EFFECT OF SPECIMEN WIDTH WHEN EVALUATING LABORATORY-MANUFACTURED, FIRE RETARDANT–TREATED STRANDBOARD

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Abstract. This research investigated the effects of specimen width on the flexural properties of laboratory-manufactured, fire retardant–treated strandboard. In this study, fire retardant-treated and untreated 864- by 864- by 10.5-mm strandboard panels were manufactured in the laboratory. Each panel was edge trimmed and cut into five specimens of various widths. Each specimen was then tested in four-point flexure across a 648-mm span. We assessed the effect of strandboard specimen width on the stability of mean and variance estimates. It is critical to recognize specimen width as an important experimental factor because the size and orientation of individual flakes and strands in narrow-width strandboard test specimens can influence the magnitude and variability of test results. The bending properties of 305-mm-wide strandboard specimens, and to a lesser extent those of 203-mm-wide specimens, were consistently greater than the 102- and 152-mm-wide treated groups. Variability of flexure results, based on coefficient of variation, was for the most part uniform. The internal bond strength was consistent at all widths tested.

Keywords: OSB, mechanical properties, specimen width.

INTRODUCTION

Because of a number of different factors, production and use of wood composite products has steadily increased relative to alternative solid wood material (Winandy et al 2008; Shmulsky and Jones 2011). Products such as oriented strandboard (OSB) are now often used for roof sheathing and wall sheathing. For the last decade, production and use of OSB in North America has exceeded that of plywood (Howard and McKeever 2012). One area of wood composite performance that has long offered challenges and raised questions is fire retardant (FR) treatment of strand-flake-wafer–based wood composite products (White 2003). A review of studies conducted on FR-treated plywood (Winandy 2001) and FR-treated hardboard products (Myers and Holmes 1975) revealed that the treatment improved the flame spread rating of the treated material but caused a decrease in mechanical properties of those products. Winandy et al (2008) examined the effect of FR treatment had on random-oriented, single-layer Siberian larch strandboard and found that the treatment did have an adverse effect on panel performance. Also, OSB that is treated with FR can experience enhanced thickness swelling and water absorption compared with untreated OSB. These values increased so much that they exceeded the minimum requirement for some building standards related to

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structural panels (Ayrilmis et al 2005). Problems with the internal bonding of composite panels have also been noted on occasion when certain borate-containing preservatives were incorporated into the panel production processes (Laks et al 1988; Sean et al 1999).

Explaining why FR treatment causes such detrimental effects on the mechanical properties of treated materials has also been an interesting topic in past research. Because of the highly acidic or alkaline nature of most FR, the pH of the wood strands and resin-curing requirements that are optimum for the production of untreated OSB panels can be affected to the point that sufficient resin cure and wood bonding cannot occur during pressing. In addition, FR may impede permeability of wood strands, which can make bonding even more difficult (Winandy et al 2008). Research on FR-treated plywood yielded similar results. Modulus of rupture (MOR) and work-to-maximum load (WML) values showed a very strong correlation between the pH of the FR and strength loss in the plywood test specimens (Lebow and Winandy 1999). Much more research needs to be conducted to help discern both short- and long-term performance when materials are used in service (Barnes et al 2010).

Effects of Sample Width of Strandboard Testing

This study examines the influence of test specimen width using test samples of various widths cut from laboratory-manufactured strandboard panels. It ascertains the sample width required to achieve a stable estimate of the true mean and variance of test populations when testing small-size samples of strandboard for bending properties. For plywood, the influence or effects of test specimen width has long been recognized. In a coordinated series of plywood studies, McNatt (1984) found that modulus of elasticity (MOE) values for American Society for Testing and materials (ASTM)-size plywood specimens tended to be lower, whereas MOR values tended to be greater when different sample sizes were tested using the same bending test setup and, at the same time, the variability in the testing results increased as width of the test specimens decreased (McNatt 1984; McNatt and Wellwood 1990). These studies were the basis for specimen-width decisions for testing treated plywood during the development of ASTM D5516 (Winandy et al 1991). Lewis (1948, 1953) studied width effects in fiberboard and particleboard and reported few practically important differences in tested properties related to the width of tested flexural specimens. McNatt and Superfesky (1984) reported that the work of Lewis (1948, 1953) formed the basis for the mandated 76-mm specimen width in ASTM (2011a). However, McNatt and Superfesky (1984) also reported that because no wide-particle structural composite products were commercially manufactured during the time of Lewis' work, his findings needed more study for wide-strand composite products.

A review of past research in this area has shown that there are some practical concerns behind the current testing methods used on strand-flake-wafer–based composite panel products (Curling et al 2003). The problem is that when smaller-width strandboard specimens are tested for strength, the results obtained could reflect the properties of only one or two wider strands or strands that span a proportionately large area on the face of the specimen in or near the area of maximum stress instead of the global properties of the strandboard sample as a whole (Curling et al 2003). For example, they found that variability in tested strength was much greater with 25-mm-wide specimens (which is even smaller than the ASTM [2011b] standard size) than with 75-mm-wide specimens. They also found that sorting the strandboard test samples based on strand size, position, and orientation on the tensile surface of the bending specimens decreased variability to a more acceptable level (Curling et al 2003). Other researchers had previously considered similar width effect when attaching plywood veneers to manufactured OSB panels (Biblis et al 1996). The flexural testing in that study used 152-mm-wide OSB bending specimens, and that width sample was specifically selected to avoid defects potentially present in the OSB and veneer material (Biblis et al 1996).

Problem

Currently, there are defined standard methods, such as ASTM D5516 and D5664 (ASTM 2011c, 2011d), for evaluating FR-treated solid lumber and structural plywood. These standards have helped to define both the initial effects of FR treatment and the effects of those treatments have on the service life of these products when they are exposed to high temperatures. No such methods currently exist for treated composites such as strandboard (White and Winandy 2006).

Objectives

The specific objective of this study was to develop an understanding of how mechanical test results for strandboard were influenced by specimen width and to determine how width of a strandboard test specimen needs to be specified in future test methods to provide test results with stable variances and means. This work was a part of the master's thesis work of Hill (2011).

MATERIALS AND METHODS

Materials and Treatments

Strand material consisting of 95% southern pine and an additional 5% mix of hardwoods and cedar was obtained from a local OSB production mill. Prior to manufacturing the strands into strandboard, about half of the strands were vacuum-soak treated to saturation with a water solution of 7% guanylurea phosphate/boric acid (GUP/B) FR. Treatments were performed in a laboratory pressure retort. To obtain sufficient quantities of treated strands, several charges were needed. Each charge consisted of placing 6000 g of strands at 4-5% MC in a wire basket, top loading the strands with a 1-kg weight, and then sealing the retort and flooding it with an 80-L FR solution. This was then followed by application of a −95 kPa vacuum for 30 min. This vacuum-soak process achieved a GUP/B retention in the strands of 10.9% w/w.

When each vacuum cycle was completed, the treated strands were allowed to drain for 3 h or until all excess solution had drained and the treated weight of that charge was obtained. Strands were then spread out flat and air-dried for 2-3 da to an appropriate level (~20-25% MC). They were then moved to a tumble dryer to dry the treated furnish to approximately 3% MC. Each individual batch of treated and dried strands was then combined and thoroughly mixed prior to further processing. After drying the treated strands, a noticeable amount of fines were lost. We visually estimated that 75% of the remaining mixed-species strands varied in width from 12 to 25 mm and 95% varied from 8 to 30 mm.

Panel Manufacturing

In manufacturing the treated and untreated panels, two basic differences existed between the 6000 g batches of treated and untreated strands. The untreated strands included a slightly larger amount of fines that, as mentioned previously, had been lost in the treating operation. The other difference was that each 6000 g batch of untreated strands was all wood, whereas each 6000 g batch of treated strands was roughly 90% wood and 10% GUP/B.

Next, individual batches of 6000 g of untreated or treated strands were selected and placed in a 1.82-m diameter by 1.22-m-deep rotary blender, and a 225 g solution of 27% liquid paraffin wax was blended onto the strands. Then 927 g of phenol formaldehyde (PF) resin (Hexion Inc., Columbus, OH) was applied using a spinning disk atomizer. The liquid resin that was added to each strand batch accounted for 4% of the total additives in the blend.

After the blending process was completed, 6000 g of blended furnish was weighed out and then the panel mat was formed using an 864- × 864-mm forming box and metal caul plates. The forming process involved hand spreading the blended strand material into the forming box in a random fashion without any strand orientation. At this point, the formed mat was labeled and marked as x axis (front to back) and y axis (left to right) from the technician. After prepressing with a

10-kg weight, the forming box was removed and another metal caul plate, sprayed with a release agent, was placed on top of the mat. The mat was then loaded into the 915- × 915-mm Diffenbacher (Eppingen, Germany) hot press. The pressing schedule included 30 s for press closing to 10.5 mm, pressing for 4 min at 198°C, and a 30-s decompression cycle. A total of 12 untreated and 12 treated strandboard panels were made.

Test Specimen Preparation

After pressing, all panels were hot stacked for 24 h. The panels were then edge trimmed evenly on all four edges to 813 × 813 mm. Panel thickness, mass, and volume were then determined, and panel density was calculated. Untreated panels had an average thickness of 10.54 mm with a standard deviation of 0.14 mm. Treated panels averaged 10.46 mm thick and had a standard deviation of 0.12 mm. Untreated panels had an average density of 740 kg/m^3 with a standard deviation of 30 kg/m^3. Treated panels averaged 750 kg/m^3 and had a standard deviation of 40 kg/m^3.

From each trimmed strandboard panel, we cut two 102-mm-wide test specimens and one each at widths of 152, 203, and 315 mm. The two 102-mm-wide specimens were cut in such a way that one followed the *x* axis of the panel (A or C) and the other the *y* axis (E) (Fig 1). This then allowed us to determine if panel orientation was indeed random. The 102-mm *y* axis specimen was 813 mm long, whereas the four *x* axis specimens were all 708 mm long.

Using these two cutting patterns minimized potential edge effects based on original specimen location in the trimmed panels. After cutting, each specimen was visually inspected for edge or face imperfections. Those with such defects were eliminated from the experiment. When all of the samples were cut, visually inspected, and sorted into groups, and they were moved to an environmental chamber and conditioned at 65% RH and 20°C for 4 wk prior to mechanical testing.

Mechanical Testing

The next stage of the evaluation process was mechanical testing of the equilibrated specimens generally using the testing methods outlined in ASTM (2011b). D3043-Method B produces more uniform area of induced constant moment. Therefore, error in the strength estimate is minimized (Winandy and Morrell 1993). A center-point flexure test induces a very narrow area of bending moment directly under the load head, but if the fracture occurs away from this area, the calculated load is not well related to the actual stress that caused failure.

All mechanical tests for this project were conducted at the ISO-accredited, mechanical testing laboratory at Mississippi State University (MSU) using a Tinius-Olsen mechanical testing machine equipped with Instron Bluehill Software (Norwood, MA) and 305-mm-wide sample support load heads. One support and both load heads were rounded and the other support had a roller head. Test span was 648 mm and the load-head span was 324 mm. This gave a span-to-depth ratio of 60:1 using an approximate quarter-point load scenario. Special attention was given to align the centerline of each varying-width specimen with the centerlines of the supports and load heads. The final modification of the testing equipment was placing an extension clip on the deflection arm of this device to ensure that it had enough depth to adequately record the deflection of each sample tested.

All untreated control specimens were tested in random order with no regard to sample width. The FR-treated specimens were likewise tested. Equipment was calibrated and checked throughout testing, and no bias was detected.

After completion of the bending tests, additional evaluations of the tested samples were conducted for internal bond (IB) and density profile testing. The IB test evaluated the adhesive bond in the tension perpendicular to the faces of wood-based composites. A 50- by 50-mm IB sample was cut from an undamaged section of each flexural test specimen. IB tests were conducted according to guidelines

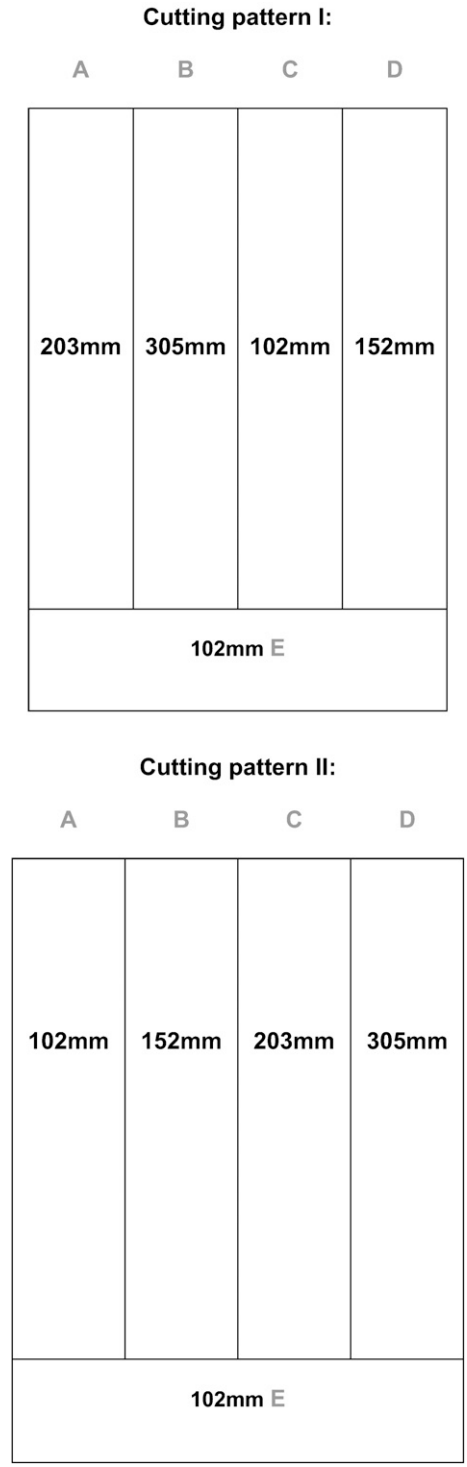

Figure 1. Diagrams for pattern used in cutting sequence I and II. Letters A-D represent *x* axis and E the *y* axis in position within original trimmed strandboard panels.

of ASTM (2011a) using an Instron table top testing machine.

Density profiling was conducted using a Quintek Measurement Systems (Knoxville, TN) QDP-01X density profiler located at the MSU mechanical testing laboratory. This machine was capable of scanning 50.8- × 50.8-mm samples, which were loaded in the machine in cassette-style racks. They were scanned with an X-ray tube that was completely enclosed inside the machine's cabinet. The sample sets that were evaluated in this portion of the testing were cut at random from the bending samples that were used in earlier bending tests.

The test data were used to calculate MOE, MOR, WML, and IB and were then evaluated using an analysis of variance (ANOVA) procedure. Comparisons of treated and untreated panels were made separately using a Tukey's studentized range test run at a 95% confidence level ($\alpha = 0.05$) to evaluate differences based on sample width. The density profile data were analyzed using ANOVA.

RESULTS

Table 1 shows density of the laboratory-manufactured strandboard, results of the mechanical testing of varying-width specimens in flexure for treated and untreated controls, and error associated with each mechanical property grouping. Again, direct comparison between untreated and treated strength results was biased in that the treated panels contained about 10% less wood material. Thus, comparative trends of the width effect of treated and untreated specimens should be studied and discussed, rather than directly

Table 1. Experimental design and results of physical and mechanical testing in flexure of varying-width strandboard specimens.

						MOE			MOR			WML	
Treatment[a]	Position Edge = A or D Center = B or C *y* axis = E	Width (mm)	Number of specimens	Density (kg/m^3)	Mean (GPa)	Standard deviation (GPa)	COV	Mean (MPa)	Standard deviation (MPa)	COV	Mean (kNm/m^3)	Standard deviation (kNm/m^3)	COV
U	Edge	102	5	640	2.94	1.37	0.46	10.0	1.8	0.18	8.3	2.8	0.33
U	Center	102	6	842	4.33	0.75	0.17	19.2	3.3	0.17	17.3	6.1	0.35
U	*y* axis	102	10	698	3.42	1.03	0.30	12.9	4.7	0.36	11.7	5.5	0.48
	E-C merged	102	21	—	3.70	1.03	—	15.0	2.62	—	13.2	4.6	—
U	Edge	152	6	722	4.14	1.22	0.29	14.8	3.1	0.21	12.4	4.3	0.35
U	Center	152	6	773	3.76	0.54	0.14	15.4	2.5	0.16	15.6	2.5	0.16
	E-C merged	152	12	—	3.95	0.92	—	15.1	2.7	—	14.0	3.8	—
U	Edge	203	6	686	3.32	0.97	0.29	13.4	1.8	0.14	13.4	2.7	0.2
U	Center	203	6	819	3.60	0.36	0.10	15.0	1.6	0.11	14.3	2.7	0.19
	E-C merged	203	12	—	3.46	0.71	—	14.2	1.84	—	13.9	2.6	—
U	Edge	305	6	782	4.91	1.18	0.24	18.1	2.3	0.13	17.1	5.1	0.3
U	Center	305	6	821	5.38	1.58	0.29	22.2	2.8	0.12	21.3	5.2	0.25
	E-C merged	305	12	—	5.14	1.35	—	20.2	3.2	—	19.2	5.4	—
T	Edge	102	5	690	1.46	0.78	0.53	4.4	1.7	0.38	2.1	1.2	0.61
T	Center	102	5	837	2.81	1.47	0.52	8.4	2.6	0.30	5.5	1.4	0.25
T	*y* axis	102	8	680	1.21	0.52	0.43	2.9	1.0	0.33	1.4	0.6	0.46
	E-C merged	102	18	—	2.20	1.16	—	6.58	2.2	—	4.0	1.3	—
T	Edge	152	5	760	1.82	0.60	0.33	4.4	1.7	0.39	2.4	1.2	0.48
T	Center	152	6	795	2.31	0.62	0.27	6.3	2.1	0.33	3.9	1.7	0.42
	E-C merged	152	11	—	2.09	0.63	—	5.5	2.1	—	3.2	1.6	—
T	Edge	203	4	654	1.72	0.75	0.44	4.2	1.6	0.38	3.2	3.2	1.01
T	Center	203	6	733	3.29	0.94	0.29	8.7	2.6	0.30	5.0	1.6	0.32
	E-C merged	203	10	—	2.67	1.16	—	6.9	3.2	—	4.2	2.4	—
T	Edge	305	5	712	3.25	0.99	0.31	6.8	1.5	0.22	3.9	1.3	0.34
T	Center	305	5	750	2.87	1.15	0.40	8.9	2.4	0.27	6.4	2.1	0.32
	E-C merged	305	10	—	3.04	1.03	—	7.7	2.3	—	5.0	2.2	—

[a] U, untreated; T, treated.

comparing treated to untreated. The results of the ANOVA of these data indicated that no significant differences existed related to edge, center, or *y* axis orientation among any individual groups of the same width. This indicated that the strand randomization process in prepress layup was effective. Thus, data from edge and center orientations for specimens of the same width from each treatment or control grouping were combined for subsequent analyses. We did not include the *y* axis orientation of the 102-mm-wide specimens because we wanted to retain a nearly equal number of replicate specimens for each group in our analysis.

For the untreated controls, the coefficient of variations (COV) for all four specimen widths were fairly consistent, which in turn allows us to discuss mean effects (Tables 2-4). The Tukey's studentized range test of means was then used to compare the mean differences among various specimen widths for the untreated controls. The Tukey's test revealed that a few significant differences existed for MOE, MOR, and WML (Tables 2-4, respectively). For MOE, no simple trend among the 102-, 152-, 203-, and 305-mm-wide groups was indicated (Table 2). The Tukey's test of MOR for the control groups clearly revealed that the 305-mm-wide samples had greater tested MOR than the other three narrower widths tested (Table 3). WML results generally followed a similar pattern in that the 305-mm-wide untreated group had significantly greater WML than the 102- or 203-mm-wide groups, but no significant differences were noted between the 305- and 152-mm-wide control groups (Table 4). Overall, for the untreated controls, the 305-mm-wide control specimens showed significantly greater results than the other control sample groups in most testing categories.

Table 2. MOE and variation of untreated and treated strandboard groups.

MOE[a] (MPa)	Mean	Standard deviation	COV	Significance[b] ($\alpha < 0.05$)
102 mm CTL	3698	1.032	0.279	B
152 mm CTL	3952	923	0.233	AB
203 mm CTL	3460	713	0.206	B
305 mm CTL	5143	1350	0.262	A
102 mm FRT	2135	1156	0.540	C
152 mm FRT	2087	633	0.303	C
203 mm FRT	2667	1158	0.434	C
305 mm FRT	3042	1033	0.340	C

[a] CTL, control; FRT, fire retardant treatment.
[b] Letters with same value denote no significant difference at $\alpha < 0.05$.

Table 3. MOR and variation of untreated and treated strandboard groups.

MOR[a] (MPa)	Mean	Standard deviation	COV	Significance[b] ($\alpha < 0.05$)
102 mm CTL	15.0	2.6	0.174	B
152 mm CTL	15.1	2.7	0.178	B
203 mm CTL	14.2	1.8	0.129	B
305 mm CTL	20.2	3.2	0.160	A
102 mm FRT	6.4	2.2	0.342	C
152 mm FRT	5.5	2.1	0.384	C
203 mm FRT	6.9	3.2	0.463	C
305 mm FRT	7.7	2.3	0.298	C

[a] CTL, control; FRT, fire retardant treatment.
[b] Letters with same value denote no significant difference at $\alpha < 0.05$.

Table 4. WML and variation of untreated and treated strandboard groups.

WML[a] (kJ/m^3)	Mean	Standard deviation	CVC	Significance[b] ($\alpha < 0.05$)
102 mm CTL	13.21	4.60	0.348	B
152 mm CTL	13.97	3.76	0.269	B
203 mm CTL	13.88	2.63	0.190	B
305 mm CTL	19.22	5.40	0.281	A
102 mm FRT	3.80	1.31	0.344	C
152 mm FRT	3.24	1.58	0.488	C
203 mm FRT	4.24	2.39	0.563	C
305 mm FRT	5.01	2.21	0.440	C

[a] CTL, control; FRT, fire retardant treatment.
[b] Letters with same value denote no significant difference at $\alpha < 0.05$.

For the treated groups, again, the COV for all four specimen widths were fairly consistent, which in turn allows us to discuss mean effects (Tables 2-4). The Tukey's tests of means indicated no significant differences existed related to width effect for MOE, MOR, or WML. The MOE results for treated specimens indicated that tested values for the 305-mm-wide treated group were about 30% greater than the 102- or 152-mm-wide treated groups and about 13% greater than the 203-mm-wide treated group (Table 2). Comparing the mean MOR values showed that the MOR of the 305-mm-wide treated group was about 17% greater than the 102-mm-wide group, 35% greater than the

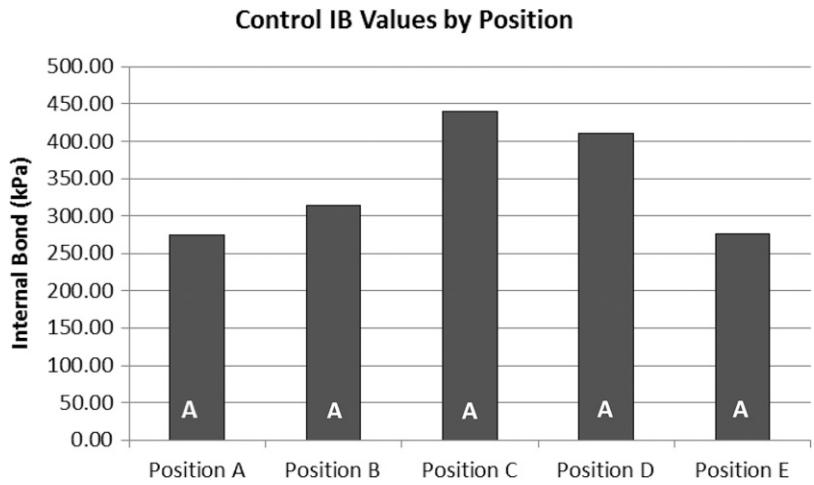

Figure 2. IB values of untreated control sample groups based on sample position. Means with the same letter are not significantly different, $\alpha = 0.05$.

152-mm-wide treated group, and about 10% greater than the 203-mm-wide treated group (Table 3). For WML data, the 305-mm-wide treated group was about 24% greater than the 102-mm group, 35% greater than the 152-mm-wide treated group, and about 15% greater than the 203-mm-wide treated group (Table 4). In summary, for all bending properties tested, the 305-mm-wide specimens, and to a lesser extent the 203-mm-wide specimens, had consistently greater values than the 102- and 152-mm-wide treated groups.

The results of IB tests showed a significant difference between the FR-treated and the untreated control panels. However, some part of these differences was probably related to the fact that the treated panels had approximately 10% fewer wood strands than the untreated panels because of the 10% GUP/B treatment. On average, samples taken from the untreated control panels performed much better than did their treated counterparts. Results revealed that the average IB value was 339 kPa for untreated panels, and the treated panels were significantly different ($\alpha < 0.05$) at 145 kPa. When comparing the results based on positioning within the panel, the ANOVA showed that there was no significant difference among any of the various widths tested for either the treated or control groups (Figs 2 and 3). ANOVA results for treated panels vs untreated control panels are summarized in Table 5.

Density profile test results showed that the treated specimens generally had on average greater density values throughout their cross section than the untreated samples. This was to be expected considering the FR-treated samples were treated with GUP/B solution to a target of 480 kg/m^3, an added component in their panels that the untreated controls did not have. That being said, the difference in average density values between the control and treated samples was not significant when the data were run through the ANOVA procedure.

DISCUSSION

An analysis of the COV of the bending test results was conducted for both untreated controls and treated groups. The results were compared in an effort to find the sample size group with the lowest values. The flexural test results indicated all tested widths generally had similar variability (based on COV) for each tested property. The analysis also indicated that increasing the width of bending samples generally yielded greater MOE, MOR, and WML values than were obtained from the narrower-width samples

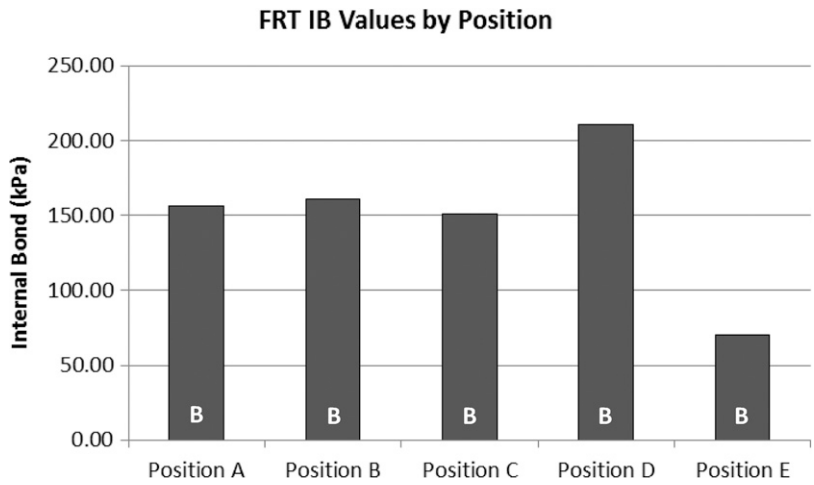

Figure 3. IB values of fire retardant (FR)–treated sample groups based on sample position. Means with the same letter are not significantly different, $\alpha = 0.05$.

Table 5. Summary of ANOVA results from IB and Quintek Measurement Systems density profile comparative tests.

ANOVA summary for IB and density testing					
Variable	Degrees of freedom	r^2	COV (%)	F value	p value
IB (treated vs untreated)	88	0.281138	59.28	34.02	<0.0001
IB untreated position comparison	47	0.185728	45.722	2.45	0.0602
IB FRT[a] position comparison	40	0.094624	86.317	0.94	0.4517
Density profile	47	0.028196	15.045	1.33	0.2539

[a] FRT, fire retardant treatment.

(Tables 3-5). For untreated samples, the bending test results for MOE, MOR, and WML from 305-mm-wide specimens were generally significantly greater than from the 102-, 152-, or 203-mm-wide groups. No significant differences occurred in test results from the three narrower-width groups. For treated samples, the bending results from 305-mm-wide specimens, and to a lesser extent from the 203-mm-wide specimens, were noticeably greater than the 102- or 152-mm-wide groups, although none of the differences were statistically significant.

We believe that the analysis of these data set should be considered in conjunction with the previous results of Curling et al (2003) and Biblis et al (1996). As such, it appears that when conducting a comparative evaluation based on the mechanical properties of laboratory-manufactured FR strandboard specimens, strandboard specimens greater than 300 mm wide, and to a lesser extent greater than 200 mm wide, should be used. Generally, the results from all three studies infer that wider specimens are more dependable and probably more reliable than narrower-width specimens. This better performance of wider specimens compared with narrower-width specimens is probably caused by the effects of size, position, and orientation of the strands within each specimen relative to the size of the specimen itself. The narrower-width specimens probably had some defects or very large or small strand elements that adversely affected the results of those narrower-width samples.

SUMMARY

In this evaluation, 864- × 864-mm strandboard panels that were 10.5 mm thick were manufactured. Each used a PF resin, and half of them included a GUP/B FR. After trimming to 813 × 813 mm, smaller samples were cut from each panel to yield four progressively wider, matched

samples with 102-, 152-, 203-, and 305-mm widths. The untreated and FR-treated samples were tested in flexure (ASTM 2011b) and IB (ASTM 2011a). The results from this study and two previous studies (Biblis et al 1996; Curling et al 2003) infer that wider specimens are more dependable and probably more reliable than narrower-width specimens. The results of this study indicated that the tested mechanical properties of strandboard samples narrower than 200 mm were generally found to have lower values than those derived from wider specimens (ie >200 mm width). Although small plywood samples experienced a similar width effect, strandboard samples were shown to need a much wider specimen to achieve mean and variance stability.

The lower mechanical properties of the FR-treated samples were probably partially caused by the boric acid component of the GUP/B formulation in the FR chemical that sometimes interferes with thermoset curing of PF resins (Laks et al 1988; Sean et al 1999). Resin curing probably can be optimized later by modifications to the experimental pressing conditions and schedules. Alternatively, the use of other resin systems, such as polymeric methylene diphenyl isocyanate, buffered PF, or melamine–urea–formaldehyde, might also have improved resin curing and bonding (Kamke and Winandy 2008).

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REFERENCES

ASTM (2011a) Standard test methods for evaluating properties of wood-base fiber and particle panel materials. D 1037-06a. American Society for Testing and Materials, West Conshohocken, PA.

ASTM (2011b) Standard test methods for structural panels in flexure. D 3043-00 (reapproved 2011). American Society for Testing and Materials, West Conshohocken, PA.

ASTM (2011c) Standard test method for evaluating the flexural properties of fire-retardant treated softwood plywood exposed to elevated temperatures. D 5516-09. American Society for Testing and Materials, West Conshohocken, PA.

ASTM (2011d) Standard test method for evaluating the effects of fire-retardant treatments and elevated temperatures on the strength properties of fire-retardant treated lumber. D 5664-10. American Society for Testing and Materials, West Conshohocken, PA.

Ayrilmis NS, Kartal S, Laufenberg T, Winandy JE, White RH (2005) Physical and mechanical properties and fire, decay, and termite resistance of treated oriented strandboard. Forest Prod J 55(5):74-81.

Barnes HM, Winandy JE, McIntyre CR, Jones PD (2010) Laboratory and field exposures of FRT plywood: Part 2—mechanical properties. Wood Fiber Sci 42(1):30-45.

Biblis EJ, Grigoriou A, Carino H (1996) Flexural properties of veneer-overlaid OSB composite panels from southern yellow pine. Forest Prod J 46(4):59-62.

Curling SF, Winandy JE, Carll C, Micales J, Tenwodle A (2003) How variability in OSB mechanical properties affects biological durability testing. Holzforschung 57(1):8-12.

Hill J (2011) An evaluation of laboratory manufactured fire retardant treated flakeboard. MS thesis, Department of Forest Products, Mississippi State University, Starkville, MS. Page 77.

Howard JL, McKeever DB (2012) U.S. forest products annual market review and prospects 2008-2012. Res Note FPL-RN-0328 USDA For Serv Forest Prod Lab, Madison, WI. 10 pp.

Kamke FA, Winandy JE (2008) Issues and concepts for making durable composites. Pages 116-124 *in* Proc American Wood Protection Association. Vol 104. Birmingham, AL.

Laks PE, Haataja BA, Palardy RD, Bianchini RJ (1988) Evaluation of adhesives for bonding borate-treated flakeboard. Forest Prod J 38(11/12):23-24.

Lebow S, Winandy JE (1999) Effect of fire-retardant treatment on plywood pH and the relationship of pH to strength properties. Wood Sci Technol 33:285-298.

Lewis WC (1948) Effect of size and shape of specimen on the tensile strength of fiberboards. FPL Rep 1716 USDA For Serv Forest Prod Lab, Madison, WI. 11 pp.

Lewis WC (1953) Effects of the variables of span, width, and speed of loading on the properties of hardboard. FPL Rep TM-88 USDA For Serv Forest Prod Lab, Madison, WI. 45 pp.

McNatt J (1984) Static bending properties of structural wood based panels. Forest Prod J 34(4):50-54.

McNatt J, Superfesky J (1984) How some test variables affect bending, tension, and compression values for particle panel products. Res Pap FPL-446 USDA For Serv Forest Prod Lab, Madison, WI. 9 pp.

McNatt J, Wellwood R (1990) Relationships between small-specimen and large panel bending tests on structural wood-based panels. Forest Prod J 40(9):10-16.

Myers GC, Holmes CA (1975) Fire-retardant treatments for dry-formed hardboard. Forest Prod J 25(1):20-28.

Sean T, Brunette G, Cote F (1999) Protection of oriented strandboard with borate. Forest Prod J 49(6):47-51.

Shmulsky R, Jones PD (2011) Forest products and wood science: An introduction. Wiley-Blackwell Publishing, Ames, IA. 477 pp.

White RH (2003) Fire resistance of engineered wood rim board products. Res Pap FPL-RP-610 USDA For Serv Forest Prod Lab, Madison, WI. 22 pp.

White RH, Winandy JE (2006) Fire performance of oriented strandboard. Pages 297-309. *in* Proc. Conference on Recent Advances in Flame Retardancy of Polymeric Materials. Vol. XVII, Applications, Research and Industrial Development Markets. BCC Research. Norwalk, CT. ISBN 1-59623-221-8.

Winandy JE (2001) Thermal degradation of fire-retardant-treated wood: Predicting residual service life. Forest Prod J 51(2):47-54.

Winandy JE, Levan SL, Ross RJ, Hoffman SP, McIntyre CR (1991) Thermal degradation of fire-retardant-treated plywood, development and evaluation of a test protocol. Res Pap FPL-RP-501 USDA For Serv Forest Prod Lab, Madison, WI. 21 pp.

Winandy JE, Morrell JJ (1993) Relationship between incipient decay, strength, and chemical composition of Douglas-fir heartwood. Wood Fiber Sci 25(3):278-288.

Winandy JE, Wang Q, White RH (2008) Fire-retardant-treated strandboard: Properties and fire performance. Wood Fiber Sci 40(1):62-71.