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Performance of 30 mm regrowth jarrah laminated signboards under exterior conditions

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SUMMARY

Regrowth jarrah (*Eucalyptus marginata* Donn ex Sm.) signboards 200 x 30 x 850 mm were glued with one of three proprietary brands of waterproof exterior adhesive, i.e. 'Bondtite 145' (B145), Timbachem 'Resobond A3' (RA3) and Timbachem 'Resobond 440' (R440), and sealed with one of four different paint systems. They were stored under water-sprays in a log stockpile for three years, during which the boards were sprayed with water for 15 minutes every two hours. Dry cleavage tests, as specified in Australian Standard AS 1328-1987, were conducted at the beginning of the trial before applying a paint finish, and then after one year and after three years, while wet cleavage tests were done after three years only.

After three years the dry cleavage tests showed that glueline strengths had declined with all adhesives, and both wet and dry tests indicated that RA3 gluelines were significantly stronger than those of B145 and R440. All gluelines satisfied the requirements of the Standard. R440 and B145 gluelines performed similarly in terms of mean percentage wood failure, but twice the number of panels glued with R440 failed the wet cleavage test.

No significant differences in percentage wood failure were found between paint systems or the interaction of adhesive and paint, but the small sample size of two replications per treatment was a constraint. The overall condition of the signboards, in terms of checking and splitting, showed that RA3 gluelines performed better than those of B145 and R440. Consequently, RA3 is recommended for gluing regrowth jarrah signboards for use in exposed outdoor conditions. Further trials using an increased sample size would be required to evaluate the performance of different paint systems.

INTRODUCTION

A panel product manufactured by edge-and-face gluing of thin boards has been developed at the Department of Conservation and Land Management's (CALM) Timber Utilisation Centre (TUC). The system enables the processing of timber from small regrowth eucalypt thinnings into a value-added product for use in furniture manufacture, and was developed to enable the forest products industry to meet the demand for furniture wood by supplementing solid timber supplies (Siemon 1990).

The product is principally used in interior applications, for example, furniture components, panelling, bench and table tops and cupboard doors. Exterior or high equilibrium moisture content (EMC) applications are possible, as in signboards, but in outdoor applications a waterproof glue (e.g. resorcinol formaldehyde) and a reliable paint system are required. Adhesives used in exterior applications are generally three to four times the cost of the interior adhesives, which increases the overall cost of the panels.

The present trial assessed the performance of regrowth jarrah signboards glued with one of three exterior adhesives, and finished with one of four paint systems or left untreated, and then stored in a water-spray stockpile where they received regular wetting and drying over three years.

MATERIALS AND METHODS

Thirty 850 x 200 x 30 mm signboards (ten per adhesive) were manufactured by edge-and-face gluing with one of three proprietary brands of waterproof exterior adhesive:

'Bondtite 145' (B145):	Polyphenolic (tannin) resorcinol formaldehyde
Timbachem 'Resobond A3' (RA3):	Resorcinol formaldehyde
Timbachem 'Resobond 440' (R440):	Phenol/resorcinol formaldehyde (heat cured) resin.

B145 is manufactured by Bondtite Adhesives Pty Ltd in South Africa, and supplies in Western Australia (WA) at the time of the trial were from Harcros Chemicals Pty Ltd.

The adhesive is now available from Polymer Coatings and Adhesives Pty Ltd. RA3 and R440 are manufactured by Bunnings Timbachem, a Division of Bunnings Forest Products Pty Ltd. Panels were glued according to the manufacturer's specifications as given in technical information sheets, i.e. B145 - Mydrin Australia (1994), and RA3 or R440 - Bunnings Timbachem (1990a) and (1990b) respectively.

Board moisture contents before gluing were between 8 and 10 per cent, based on oven-dry weight. Each edge was dressed immediately prior to gluing, allowing a maximum time of one hour between dressing and gluing. An 'Orma' glue press with an oil-heated platen was used for edge-gluing, and a cold press for face-gluing. Details of temperature, vertical and horizontal pressures, and curing time are regarded as part of the intellectual property of the process. Face glueline strength was assessed on the panels before exposure, according to the requirements of the AS1328-1987 (Standards Association of Australia 1987) dry cleavage test. The percentage of wood failure compared with adhesive failure was estimated for each glueline.

Two of the ten signboards in each glue type were then randomly allocated to one of the following treatments:

unpainted (control)
water based primer
oil based primer
water based primer and acrylic paint ('Mission brown')
oil based primer and acrylic paint ('Mission brown').

Signboards were then placed in the TUC stockpile in October 1990 under a watering schedule of 15 minutes in every two hours. Boards were supported on their edges on a flat wooden surface about 300 mm above the ground, giving an orientation of 90° to the sun, and allowing some water trapping, which was intended to accelerate deterioration.

Visual assessments of the condition of the gluelines after one year (November 1991) and three years (November 1993) were conducted using the following classifications:

1 - excellent - no defective gluelines
2 - good - no more than two hairline splits greater than 150 mm long
3 - average - no limit on hairline splits
4 - poor - splits wider than 1 mm.

After this assessment, a detailed examination of the glueline was done by inspecting the freshly cut ends of each sample after cleavage samples had been docked. Grading was by the following classification:

0 - no checks
1 - hairline checks <1 mm
2 - checks >1 mm
3 - splits from one surface to another surface.

Although the 1990 and 1991 assessments were done by Mr S.L.Ward and the 1993 assessment by the other authors, the quantitative systems reduced the possibility of operator bias by different interpretations of board conditions.

Dry cleavage tests as described in AS 1328 -1987 (Standards Association of Australia 1987) were done in 1991. The cut ends of the signboards were then resealed and the boards re-positioned in the TUC stockpile. Wet and dry cleavage tests were done at the completion of the trial in November 1993, and board condition was rated using the above criteria. Analysis of variance was used to determine whether there was a difference between glues and treatments, both within the same year and between years.

RESULTS AND DISCUSSION

Tables 1 and 2 show the mean percentage wood failure for face joints and the percentage of gluelines failing the dry or wet cleavage tests for each adhesive. The initial dry cleavage tests (before applying the paint systems and commencing the exposure phase of the trial) indicated that R440 gluelines had significantly less strength ($p<0.01$) than those of RA3 and B145. Mean percentage wood failure for R440 gluelines was 72 per cent and those of RA3 and B145 gluelines 100 per cent.

Newby and Siemon (1989) had assessed the performance of a range of commercially available adhesives used by the furniture industry in WA. They found that when edge-gluing 60-year-old regrowth jarrah, four of the five adhesives tested, i.e. urea formaldehyde ('Grasp'), melamine-fortified urea formaldehyde, pure resorcinol formaldehyde (RA3) and melamine formaldehyde gave very good results from the dry cleavage test outlined in AS 1328 - 1987 (Standards Association of Australia 1987). The fifth adhesive, polyvinylacetate or PVA, could not be recommended.

After one year's exposure the strength of all glues decreased, with RA3 gluelines showing greater strength than those of R440 and B145 gluelines. A significant difference was found between the R440 and RA3 gluelines ($p<0.05$), but no difference in wood failure percentage occurred between the paint systems.

Exposing the signboards for another two years resulted in the dry cleavage tests showing a 12 per cent decrease in glue strength for B145 gluelines, and a 6 per cent increase in strength for R440 gluelines, although this may reflect the different assessor's interpretations of wood failure, and no change for RA3 gluelines. Wet cleavage tests require samples to be subjected to a six-hour vacuum-and-pressure cycle in an autoclave before cleaving each glueline with a chisel, hence it is a more severe test of strength, and recommended for assessing waterproof glues. Wet and dry cleavage results were similar in terms of the mean percentage of wood failure (Table 2), but more panels glued with RA3 or R440 failed the wet cleavage test.

Dry and wet cleavage tests indicated that RA3 gluelines were significantly stronger than those of both B145 and R440 ($p<0.01$). RA3 gluelines had a mean

TABLE 1

Effect of adhesive on percentage wood failure in face-glued regrowth jarrah signboards after one or three years exposure (dry cleavage test).

ASSESSMENT (YEAR)	ADHESIVE	WOOD FAILURE (%)				PANEL FAILURE (%)
		MEAN	S.D.	RANGE	No.	
0	B145	100	0	-	6	0
	RA3	100	0	-	6	0
	R440	72.0	29.6	30-100	6	0
1	B145	82.0	27.5	5-100	39	20
	RA3	88.2	22.8	0-100	40	10
	R440	62.4	31.2	0-100	40	30
3	B145	70.4	29.3	0-100	80	20
	RA3	89.0	17.5	25-100	80	0
	R440	68.6	26.6	10-100	80	20

TABLE 2

Effect of adhesive on percentage wood failure in face-glued regrowth jarrah signboards after three years exposure (wet cleavage test).

ADHESIVE	WOOD FAILURE (%)				PANEL FAILURE (%)
	MEAN	S.D.	RANGE	No.	
B145	66.3	29.2	0-100	80	20
RA3	85.0	20.1	10-100	80	10
R440	60.3	26.6	10-100	80	40

percentage wood failure of 89 per cent (dry) and 85 per cent (wet), and 10 per cent of signboards failed the wet cleavage test after three years exposure. The B145 gluelines had mean percentage wood failures of 70.4 per cent (dry) and 66.3 per cent (wet), and 20 per cent of signboards failed the wet cleavage test after three years exposure. In comparison, R440 gluelines had a mean percentage wood failure of 68.6 per cent (dry) and 60.3 per cent (wet), and 40 per cent of signboards failed the wet cleavage test.

Appendix 1 lists the condition of individual gluelines for each adhesive and paint system after three years exposure. No significant differences were found between paint systems or the combination of adhesive and paint finish, although the small sample size should be taken into consideration.

RA3 gluelines are performing better than both R440 and B145 in terms of mean percentage wood failure and the number of panels failing. R440 and B145 gluelines performed similarly in terms of mean percentage wood failure, but twice the number of panels glued with R440 failed the wet cleavage test after three years exposure.

For the combined dry cleavage results of all adhesives, the results showed significant decreases in glueline strength from year 0 to year 1 ($p<0.01$), and from year 0 to year 3 ($p<0.001$). However, only B145 gluelines showed a significant strength decrease from year 0 to year 3 ($p<0.01$). RA3 and R440 gluelines had no significant loss in strength over the period. The initial dry cleavage results for R440 indicated a lower glueline strength.

The dry cleavage results of the paint system for all years indicated a significant difference ($p<0.05$) between R440 sealed with oil primer and acrylic paint and RA3 sealed with water primer or water primer plus paint. These significant differences could be due to the varying performances between R440 and RA3 affecting the paint systems.

Table 3 lists the condition of the edge-and-face gluelines after three years exposure. Signboards glued with RA3 performed better than those glued with B145 or R440, with a small percentage of signboards with checks greater than 1 mm and no signboards with splits. Face gluelines on the exposed or unexposed edges of all boards performed similarly. Consequently, RA3 is considered to give the best results in gluing regrowth jarrah signboards for use in exposed outdoor conditions. Further trials using an increased sample size would be required to evaluate the performance of different paint systems.

TABLE 3

Glueline performance of edge-and-face jointed 30 mm regrowth jarrah signboards glued with one of three different adhesives after three years exposure to exterior conditions (% in parentheses).

ADHESIVE	GLUELINE PERFORMANCE CODE[a]	EXPOSED FACE GLUELINES[b]	UNEXPOSED FACE GLUELINES[b]	EDGE 1	EDGE 2
B145	0	8 (40)	15 (75)	23 (50)	28 (61)
	1	4 (20)	2 (10)	5 (11)	4 (9)
	2	6 (30)	1 (5)	6 (13)	1 (2)
	3	2 (10)	2 (10)	12 (26)	13 (28)
RA3	0	17 (85)	19 (95)	48 (100)	47 (100)
	1	2 (10)	0	0	0
	2	1 (5)	1 (5)	0	0
	3	0	0	0	0
R440	0	12 (60)	15 (79)	45 (90)	38 (79)
	1	2 (10)	2 (10.5)	2 (4)	2 (4)
	2	5 (25)	2 (10.5)	1 (2)	2 (4)
	3	1 (5)	0	2 (4)	6 (13)

[a] Code 0 - no checks
1 - hairline checks <1 mm
2 - checks >1 mm
3 - splits from one surface to another surface

[b] Number of gluelines with a particular code and percentages in parentheses are given. (Assessment was done on edges after cutting cleavage samples, enabling clear identification of gluelines.)

In subsequent research on gluing jarrah and karri (*E. diversicolor* F. Muell.), Balfas (1993) found that sanding with a coarse abrasive (80 grit paper) prior to gluing substantially increased wettability and dry bond strength of jarrah and karri in both the dry and wet conditions. He also found that surface treatment with sodium hydroxide (NaOH) also improved wettability and glueline strength with the dry cleavage test, but only slightly increased glueline strength when the wet cleavage test was applied. A combination of coarse sanding (80 grit paper) and NaOH treatment increased wettability and bond strength gave better results. In addition, Balfas (1994) found that surface activation using lithium and sodium hydroxides significantly increased wettability and glueline strength when gluing jarrah and karri. Results from these studies need to be included in future trials assessing the overall performance of glued panels exposed under exterior conditions.

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APPENDIX 1

Effect of adhesive and paint system on glueline performance of edge-and-face jointed 30 mm regrowth jarrah laminated signboards after three years exposure to exterior conditions (% in parentheses).

GLUELINE PERFORMANCE CODE[a]	EXPOSED FACE[b]	UNEXPOSED FACE[b]	EDGE 1	EDGE 2
		B145		
		Untreated (control)		
0	0 (0)	1 (25)	0	0
1	1 (25)	2 (50)	0	0
2	3 (75)	1 (25)	1 (12.5)	1 (12.5)
3	0 (0)	0 (0)	7 (87.5)	7 (87.5)
TOTAL	4 (100)	4 (100)	8 (100)	8 (100)
		Oil primer		
0	2 (50)	4 (100)	5 (50)	5 (50)
1	0	0	2 (20)	2 (20)
2	1 (25)	0	0	0
3	1 (25)	0	3 (30)	3 (30)
TOTAL	4 (100)	4 (100)	10 (100)	10 (100)
		Water primer and paint		
0	3 (75)	4 (100)	6 (75)	6 (75)
1	0	0	1 (12.5)	1 (12.5)
2	1 (25)	0	0	0
3	0	0	1 (12.5)	1 (12.5)
TOTAL	4 (100)	4 (100)	8 (100)	8 (100)
		Water primer		
0	1 (25)	4 (100)	7 (70)	10 (100)
1	1 (25)	0	2 (20)	0
2	2 (50)	0	1 (10)	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	10 (100)	10 (100)
		Oil primer and paint		
0	1 (25)	4 (100)	5 (50)	7 (70)
1	2(50)	0	0	1 (10)
2	0	0	4 (40)	0
3	1 (25)	0	1 (10)	2 (20)
TOTAL	4 (100)	4 (100)	10 (100)	10 (100)
		R440		
		Untreated (control)		
0	0	1 (33)	7 (70)	3 (30)
1	2 (50)	2 (67)	1 (10)	0
2	1 (25)	0	0	1 (10)
3	1 (25)	0	2 (20)	6(60)
TOTAL	4 (100)	4 (100)	10 (100)	10 (100)
		Oil primer		
0	3 (75)	4 (100)	10 (91)	10 (100)
1	0	0	1 (9)	0
2	1 (25)	0	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	11 (100)	10 (100)
		Water primer and paint		
0	4 (100)	4 (100)	9 (100)	7 (78)
1	0	0	0	1 (11)
2	0	0	0	1 (11)
3	0	0	0	0
TOTAL	4 (100)	4 (100)	9 (100)	9 (100)

Appendix 1 (continued)

GLUELINE PERFORMANCE CODE[a]	EXPOSED FACE[b]	UNEXPOSED FACE[b]	EDGE 1	EDGE 2
		R440 (continued)		
		Water primer		
0	3 (75)	4 (100)	10 (91)	10 (91)
1	0	0	0	0
2	1 (25)	0	1 (9)	1 (9)
3	0	0	0	0
TOTAL	4 (100)	4 (100)	11 (100)	11 (100)
		Oil primer and paint		
0	2 (50)	2 (50)	9 (100)	9 (100)
1	0	0	0	0
2	2 (50)	2 (50)	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	9 (100)	9 (100)
		RA3		
		Untreated (control)		
0	4 (100)	4 (100)	9 (100)	8 (100)
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	9 (100)	8 (100)
		Oil primer		
0	3 (75)	4 (100)	9 (100)	9 (100)
1	0	0	0	0
2	1 (25)	0	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	9 (100)	9 (100)
		Water primer and paint		
0	4 (100)	3 (75)	10 (100)	10 (100)
1	0	0	0	0
2	0	1 (25)	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	10 (100)	10 (100)
		Water primer		
0	2 (50)	4 (100)	9 (100)	9 (100)
1	2 (50)	0	0	0
2	0	0	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	9 (100)	9 (100)
		Oil primer and paint		
0	4 (100)	4 (100)	11 (100)	11 (100)
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
TOTAL	4 (100)	4 (100)	11 (100)	11 (100)

[a] Code 0 - no checks
1 - hairline checks <1 mm
2 - checks >1 mm
3 - splits from one surface to another surface

[b] Number of gluelines with a particular code and percentages in parentheses are given. (Assessment was done on edges after cutting cleavage samples, enabling clear identification of gluelines.)