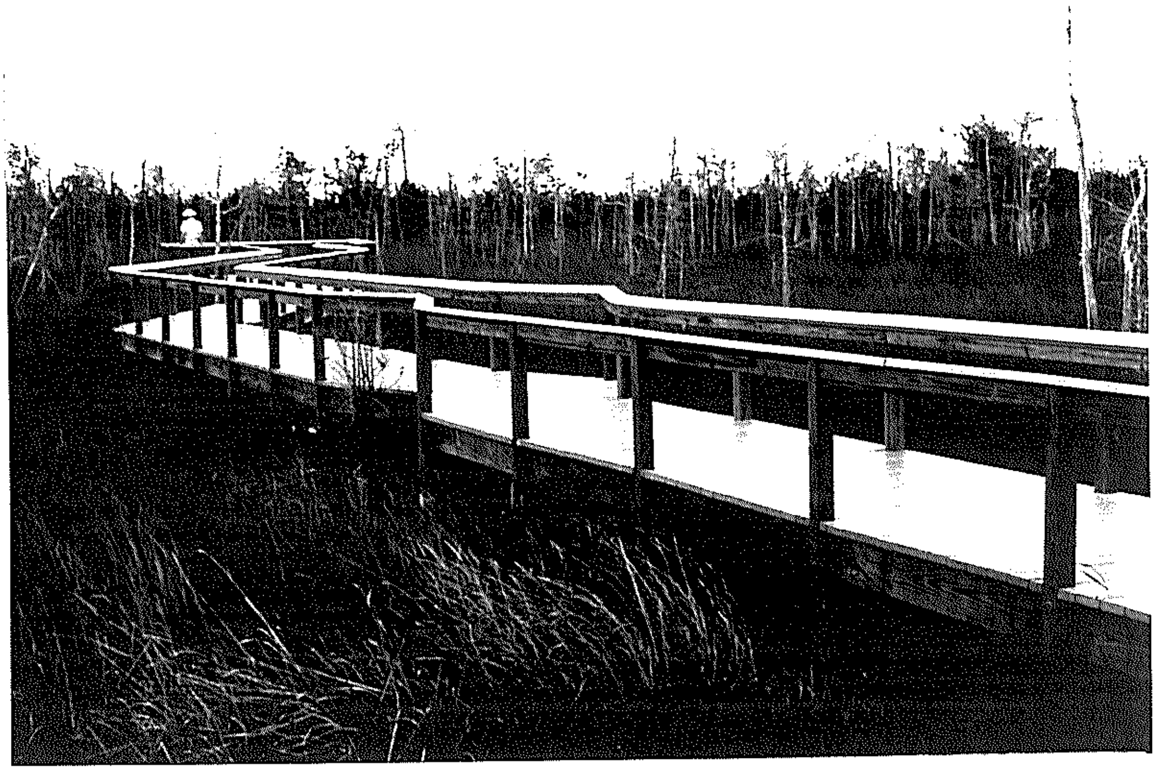

Figure 3 Wood-supported recycled-plastic-lumber walkway

Figure 4 Joists 1 foot on centre - plastic/wood composite lumber

Figure 5 G. striatum on plastic/wood composite lumber

Figure 6 P. sanguineus on plastic/wood composite lumber

Figure 7 Bluestain on the surface of plastic/wood composite lumber

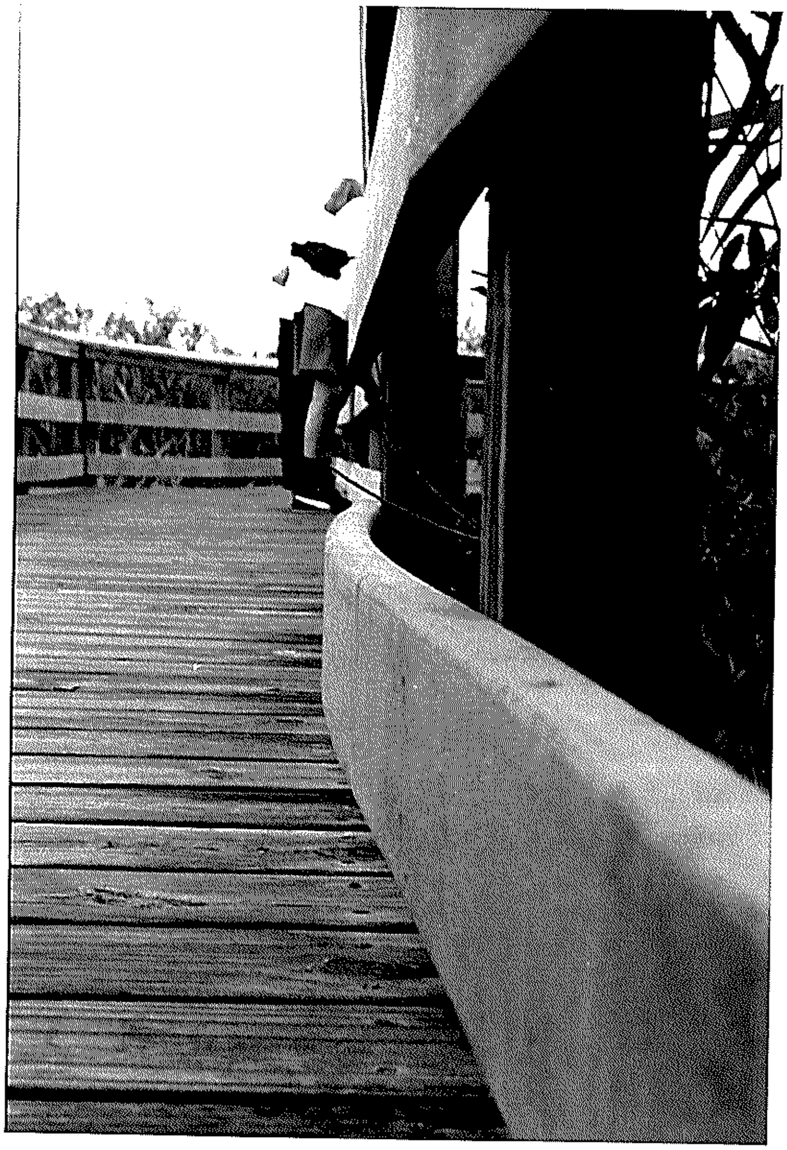

Figure 8 Bowed horizontal boards of plastic/wood composite lumber

Figure 9 Trash container showing warping of recycled plastic lumber