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HIGH-PERFORMANCE WOOD DECKING

By

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Summary

In the early 70's CCA treated wood was introduced to the decking market, and has since dominated the market in North America. Currently deck surface boards represent approximately 20% of the treated wood market. This market share has been declining since the introduction of plastic/composite decking. Consumers have indicated that between 25 to 33% of future decks, new and replacement will be made using plastic/composite decking. Plastic lumber has raised the bar, it has a more uniform appearance and claims good performance, but at a 3 to 5 times the cost. Using treated wood's price advantage over plastic lumber, there appears to be an opportunity to introduce new wood decking products. The simplest and cheapest way to improve appearance and performance of wood decking is to profile the surface.

In September 2003, Forintek Canada Corp. set up a decking test to compare ribbed decking to radius edge (or flat) decking, treated with CCA, CA and ACQ. After 23 months exposure all of the preservative treated ribbed decking samples, had significantly lower average check lengths, shallower check depths, narrower check widths and better average appearance (checking) ratings compared to the same preservative treated radius edge specimens. Profiling appears to be reducing and also concealing the checks.

1 Background

Approximately 40 years ago the decking market consisted of decking made from cedar/redwood, concrete or tropical hardwoods. Chromated copper arsenate (CCA) decking materials were introduced in the early 70's, this in turn created and dominated the decking market in North America. In the early 90's wood plastic composites, then pure plastics and lately aluminum decking products were introduced into the decking arena. Most recently, there has also been a resurgence of tropical hardwoods being used for decking.

Since the introduction of plastic/composite decking into the decking market, the treated lumber market share has been declining. Between 1995 and 2000, Table 1, plastic/composite decking took up only 2 to 4% of the decking market share. By 2003 consumers have indicated that between 25 to 33% of future decks, new and replacement, will be made using plastic/composite decking.

Table 1: Plastic/Composite Decking Market Share Estimates

Year	Share	Market	Region	Source[1]
1995	2%	New and R&R	US	Freedonia, 2001
2000	4%	New and R&R	US	Freedonia, 2001
2003	33%*	Builders and deck contractors	US	CINTRAFOR, 2005
2004	25%**	Consumers	US	Forintek, 2005

* Deck surfaces only
** Next planned deck material
[1] Freedonia came out of the CINTRAFOR report.

Currently approximately 71% of decks in place have been built with treated lumber. From a recent survey (Fell and Brooks 2005), consumers indicated that for their next deck that number would fall to less than 50% of market share for treated lumber. Plastic/composite decking would gain the greatest market share increase, from 5% to approximately 25%.

The plastic/composite decking industry has been doing a good job of marketing its product; including indicating the material is "maintenance free". A quote from Home Depot® catalog in May 2005: "….. is a virtually indestructible alternative to wood. It will not splinter, crack, warp or rot. Unlike wood, ….. has no enemies. Heat, UV rays, snow, insects and inclement weather are no match for an ….. deck."

Using prices obtained from The Home Depot® fliers from March 14th, 2005 and April 7th, 2005 the following is a price comparison for a 12 foot by 5/4" x 6" deck board (rounded to nearest $ and excluding taxes):

Treated lumber	$10
Cedar	$15
Plastic/composite	$29 to $48

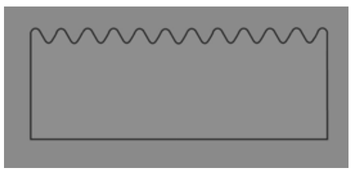
With the price of crude oil/gas increasing, and with world oil production being projected to reach maximum capacity this decade, the price of pure plastic will also increase. Recycled plastic material costs will most likely follow virgin material costs. The higher cost of crude has already had an impact of the plastic lumber industry with one major manufacturer posting a 2nd quarter 2005 loss partly due to higher raw material costs, when compared to 2004.

Is plastic lumber a problem or an opportunity for the treated wood decking market? Plastic lumber has raised the bar, it has a more uniform appearance and claims good performance, but at a 3 to 5 times the cost. Using treated wood price advantage over plastic lumber, there appears to be an opportunity to introduce new wood decking products. This could be done a number of ways. The grade of the lumber used for decking could be improved, or colour (coatings) could used to improve appearance. But the simplest and cheapest way to improve appearance and performance is to profile the wood decking.

Profiled decking has been used in Australasia for approximately 20 years (Morris 1990), and is now widely used in Europe. Is has been tried a couple of times in North America. While it was always the right idea, now is the right time to re-introduce profiled decking in North America.

Some of the reasons for focusing on profiling are obvious, it has a new (to North America) look, patterns can be made by alternating flat and ribbed side up, and it is slip resistant.

In terms of the look, there are three basic profile options (although virtually unlimited variations). We propose the following nomenclature to help in the discussion of these options: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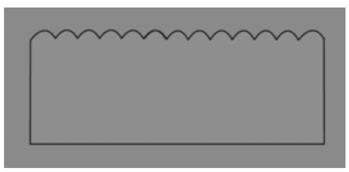
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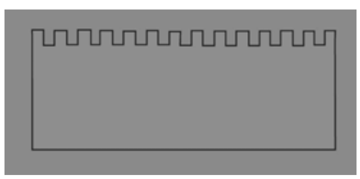
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In September 2003, Forintek Canada Corp. set up a field trial to compare ribbed decking to radius edge (flat) decking.

2 Materials and Methods

2.1 Field Trial

2.1.1 Source Decking Lumber

Canfor Corp. in Surrey, British Columbia, manufactured decking boards from sub-alpine fir vertical grain and flat grain. Fifty boards of radius edge decking, 26 mm x 133 mm x 2.43 m, and fifty boards of profiled/ribbed decking, 26 mm x 131 mm x 2.43 m, were selected based on visual criteria. The moisture content of the decking material was found to range from 15 to 18%. Ten boards from each group (radius and profile/ribbed decking) were put aside as untreated control specimens. These boards were cut into two end-matched samples 0.6 m long. Each of the remaining 40 boards per group was then cross-cut into three end-matched 0.8 m long samples and labeled. Each of these three end-matched samples was treated with a different preservative. These samples were then end-sealed with three coats of a two-part epoxy resin.

2.1.2 Preservative Treatments

Three preservative systems were used to treat the samples as in Table 2.

Table 2: Preservative Systems for Decking Test

Preservative	Solution Temperature (°C)	Solution Concentration Actives (%)
Chromated Copper Arsenate (CCA)	≈ 20	1.98
Alkaline Copper Quat – Type D [Carb.] - (ACQ-D)	40	1.62
Copper Azole (CA)	40	0.89

The solution strength for CA was based on previous tests. The solution strengths for ACQ-D and CCA were adjusted based on the uptake data for CA. The following treating schedule was used for all preservative systems:

- 30 min vacuum 635mm Hg
- Fill retort under vacuum with treating solution (as in Table 1)
- 5 minutes to full pressure
- 180 minutes at full pressure - 1035 kPa
- 10 min pressure relief to atmospheric
- Empty retort
- 15 minute final vacuum 635 mm Hg

All charges were monitored by the pilot plant software. Samples were weighed individually before and after treatment, to determine uptakes. The samples were then wrapped, in treatment groups, in polyethylene sheet to retard drying, and stored at approximately 25°C for 2 weeks to allow preservative stabilization. Following stabilization the specimens were unwrapped and allowed to air-dry.

One group of 40 boards was treated with CA first. Following drying, a 5mm cross-section was cut from both ends of the samples to remove the end-seal. Two 25 mm cross-sections were then taken, from one end, for penetration and retention analysis. One of these cross-sections was sprayed with Chrome-Azurol S indicator solution (American Wood Preservers' Association 1997a), and the treated zone was measured. The penetration measurement was taken on the edge of the sample to simulate the location typically sampled during quality assurance inspections. Using the second cross-section, a 5 mm long by 15 mm wide sub-sample was cut from the edge, to represent an increment boring. The sub-sample was oven-dried and then ground to pass through a 40-mesh screen, 0.4 g of each sub-sample was combined with 0.1 g of cellulose and compressed to form a pellet. These pellets were analysed on a Tracor Northern energy dispersive X-ray spectrometer which had been calibrated for chromium, copper and arsenate (American Wood Preservers' Association 1997b). The reference specific gravity of alpine fir (331 kg/m^3) was used to convert results from a weight per weight to the weight per volume unit (kg/m^3) used to express preservative retention.

Using the CA penetration and retention data, 20 samples were selected that met, or closely met, the CSA O80.32 decking standard (Canadian Standards Association 1999). The 20 end-matched samples, from the CCA and ACQ-D groups, were then analysed for penetration and retention analyses, using the method described above.

2.1.3 Deck Assembly

For each preservative system deck, alpine fir framing boards 138 mm x 89 mm x 2.44 m were treated with the same preservative. The frames were cut to size, and two coats of copper naphthenate were applied to the cut ends. The frames were then assembled using stainless steel (SS) screws.

Of the twenty boards per treated deck, ten boards had two coats of copper naphthenate applied to the ends, with the remaining ten boards being left without field treatment. The deck boards were pre-drilled and then screwed to the frames using SS screws. A total of eight decks were constructed, and labeled as follows: ACQ-D/ribbed; ACQ-D/radius edge; CA/ribbed; CA/radius edge; CCA/ribbed; CCA/radius edge; Untreated/ribbed and Untreated/radius edge.

The decks were then installed (Figure 1) level on cinder blocks, on September 18th, 2003 at the Malcolm Knapp Research Forest in Haney, British Columbia.

Figure 1: Decks installed at the Malcolm Knapp Research Forest

2.1.4 Evaluation

The decking samples were rated at 5, 9, 17 and 23 months after installation, during periods of relatively dry weather, for the following dimensional stability characteristics. Cupping, length, depth and width of checks were measured for each sample individually on the top face (exposed face). These properties were measured as follows:

Cupping: maximum deviation on the face from a straight line drawn from edge to edge of a piece (mm)

Check length: the total length of all the checks added together (mm)

Check depth: the deepest check measured with a 0.006" feeler gauge

Check width: the maximum width of the largest check on the surface of the specimen (mm)

The overall checking appearance was visually rated on a 0 to 4 scale, with 0 (Good) having no checks and 4 (Failure) being severe checking affecting structural performance. A rating of 2 would make the consumer unhappy but they would not likely replace the deck. A rating of 3 would make the consumer replace the deck. The data was then collated and statistically analysed using a two-sample t-test.

3 Results and Discussion

3.1 Field Trial

3.1.1 Penetration Data

Penetration data are given in Table 3 as mean penetration and percent penetration over 10 mm. As expected, there was no apparent difference in preservative penetration between the radius edge and ribbed decking profiles. The mean penetration for the CCA treated deck boards was shown to be significantly lower for the ribbed decking when compared to the copper azole and ACQ-D treated deck boards.

The Canadian decking standard, CSA O80.32-97, requires 80% at or over 5 mm penetration for CCA treated deck boards. The copper azole treated deck boards, both ribbed and radius edge, and the ACQ-D radius edge decking met the penetration requirement. The ACQ-D ribbed decking had 75% of the samples met the criteria, almost meeting the penetration requirement. The CCA treated deck boards failed to meet the standard with only 55% and 40% of the deck boards meeting the penetration requirement for the radius edge and ribbed decking, respectively. There were significant differences in mean penetrations between ACQ-D and CCA ribbed decking ($p<0.05$), and between copper azole and CCA ribbed decking ($p<0.05$).

Table 3: Penetration Data Summary

Preservative	Decking Type	Mean Penetration[2] (mm)	Penetration % ≥ 5 mm
Copper Azole	Radius Edge	9.4 (6.8)[1]	90
ACQ-D (carb.)	Radius Edge	14.1 (14.1)	80
CCA	Radius Edge	8.4 (8.2)	55
Copper Azole	Ribbed	11.3 (10.7)	80
ACQ-D (carb.)	Ribbed	10.1 (8.0)	75
CCA	Ribbed	5.3 (4.1)	40

[1] Numbers in parentheses are standard deviations (n = 20)
[2] Max. penetration measured = 16 mm

For this study the penetration measurements were taken from the sapwood and heartwood face of the deck boards at random.

3.1.2 Retention Data

The Canadian decking standard, CSA O80.32-97, requires an assay retention of 6.4 kg/m^3, in a 5 mm assay zone for CCA treated deck boards. This would correlate to 6.4 kg/m^3 retention requirement for ACQ-D and a 3.3 kg/m^3, as copper metal, for copper azole. All of the treatments, both radius edge and ribbed decking, met the retention requirement.

Table 4: Retention Data Summary

Preservative	Decking Type	Mean Retention[2] (kg/m^3)
Copper Azole	Radius Edge	4.0 (1.1)[1]
ACQ-D (carb.)	Radius Edge	9.6 (3.3)
CCA	Radius Edge	11.9 (4.8)
Copper Azole	Ribbed	3.8 (1.1)
ACQ-D (carb.)	Ribbed	9.7 (4.5)
CCA	Ribbed	9.6 (4.5)

[1] Numbers in parentheses are standard deviations (n = 20)

3.1.3 Dimensional Stability/Checking Results

With only a few specimens showing a small amount of cup, Table 5, this characteristic was discarded as not significant to the test material. The specimens that did show cupping had 0.5 mm or less cupping present.

Table 5: 23 Month - Cupping Results Summary

Preservative	Decking Type	Average Cupping (mm)
Untreated (Control)	Radius Edge	0.2 (0.2)[1]
Copper Azole	Radius Edge	0.2 (0.2)
ACQ-D (carb.)	Radius Edge	0.2 (0.3)
CCA	Radius Edge	0.2 (0.2)
Untreated (Control)	Ribbed	0.1 (0.2)
Copper Azole	Ribbed	0.1 (0.2)
ACQ-D (carb.)	Ribbed	0.1 (0.2)
CCA	Ribbed	0.2 (0.3)

[1] Numbers in parentheses are standard deviations (n = 20)

Checks represent relief of stresses in the wood. All of the preservative treated ribbed decking samples, had significantly lower ($p < 0.05$) average check lengths, shallower check depths, narrower check widths and better average appearance (checking) ratings after 23 months exposure compared to the same preservative treated radius edge specimens (Tables 6-9). The untreated samples, both ribbed and radius edge, had lower average check lengths, shallower check depths, narrower check widths and better average appearance (checking) ratings than their preservative treated equivalents. This is typical of chemically pressure treated decking as the lumber has already been through a severe wetting and drying and has a small increase in surface brittleness, making the lumber more susceptible to checking. However UV/weathering of the untreated lumber over time normally results in ultimately more checking in untreated material.

Table 6: Average Check Width: Summary

Preservative	Decking Type	5 Months (mm)	9 Months (mm)	17 Months (mm)	23 Months (mm)
Untreated (Control)	Radius Edge	0.3	0.6	0.3	0.5
Copper Azole	Radius Edge	0.6	0.9	0.5	0.8
ACQ-D (carb.)	Radius Edge	0.6	0.9	0.5	0.6
CCA	Radius Edge	0.5	0.8	0.5	0.6
Untreated (Control)	Ribbed	0.0	0.2	0.1	0.2
Copper Azole	Ribbed	0.1	0.4	0.2	0.2
ACQ-D (carb.)	Ribbed	0.0	0.3	0.1	0.2
CCA	Ribbed	0.0	0.2	0.1	0.2

Table 7: Average Check Depth: Summary

Preservative	Decking Type	5 Months (mm)	9 Months (mm)	17 Months (mm)	23 Months (mm)
Untreated (Control)	Radius Edge	2.7	5.0	2.8	5.8
Copper Azole	Radius Edge	6.3	8.5	4.6	7.9
ACQ-D (carb.)	Radius Edge	5.2	6.6	4.0	6.9
CCA	Radius Edge	5.9	7.5	4.4	6.9
Untreated (Control)	Ribbed	0.5	1.6	0.8	2.7
Copper Azole	Ribbed	1.1	4.7	1.4	5.0
ACQ-D (carb.)	Ribbed	0.6	4.3	2.9	4.1
CCA	Ribbed	0.3	2.7	2.3	2.7

The preservative treated radius edge samples, Table 8, had average check lengths of approx. 733 mm compared to the ribbed decking samples with average check lengths of approx. 101 mm. After 23 months exposure the average check length of the preservative treated radius edge samples had increased to 2639 mm, while the ribbed decking samples had only increased to an average of 271 mm. This indicates almost a 10 fold increase in checking when comparing radius edge to ribbed decking.

Table 8: Average Check Length: Summary

Preservative	Decking Type	5 Months (mm)	9 Months (mm)	17 Months (mm)	23 Months (mm)
Untreated (Control)	Radius Edge	193	1281	1320	1493
Copper Azole	Radius Edge	737	1938	2193	2798
ACQ-D (carb.)	Radius Edge	748	2059	2115	2584
CCA	Radius Edge	714	1523	2130	2543
Untreated (Control)	Ribbed	75	246	108	164
Copper Azole	Ribbed	147	780	169	309
ACQ-D (carb.)	Ribbed	109	588	131	256
CCA	Ribbed	48	577	114	252

An average appearance rating of 2 (Poor) is our estimate of the level of checking at which the consumer would be unhappy but most likely would not yet want to replace the deck. Having the most visual effect, the check width had the greatest influence on the appearance rating. After 6 months the preservative treated radius edge samples, Table 9, had an average rating of 1.4. Although the radius edge decking samples are not at the stage where replacement of the deck would be required, the surface appearance looks noticeably checked when compared to the ribbed decking samples with average appearance ratings of between 0.1 and 0.2. After 23 months the preservative treated radius edge samples, had average ratings of 2.1 to 2.3 compared to 0.4 to 0.7 for the ribbed decking samples. After only 23 months the consumer would be unhappy with the radius edge decking due to poor appearance from checking. However the ribbed decking still looked almost like new.

Table 9: Average Overall Appearance: Summary

Preservative	Decking Type	5 Months (mm)	9 Months (mm)	17 Months (mm)	23 Months (mm)
Untreated (Control)	Radius Edge	0.5	1.6	1.7	2.2
Copper Azole	Radius Edge	1.4	2.0	1.9	2.3
ACQ-D (carb.)	Radius Edge	1.4	2.0	1.9	2.1
CCA	Radius Edge	1.4	1.9	1.9	2.3
Untreated (Control)	Ribbed	0.1	0.2	0.3	0.3
Copper Azole	Ribbed	0.2	0.5	0.3	0.5
ACQ-D (carb.)	Ribbed	0.1	0.4	0.3	0.7
CCA	Ribbed	0.1	0.3	0.3	0.4

The profiling appears to force the checks to follow the groove itself. When evaluating the decks the majority of the checks in the ribbed decking are not visible from a standing height, only from close up. The ribbed (profiled) decking appears to be reducing and also concealing the checks.

4 Conclusions

Treated decking is losing market share. Consumers have indicated that between 25 to 33% of future decks, new and replacement, will be made using plastic/composite decking.

Plastic lumber has raised the bar, it has a more uniform appearance and claims good performance, but at a 3 to 5 times the cost.

To retain or gain market share treated decking needs a makeover and profiled decking is part of the solution.

Profiling decking reduced and also concealed the checks. After 23 months there was one tenth the check length in ribbed compared to radius (flat) edge decking.

5 Acknowledgements

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