IRG/WP 02-40233

THE INTERNATIONAL RESEARCH GROUP ON WOOD PRESERVATION

Section 4 **Processes and Properties**

Decay Resistance and Bonding Properties of Structural Flakeboard

Todd F. Shupe
Assistant Professor
School of Renewable Natural Resources
Louisiana State University Agricultural Center
Baton Rouge, LA 70803

Chung Y. Hse
Principal Wood Scientist
Southern Research Station
USDA Forest Service
Pineville, LA 71360

Paper prepared for the 33rd Annual Meeting
Cardiff, Wales, United Kingdom
12-17 May 2002

IRG SECRETARIAT
SE-100 44 Stockholm
Sweden

Decay Resistance and Bonding Properties of Structural Flakeboard

Todd F. Shupe
Assistant Professor
School of Renewable Natural Resources
Louisiana State University Agricultural Center
Baton Rouge, LA 70803

Chung Y. Hse
Principal Wood Scientist
Southern Research Station
USDA Forest Service
Pineville, LA 71360

Abstract

Experimental structural flakeboard panels consisting of differing furnishes and resins were produced and tested for internal bond, linear expansion, thickness swell, and decay resistance. One group of panels was produced with recycled CCA-treated wood as the furnish and commercial phenol formaldehyde (PF) resin as the binder. Other groups of panels were produced with either mixed hardwoods or southern pine as the furnish and then sprayed with a co-reacted soy-flour PF resin or a commercial face or core resin. The recycled CCA-treated panels contained 5 different furnish ratios (0:100, 25:75, 50:50, 75:25, and 100:0) of recycled CCA-treated southern pine and virgin, untreated southern pine. Tests on the panels bonded with co-reacted soy flour PF indicated that 30% substitution of phenol with soy flour in the resin system did not appreciably promote decay or reduce IB strength. As expected, panels produced with a higher ratio of recycled CCA-treated wood furnish, were generally subject to less weight loss during decay tests for brown rot (*Gloeophyllum trabeum*, ATCC 11539) and white rot (*Trametes versicolor*, ATCC 42462) but yielded lower IB values. Research in currently in progress to assess the resistance of all the aforementioned panel types to the Formosan subterranean termite (*Coptotermes formosanus* Shiraki).

Key words: flakeboard, internal bond, linear expansion, thickness swell, weight loss

Introduction

Flakeboard is significant wood-based panel product in the structural composite panel market. In commercial production the flakes are typically oriented, to provide increased mechanical and physical properties. Oriented strand board (OSB) has taken a large percentage of the structural wood composite panel market away, which was once dominated by plywood.

The durability of wood and wood-based panels has become increasingly important in recent years due to increased market competition from non wood alternatives, increased consumer awareness, and significant outbreaks of damage from the Formosan subterranean termite (FST) (*Coptotermes formosanus* Shiraki) in the U.S. South and eastern seaboard (Shupe and Dunn 2000). Moreover, recent research has shown that most home owners feel that decay resistance is an important criteria in new home selection (Vlosky and Shupe 2002).

When compared to untreated samples, preservative treatments can reduce internal bond (IB) strength (Boggio and Gertjejansen 1982). The decrease in panel mechanical properties has been explained by the incompatibility of the adhesive, phenol formaldehyde resins, with the adherend, CCA-treated wood (Gertjejansen et al. 1988; Vick 1980; Vick et al. 1990; Vick et al. 1996). It has been suggested that insoluble chromium, copper, and arsenic solids present on cell walls can interfere with bonding between the adhesive and the adherend. The use of poly methylene diphenol diisocyanate (pMDI) has been shown to be promising for bonding recycled CCA-treated lumber in flakeboards (Mengeloglu and Gardner 2000)

There is great potential to improve panel properties and reduce the cost factor of panel production by developing new resin formulations. Resin formulations that also include soy-flour as a component are additionally advantageous from an environmental and value-added perspective. Research by Hse and Bryant (2000) on resin formulations consisting of co-reacted soy-flour phenol formaldehyde resin has yielded promising results with regards to panel mechanical and physical properties.

Therefore, research that investigates the decay resistance of flakeboard is considered important. Chemical treatments to flakeboard that are intended to increase decay resistance must also be evaluated for potential impacts on mechanical and physical properties as well so that the entire effect of the treatment is known. Accordingly, the objectives of this study were to (1) evaluate the decay resistance, internal bond, linear expansion, and thickness swell of flakeboard made from furnishes consisting of either (a) mixed U.S. southern hardwood, (b) untreated southern pine (*Pinus* sp.), and (c) recycled CCA-treated southern pine and (2) evaluate the potential of a co-reacted soy-flour resin on panel properties.

Materials and Methods

The raw material for panels made from recycled CCA-treated southern pine wood came from highway guard rails that were placed in service near Abilene, TX, USA in May, 1986 and taken out of service in September, 1999. They were collected in June, 2000 from Arnold Forest Products Co. in Shreveport, LA, USA. The guard rails measured 69 inches in height and 8 inches in diameter. They had been placed 38 inches into the ground. The top of the guard rails were dome shaped and a hole of approximate 22 inches in diameter was located 10 inches from the top of the dome. The target retention of the preservative treatment was 0.50 pcf in the outer 1-inch zone from the surface. The raw material for the mixed hardwoods and untreated southern pine panels was provided by a local oriented strand board facility.

The guard rails were live sawn into 1-inch thick lumber using a WoodMizer sawmill. The lumber was submerged for 24 hours in water and then reduced to 3 in. x 1 in. x 0.050 in. flakes using a laboratory disk flaker. Freshly sawn SYP lumber of similar thickness was obtained from a local sawmill and reduced to flakes in the same manner.

All flakes for all panel types were dried to an average moisture content (MC) of 3 % before resin application and a common, commercial phenol formaldehyde (PF) resin (51 % solids content) was applied at a rate of 4.5 %. For the mixed hardwoods panels and untreated southern pine panels, a commonly used commercial PF resin with (50% solids content) and a laboratory prepared resin consisting of co-reacted soy-flour and PF resin were used, which included 30% substitution of phenol with soy flour in the resin system. The two resins that were applied to the mixed hardwoods and untreated southern pine panels with press times of 3.5 and 5.0 minutes. For all panel types, no wax was applied so that the true effect of other variables could be evaluated. The target density for all panel types was 46 pcf.

The recycled CCA treated panels were produced according to the ratio of recycled CCA-treated flakes and virgin untreated SYP flakes (Table 1). All panels measured 16.5 in. x. 20 in. x 0.5 in. were pressed at 370° F with a hot press time of 5.5 minutes and a press closing time of 30 seconds to stops. All panel types were replicated two times. From each board, 3 specimens were tested for linear expansion (LE), thickness swell (TS), and water absorption (WA). However, WA was not assessed for the mixed hardwood panels. The LE and TS values were measured after ovendry, vacuum, pressure, and soak (ODVPS) treatment. The internal bond (IB) was assessed with 12 replications per panel that were prepared from undamaged portions of failed bending specimens. Mechanical and physical testing was performed in accordance with ASTM D1037-93 (1) (ASTM 1993).

The soil block decay tests were conducted in accordance with AWPA E10-91 (AWPA 2000). Testing for the recycled CCA treated panels, mixed hardwoods panels, and southern pine panels were conducted with 10, 8, and 8 samples, respectively for brown rot (*Gloeophyllum trabeum*, ATCC 11539) and white rot (*Trametes versicolor*, ATCC 42462).

Results and Discussion

The IB and physical properties of the flakeboard panels are summarized in Tables 2 and 3. In Table 2, it is apparent that the properties were less favorable with an increase in the amount of CCA-treated wood in the furnish. This finding is in agreement with the findings of similar studies in this area (Gertjejansen et al. 1988; Vick 1980; Vick et al. 1990; Vick et al. 1996; Munson and Kamdem 1998). There was not a substantial decrease in the mean IB properties when comparing Group 5 (100 % untreated wood) versus Group 1 (100% CCA-treated wood). There was a more substantial decrease in MOR and MOE as the percentage of recycled treated wood was increased in the furnish (Shupe and Hse 2001).

The differences in the physical properties were not as pronounced as the mechanical properties. Group 1 (100% CCA-treated wood) was slightly the highest group for LE and WA. The two groups with the lowest amount of CCA-treated wood in the furnish (Groups 4 and 5) gave the highest mean TS values. However, the range of the mean TS values was minimal. In short, the incremental additions of treated wood to the furnish had a minimal effect on physical properties of the panels.

The samples from the recycled CCA-treated panels showed weight loss in general accordance with the ratio of untreated, virgin southern pine wood to recycled CCA-treated wood (Figure 1). Panels that contained higher amounts of recycled CCA in the furnish, tended to yield lower weight losses for both white and brown rot. It is interesting to note that the solid wood samples taken from the decommissioned CCA-treated guard rails yielded fairly low weight losses as well. Clausen et al. (2001) fabricated particleboard made from remediated CCA-treated wood and reported weight losses for samples exposed to *Postia placenta* (≤%5) and weight losses ranging from 11 – 25% for untreated and remediated samples exposes to *Gloeophyllum trabeum*.

All of the resin system combinations that were employed for the untreaed panels yielded good decay resistance results. Tests on the panels bonded with co-reacted soy flour PF indicated that 30% substitution of phenol with soy flour in the resin system did not appreciably promote decay or reduce IB strength. However, the commercial PF resin yielded significant differences with regards to the decay fungi and the panel furnish (Figure 2). As expected, pine samples exhibited higher weight loss for brown rot fungi and the mixed hardwood samples showed more weight loss for white rot fungi.

Conclusions

This study has focused on the bonding and decay properties of flakeboard from recycled CCA-treated wood as well as flakeboard from untreated wood using a co-reacted soy-flour and PF mixture. It was found that mechanical and physical properties do not substantially decrease with as much as 50 percent treated material in the furnish of the panels. Tests on the panels bonded with co-reacted soy flour PF indicated that 30% substitution of phenol with soy flour in the resin system did not appreciably promote decay or reduce IB strength. The weight loss of the recycled CCA-panels was highest for those panels with lower amounts of treated wood in the furnish.

References Cited

American Society for Testing and Materials (ASTM). 1994. Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials. D1037-93. Philadelphia, PA. pp. 150-179.

American Wood Preservers' Association (AWPA). 2000. Standard E10-91 Standard method of testing wood preservatives by laboratory soil-block cultures. Woodstock, MD. pp 397-407.

Boggio, K. and R. Gertjejansen. 1982. Influence of ACA and CCA waterborne preservatives on the properties of aspect waferboard. Forest Prod. J. 32(3):22-26.

Clausen, C.A., S.N. Kartal, and J. Muehl. 2001. Particleboard made from remediated CCA-treated wood: Evaluation of panel properties. Forest Prod. J. 51 (7/8):61-64.

Gertjejansen, R.O., E.L. Schmidt, and D.C. Ritter. 1988. Assessment of preservative-treted aspen waferboard after 5 years of field exposure. Forest Prod. J. 39(4) :15-19.

Hse, C.Y., F. Fu, and B.S. Bryant. 2000. Development of formaldehyde-based wood adhesives with co-reacted phenol/soybean flour. In: Wood Adhesives 2000. June 22-23, South Lake Tahoe, NV. Forest Products Society. Madison, WI. pp. 13-19.

Mengeloglu, F. and D.J. Gardner. 2000. Recycled CCA-treated lumber in flakeboards: Evaluation of adhesives and flakes. Forest Prod. J. 50(2):41-45.

Munson, J.M. and D.P. Kamdem. 1998. Reconstituted particleboards from CCA-treated red pine utility poles. Forest Prod. J. 48(3):55-62.

Shupe, T.F. and M.A. Dunn. 2000. The Formosan subterranean termite in Louisiana: Implications for the forest products industry. Forest Prod. J. 50(5):10-18.

Shupe, T.F and C.Y. Hse. 2001. Properties of flakeboard from recycled CCA-treated wood. In: A. M. Kenderes (ed.). Proceedings of managing the treated wood resource: recycle and reuse of treated wood. May 19, 2001. American Wood Preservers Association Annual Meeting. Minneapolis, MN.

Vick, C.B. 1980. Structural bonding of CCA-treated wood for foundation systems. Forest Prod. J. 30(9):25-32.

Vick, C.B. and R.C. DeGroot, and J. Youngquist. 1990. Compatibility of nonacid waterborne preservatives with phenol-formaldehyde adhesive. Forest Prod. J. 40(2):35-40.

Vick, C.B., R.L. Geimer, and J.E. Wood, Jr. 1996. Flakeboards from recycled CCA-treated southern pine lumber. Forest Prod. J. 46(11/12):89-91.

Vlosky, R.P. and T.F. Shupe. 2002. Consumer Attitudes and Preferences for Building Materials With An Emphasis on Treated Wood Products. Forest Prod. J. (in review).

Table 1. Panel ratios and basic properties of recycled southern yellow pine, CCA treated wood and virgin wood.

Group	Percentage of virgin wood	Percentage of recycled CCA-treated wood
1	0	100
2	25	75
3	50	50
4	75	25
5	100	0

Table 2. Mean mechanical and physical properties of structural flakeboard made from recycled southern yellow pine, CCA treated furnish.

Group	MC[1] (%)	Density[2] (pcf)	IB[3] (psi)	IB ODVPS[4] (psi)	IB Reduction (%)	ODVPS LE[5] (%)	ODVPS TS[6] (%)	WA[7] (%)
1	7.8	47.0	84.8	48.6	43	0.0032	26.2	103
2	7.6	48.4	65.1	34.9	46	0.0031	28.4	100
3	7.3	47.5	74.4	44.4	40	0.0020	31.3	94
4	7.6	46.4	72.2	33.0	54	0.0026	33.2	98
5	7.1	49.5	89.3	55.7	38	0.0027	32.0	99

[1]Ovendry moisture content based on 4 samples per group.
[2]Density is reported on an ovendry weight and volume basis and is based on 4 samples per group.
[3]Internal bond is based on 24 samples per group.
[4]Internal bond following ovendry, vacuum, pressure, soak treatment is based on 16 samples per group.
[5]Linear expansion following ovendry, vacuum, pressure, soak treatment is based on 4 samples per group.
[6]Thickness swelling following ovendry, vacuum, pressure, soak treatment is based on 4 samples per group.
[7]Water absorption is based on 4 samples per group.

Table 3. Mean mechanical and physical properties of structural flakeboard made from southern pine and U.S. mixed hardwoods using co-reacted soy-PF and commercial PF resins.

Group	Furnish/Resin	MC[1] (%)	Density[2] (pcf)	IB[3] (psi)		LE[4] (%)		TS[5] (%)	
				PT[6] (min.)		PT (min.)		PT (min.)	
	Pine Flakeboard			3.5	5.0	3.5	5.0	3.5	5.0
6	Soy/PF I	7.7	47.1	72.0	82.5	0.493	0.489	36.3	36.8
7	Soy/PF II	7.5	47.5	73.3	88.7	0.472	0.450	35.3	33.9
8	PF Resin (face)[3]	7.6	47.5	46.6	58.7	0.537	0.545	35.9	37.6
9	PF Resin (core)[4]	7.6	46.7	74.8	80.2	0.480	0.416	33.8	31.9
	Hardwood Mix Flakeboard								
10	Soy/PF-1	7.8	47.0	107	132	0.591	0.625	30.5	30.7
11	Soy/PF II	7.6	47.3	107	116	0.572	0.569	32.1	30.9
12	PF Resin (face)[3]	7.6	47.3	76	103	0.546	0.527	25.9	25.7
13	PF Resin (core)[4]	7.7	46.7	94	117	0.559	.0559	30.5	29.6
14	Southern pine (control)								

[1]Ovendry moisture content based on 4 samples per group.
[2]Density is reported on an ovendry weight and volume basis and is based on 4 samples per group.
[3]Internal bond is based on 12 samples per group.
[4]Linear expansion is based on 4 samples per group.
[5]Thickness swelling following ovendry, vacuum, pressure, soak treatment is based on 4 samples per group.
[6]PT = press time.

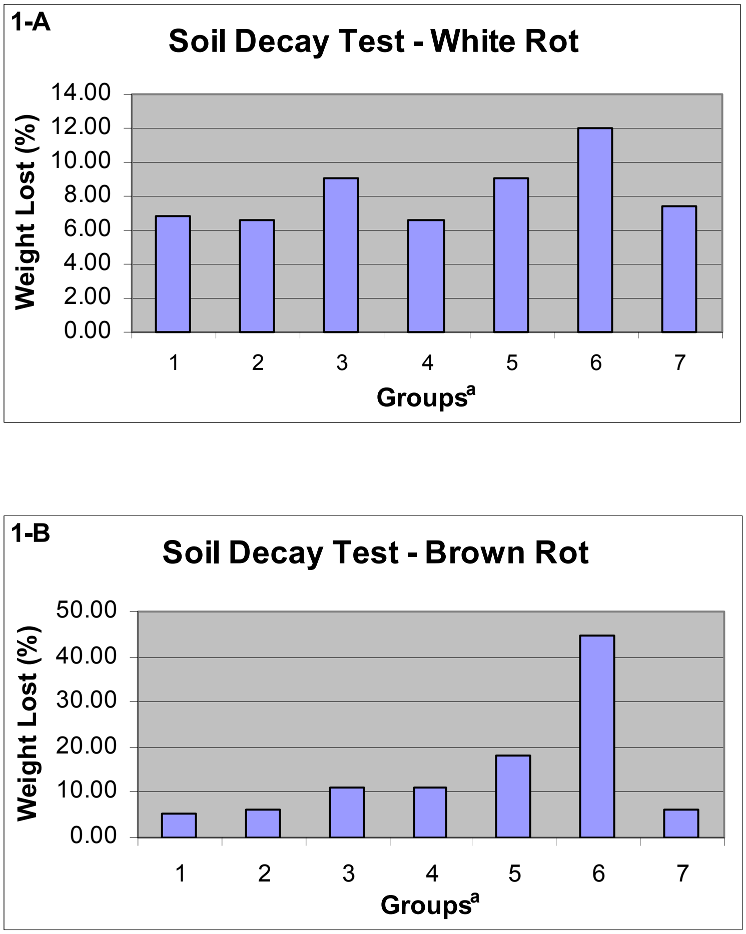

Figure 1. (A) Soil block decay test using white rot fungi, and (B) soil block decay test using white rot fungi.

[a]1 0 % virgin wood, 100 % recycled CCA-treated wood
2 25 virgin wood, 75 recycled CCA-treated wood
3 50 virgin wood, 50 recycled CCA-treated wood
4 75 virgin wood, 25 recycled CCA-treated wood
5 100 virgin wood, 0 recycled CCA-treated wood
6 Fresh cut southern pine lumber (control)
7 Decommissioned CCA-treated southern pine guard rail

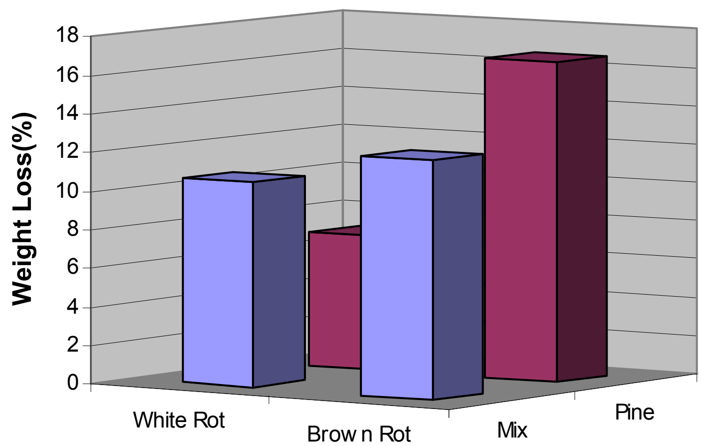

Figure 2. Soil block decay test using white rot and brown rot fungi of mixed hardwoods and pine flakeboard panels bonded with a common, commercial PF resin.   The press times have been pooled.