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FIELD TESTING OF WOOD PRODUCTS IN CANADA XVII: HIGH-PERFORMANCE PROFILED WOOD DECKING

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Abstract

The premature removal of treated wood from service, due to weathering rather than decay, has led to increased acceptance of alternative products promoted as "low maintenance". Wood-plastic and pure plastic products threaten to take considerable market share from preservative treated softwoods. These competing products have raised the bar for performance and price of deck surface boards. Profiling lumber shows promise to provide a makeover with a new look and reduced checking. Application of a durable coating should further reduce the effects of weathering. A service trial was therefore initiated of various profiles and coatings. Pacific silver fir and Mountain Pine Beetle-affected lodgepole pine lumber were used. Five different profiles were applied: rippled-flat edge, rippled to edge, ribbed-eased edge, ribbed-flat edge and centre, and flat. Two preservative systems were included ACQ, coated and uncoated and a carbon-based preservative, pigmented or coated. The boards were built into a demonstration deck in the FPInnovations courtyard.

After one year of exposure, all types of profiling significantly reduced check length compared to flat boards for both species, however, the pattern with the central flat strip showed checking down that strip. The ribbed profile was best for hiding the checks that did occur. Post-MPB pine, rippled-flat edge showed the lowest check length and depth compared to any other profile, for both pith face up and bark face up. Pacific silver fir, ribbed-eased edge showed the lowest check length compared to any other profile for both pith face up and bark face up. Pacific silver fir showed lower check depths than post-MPB-pine, for all profiles and orientations with one minor exception and lower check length on flat bark face up. Pith face up showed less checking than bark face up in Post-MPB pine for all profiles, but the difference was not statistically significant for Pacific Silver Fir. At this stage the effect of coating on checking was not statistically significant.

1. Introduction

The premature removal of treated wood from service, due to weathering (checking, distortion and UV degradation), rather than decay has led to increased acceptance of products promoted as low maintenance. Wood-plastic composite decking in the USA is anticipated to post 15% annual growth through 2009 to almost 900 million board feet (Freedonia Group 2003). Plastic and wood-plastic composite lumber are projected to capture 25% of the decking surface board market in the USA. This is a direct threat to the approximately 2 million cubic metres of softwood lumber annually treated with copper amine-based wood preservatives for residential and commercial exterior products. Plastic and wood-plastic composite products have also raised the bar for performance and price, 2 to 3 times that of wood decking.

Very little work has been done on checking of wood and how to prevent this, notable exceptions being the work of Evans e*t al.* (2003) and Urban and Evans (2005, 2007). Application of a durable coating should reduce the effects of weathering. FPInnovations – Forintek Division demonstrated that one type of profiling reduced checking and masked the checking that did occur (McFarling and Morris 2005). This material was re-inspected after 3 and 5 years and the results are presented here. Other types of profiling may be more or less effective than the pattern tested. Furthermore the ability of these patterns to stand up to wear was unknown, so a service trial of various profiles and coatings was initiated. This included an evaluation of the effect of grain orientation in these two species since authorities differ in their recommendations on this aspect of deck construction. In addition four deck sections were displayed at the Vancouver Home and Garden Show to test consumer reaction to different profiles. Over 90% of consumers surveyed at the show preferred some form of profiling over flat decking when they were informed that it minimizes the appearance of checking (McFarling et al. 2007). This paper presents results on serviceability of the experimental deck after one year exposure using the inspection methods in a draft AWPA standard test for serviceability.

2. Materials and Methods

Note: For description of the original experiment set up in 2002/03 see McFarling and Morris (2005)

Profiling, Treating and Coating

Eight-foot kiln dried boards were obtained for two species: Pacific silver fir (*Abies amabilis*), and lodgepole pine (*Pinus contorta* var. *latifolia*). The Pacific silver fir (finished size: 1-¼" x 5-½") was obtained from Cascadia Custom Cut, Vancouver, BC. Mountain Pine Beetle-affected (post-MPB) lodgepole pine (finished size: 1-½"x 5-½") was sourced from Canfor Corporation, Quesnel, BC. The Pacific silver fir and post MPB lumber were planed to 1-¼", sorted, and cut into two end-matched four-foot samples with one sample being marked pith face up and the other bark face up, before profiling.

The Pacific silver fir boards were grouped into ten sets of twenty boards and profiled as per groups 1 to 10 (Table 1). The post-MPB boards were grouped into five sets of ten boards and profiled at Pacific Rim Reman Ltd., Langley, on June 26th, 2006 to specifications drawn up by FPInnovations staff. The four profiles shown in Figure 1, as well as flat decking, were manufactured.

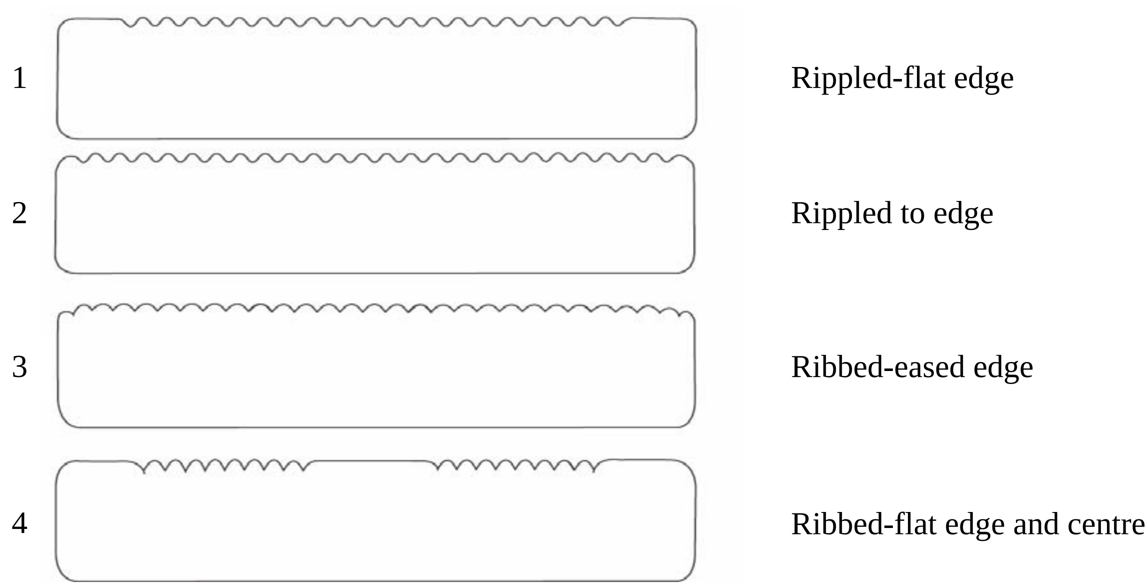

Figure **1:** Four of the profiles used for decking (Profile 5, flat not shown)

The boards were cut to 815 mm to match the joist spacing and were weighed before treatment. The treating schedule used was: an initial 30 minute vacuum at 29” Hg, followed by 90 minutes at a pressure of 150 psi, then a final 15 minutes of vacuum. The boards were treated using one of three preservative solutions, ACQ-D (carb), a Carbon-based preservative and the same C-based preservative incorporating 0.87% of a blend of transparent iron oxides. There was no significance to the selection of ACQ over copper azole, since the only objective was to ensure the boards did not decay before their serviceability could be evaluated.

Each board was weighed after treatment. The ACQ-D (carb.) boards were wrapped for one week prior to air drying. The C-based preservative treated deck boards were stacked to air-dry immediately after treatment. After approximately 48 hours, boards from selected groups were coated with one coat of Natural Deck Oil™ (Napier Environmental Technologies Inc.). All the boards were air dried to approximately 19% moisture content.

The deck was constructed in the FPInnovations courtyard in August, 2006. The old deck was dismantled, and new joists were installed where necessary. The deck was constructed using #8 2.5” screws. Three different coated screws were chosen but results on fasteners are not discussed in this paper. The boards were pre-drilled with two holes near each end and two holes near the centre, lining up with the joist spacing. Each deck board had two screws from each type. The boards were installed in groups of ten (same profile), five end-matched pith face up and bark face up samples. All the groups were randomly positioned across the deck, photographed and mapped. The completed deck is shown in Figure 2. Three interpretive signs, describing the study, were prepared for display in the courtyard. The courtyard is well utilized during the spring/summer/autumn months, which provides a good indication of wear on the different profiles.

Figure ***2:*** FPInnovations courtyard deck

The boards were rated using a draft AWPA standard for serviceability of decking, developed by FPInnovations, for the following dimensional stability characteristics. Cupping, and length, depth and width of checks were measured individually for each sample on the top face, as follows:

Cupping: maximum deviation on the face from a straight line drawn from edge to edge
Check length: the total length of all the checks added together
Check depth: the deepest check measured with a 0.008" feeler gauge
Check width: the maximum width of the largest check on the surface of the specimen

The overall checking appearance was visually rated on a 10 to 0 scale, with 10 (Good) having no checks and 0 (Failure) being severe checking affecting structural performance. The samples were also photographed and the data collated. The coating was evaluated for black stain, colour change and coating erosion (Table 1).

Table 1: Evaluation Methods

Evaluation	**Method**
Colour Change	Subjective visual assessment similar to ASTM D 3274-88
Mold/stain	ASTM D 3274-88
Coating Erosion	ASTM D 662-93

A performance rating of 10 indicates no change from the original un-weathered condition; 5 indicates that refinishing would normally be required but without extensive preparation; and 1 represents a total failure. The time required for the coating to reach a level of 5 serves as a convenient measure of coating durability. Statistical comparisons were made using Student's t test or, where samples were end matched, using a paired t test.

3. Results and Discussion

2003 Experiment

The data after 1 year exposure showed a 90% reduction in check length due to profiling (McFarling and Morris 2005). After 3 and 5 years, check length increased in both profiled and flat boards but the profiled boards still showed 84% reduction in check length. Measurement of check length required getting down on hands and knees. Standing on these boards, the checks were unnoticeable. Check lengths for these boards were considerably greater than those for the material in the 2006 experiment. This is likely because the material was subalpine fir which has a high tendency to check and because the boards were nominal 2 x 4 inch with a greater potential for surface to interior moisture differentials.

Table 2: Change in Check Length over Time

		Mean Check Length mm		
Profile	**Preservative**	**1 yr**	**3 yrs**	**5 yrs**
Flat	CA-B	2798	3120	4169
Flat	CCA	2543	2897	3357
Rib	CA-B	309	518	672
Rib	CCA	252	325	519

2006 Experiment

The Canadian standard for Group A small dimension and profiled products (CSA O80 series) requires a gauge retention of 2.0 kg/m^3 for ACQ-D (carb.). The carbon-based preservative is not yet in the CSA standards. The Pacific silver fir and post-MPB pine treated with ACQ-D (carb.) both exceeded the gauge retention requirement (Table 3).

Table 3: Retention Data

Preservative	Species	Group #	Mean Gauge Retention[1] (kg/m^3) Active Ingredients
ACQ-D (carb.)	Pacific Silver Fir	1-10	5.7 (1.0)[2]
ACQ-D (carb.)	Lodgepole Pine (post-MPB)	1,3,5,7,9	3.2 (1.0)
Experimental C-based	Pacific Silver Fir	2,4,6,8,10	0.6 (0.3)

[1] Only gauge retentions were recorded, all of the boards were required for the test so no borings/samples could be taken
[2] Average of all groups; numbers in parentheses are standard deviations

Post-MPB Pine Data

With only a few specimens showing a small amount of cupping (Table 4) this was not a noteworthy characteristic of the test material. The specimens that did show cupping had 1.2 mm or less cupping present. Cupping measured in the rippled, flat edge is partly due to the tops of the ripples being machined below the level of the flat edge.

Table 4: Post-MPB Pine – Cupping Data

Profile Type	Grain Orientation	Average Cupping (mm)
Flat	Pith face up	0.2
Ribbed; Eased Edge	Pith face up	0.3
Ribbed; Flat Edge & Center	Pith face up	0.2
Rippled to Edge	Pith face up	0.1
Rippled; Flat Edge	Pith face up	0.6
Flat	Bark face up	0.8
Ribbed; Eased Edge	Bark face up	0.5
Ribbed; Flat Edge & Center	Bark face up	0.3
Rippled to Edge	Bark face up	0.4
Rippled; Flat Edge	Bark face up	1.2

When comparing groups with the same grain orientation, all the profiled boards had significantly lower ($p < 0.05$) check lengths than flat, but ribbed-flat edge and centre bark face up had greater checking than other profiles. The checks showed up in the flat centre section. Rippled-flat edge (pith face and bark face up) as well as ribbed-flat edge & center (pith face up) were the only samples to show a significantly lower ($p < 0.05$) average check depth than flat. With the exception of the ripple to edge (pith face and bark face up), which had one board with a large split, and ribbed-flat edge & center (bark face up), the remaining profiled sets showed significantly lower ($p < 0.05$) check width than flat. Among the profile types, rippled-flat edge had significantly shallower check depths ($p < 0.05$) for both bark face and pith face up orientations. Pith face up showed less checking than bark face up in post-MPB pine for all profiles. Urban and Evans (2005) found similar results for southern pine, however pith face up is not recommended for this species (Williams and Knaebe 1995) due to separation between growth rings creating spears on the surface (shelling). While putting boards bark face up might be expected to put the more treatable sapwood in the more vulnerable upper surface (Williams and Knaebe 1995), the relatively thin sapwood in most Canadian species means there is little or no sapwood in the middle of the top surface of nominal 6 inch boards typically used for deck surfaces in Canada. Furthermore Choi et al (2004) showed checks penetrating through the treated zone are protected against the spores of wood rotting basidiomycetes by mobile copper.

The two groups that had slightly (but not significantly) lower average appearance ratings after one year, compared to all other groups, were the bark face up flat and the ribbed-flat edge & center (Table 5).

Table 5: Post-MPB Pine – Checking Data

Profile Type	Grain Orientation	Total Average Check Length (mm)	Total Average Check Depth (mm)	Average Check Width (mm)	Average Overall Appearance
Flat	Pith face up	1525	9.6	0.8	8.8
Ribbed-eased edge	Pith face up	513	7.3	0.3	9.3
Ribbed-flat edge & center	Pith face up	532	5.3	0.3	9.0
Rippled to edge	Pith face up	356	9.2	0.5	9.1
Rippled-flat edge	Pith face up	286	4.3	0.3	9.6
Flat	Bark face up	2470	10.5	0.9	8.1
Ribbed-eased edge	Bark face up	971	10.5	0.5	9.0
Ribbed-flat edge & center	Bark face up	1266	10.3	0.7	8.3
Rippled to edge	Bark face up	936	12.2	1.1	9.0
Rippled-flat edge	Bark face up	634	6.7	0.5	8.9

After one year of exposure there were no significant differences between coatings on any of the profiles (Table 6).

Table 6: Post-MPB Pine – Coating Data

Profile Type	Grain Orientation	Colour Change	Mold/ Stain	Coating Erosion
Flat	Pith face up	9	9	9
Ribbed; Eased Edge	Pith face up	9	10	9
Ribbed; Flat Edge & Center	Pith face up	8	10	9
Rippled to Edge	Pith face up	9	10	9
Rippled; Flat Edge	Pith face up	7	9	8
Flat	Bark face up	9	9	9
Ribbed; Eased Edge	Bark face up	9	10	9
Ribbed; Flat Edge & Center	Bark face up	8	10	9
Rippled to Edge	Bark face up	9	10	9
Rippled; Flat Edge	Bark face up	8	10	9

Pacific Silver Fir (PSF) Data

With only a few specimens showing a small amount of cupping (Table 7) this was not a noteworthy characteristic of the test material. The specimens that did show cupping had 0.8 mm or less cupping present. Cupping measured in the rippled, flat edge is partly due to the tops of the ripples being machined below the level of the flat edge.

Table 7: PSF – Cupping Data

Profile Type	Grain Orientation	Average Cupping (mm)
Flat	Pith face up	0.3
Ribbed; Eased Edge	Pith face up	0.1
Ribbed; Flat Edge & Center	Pith face up	0.2
Rippled to Edge	Pith face up	0.4
Rippled; Flat Edge	Pith face up	0.5
Flat	Bark face up	0.2
Ribbed; Eased Edge	Bark face up	0.2
Ribbed; Flat Edge & Center	Bark face up	0.4
Rippled to Edge	Bark face up	0.4
Rippled; Flat Edge	Bark face up	0.8

The ribbed-eased edge profile had the lowest average check length in the bark face-up ($p < 0.05$) orientation (Table 8). The profile with the flat centre section showed checking in the flat centre part. There was no significant difference among the profiles with respect to the check depth and width (Table 8). The average appearance at one year showed the flat specimens to have slightly (but not significantly) lower appearance ratings than the profiles (Table 8). There was a significantly better performance from the rippled to edge and ribbed; eased edge (bark face up) profiles ($p < 0.05$). With Pacific silver fir, there were no significant differences between grain orientations, possibly because there is little permeability difference between heartwood and sapwood in this species.

Table 8: PSF – Checking Data

Profile Type	Grain Orientation	Total Average Check Length (mm)	Total Average Check Depth (mm)	Average Check Width (mm)	Average Overall Appearance
Flat	Pith face up	916	6.6	0.7	8.8
Ribbed-eased edge	Pith face up	263	5.1	0.4	9.6
Ribbed-flat edge & center	Pith face up	526	5.6	0.6	9.2
Rippled to edge	Pith face up	483	4.0	0.3	9.5
Rippled-flat edge	Pith face up	711	6.8	0.6	9.4
Flat	Bark face up	1105	6.5	0.6	8.8
Ribbed-eased edge	Bark face up	320	4.0	0.2	9.6
Ribbed-flat edge & center	Bark face up	591	4.3	0.6	9.4
Rippled to edge	Bark face up	668	4.3	0.4	9.4
Rippled-flat edge	Bark face up	693	6.0	0.5	9.3

After one year of exposure the effect of coating ACQ treated samples was not statistically significant (Table 9). It was also too early to distinguish differences in grain orientation and overall appearance.

Table 9: PSF – Coated vs. Uncoated ACQ Checking Data

Coated vs. Uncoated	Grain Orientation	Total Average Check Length (mm)	Total Average Check Depth (mm)	Average Check Width (mm)	Average Overall Appearance
Coated	Pith face up	506	5.1	1.1	9.4
Uncoated	Pith face up	881	6.0	0.6	9.1
Coated	Bark face up	547	5.4	0.4	9.4
Uncoated	Bark face up	1134	6.0	0.6	9.0

The effect of coating carbon-based preservative treated samples in reducing checking was substantial but not statistically significant (Table 10). It was also too soon to distinguish differences in grain orientation and overall appearance.

Table 10: PSF – Coated vs. Pigmented Carbon-Based Preservative Checking Data

Coated vs. Pigmented	Grain Orientation	Total Average Check Length (mm)	Total Average Check Depth (mm)	Average Check Width (mm)	Average Overall Appearance
Coated	Pith face up	389	5.1	0.4	9.4
Pigmented	Pith face up	543	6.3	0.5	9.3
Coated	Bark face up	379	3.2	0.2	9.6
Pigmented	Bark face up	642	5.4	0.6	9.3

After one year of exposure there were no significant differences among coatings (Table 11).

Table 11: PSF – Coating Data

Profile Type	Grain Orientation	Colour Change	Mold/ Stain	Coating Erosion
Flat	Pith face up	7	9	8
Ribbed; Eased Edge	Pith face up	8	10	9
Ribbed; Flat Edge & Center	Pith face up	8	10	9
Rippled to Edge	Pith face up	8	10	9
Rippled; Flat Edge	Pith face up	8	10	9
Flat	Bark face up	7	9	9
Ribbed; Eased Edge	Bark face up	8	10	9
Ribbed; Flat Edge & Center	Bark face up	8	10	9
Rippled to Edge	Bark face up	8	10	9
Rippled; Flat Edge	Bark face up	8	10	9

Comparison between Wood Species

Pacific silver fir showed lower ($p < 0.05$) check depths than post-MPB pine, for all profiles and orientations with one minor exception. Flat Pacific silver fir showed lower ($p < 0.05$) check lengths than post-MPB pine (bark face up) but there was no similar definitive pattern for the profiled boards.

Summary

Profiling shows promise to provide a makeover with a new look plus reduced checking. A profiled and coated treated wood product could be priced well below plastic decking and command a healthy premium above conventional treated lumber.

4. Conclusions

- All types of profiling significantly reduced check length for both species.
- The pattern with the central flat strip showed checking down that strip.
- For post-MPB pine, the rippled-flat edge showed the lowest check length and depth compared to any other profile.
- For Pacific silver fir, the ribbed-eased edge showed the lowest check length compared to any other profile.
- Pacific silver fir showed lower check depths than post-MPB pine, for all profiles and orientations, with one minor exception, and lower check length in flat, bark face up.
- Pith face up showed less checking than bark face up in post MPB pine for all profiles, but there was no significant difference in Pacific silver fir.
- The reduction in checking provided by profiling is not a short term phenomenon.

5. Acknowledgements

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