EFFECT OF MOISTURE ON THE FLEXURAL PROPERTIES OF COMMERCIAL ORIENTED STRANDBOARDS[1]

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ABSTRACT

Moisture content (MC), thickness swelling (TS), and bending properties of five commercial oriented strandboards (OSBs) made of two wood species were measured. The measurements were made after specimens were conditioned to equilibrium at 35, 55, 75, 85, 95% relative humidity (RH) and 24°C. It was shown that bending modulus of elasticity (MOE) and modulus of rupture (MOR) decreased with increases in board MC. Both MOE and MOR followed a linear relation with MC over the given MC change. Thickness swelling of these OSBs was shown to have a large nonrecoverable component, which mainly occurred with MC increases above the 8 to 10% level. For an MC change from 4 to 24%, the combined effect of increased MC and TS led to an average MOE loss of 72% in the parallel direction and 83% in the perpendicular direction; and to an average MOR loss of 58% in the parallel direction and 67% in the perpendicular direction. Predictive equations expressing the bending MOE/MOR and thickness swelling as a function of MC and MOE/MOR loss as a function of thickness swelling were established for various products.

Keywords: Bending, modulus of elasticity, modulus of rupture, strength and stiffness loss, structural wood composite, thickness swelling.

INTRODUCTION

The main applications of oriented strandboard (OSB) are wall and roof sheathing, I-beam web, single-layer flooring, and underlayment in light-frame construction (USDA Forest Service 1987). Sustained high board strength and stiffness are required in most of these situations. However, both board strength and stiffness can be substantially reduced due to increases in board moisture content (MC) and ensuing thickness swelling (TS) in service. These changes in MC may be caused by exposing unprotected panels to high humidity conditions and even rain during construction and by seasonal variation in atmospheric conditions during service.

The extent of moisture and thickness swelling-related reduction in both strength and stiffness for commercial OSBs needs to be established so that allowance can be made in design

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and in field inspection. In this study, moisture content (MC), thickness swelling, and flexural properties of five types of commercial OSBs of two species were measured. The objectives of the study were: (a) to develop experimental data on bending modulus of elasticity (MOE), modulus of rupture (MOR), and TS at various levels of moisture content; and (b) to examine the relationships between strength and stiffness loss and MC or TS of different products.

BACKGROUND

The effect of moisture on the mechanical properties of solid wood has been extensively studied (e.g., Wilson 1932). A comprehensive review of related studies was made by Gerhards (1982). These studies have led to the establishment of a moisture content adjustment factor for the flexural properties of structural lumber (ASTM 1994).

Extensive information is available describing the effects of moisture change on strength and dimensional stability of wood-based composite panels (Halligan 1970; Suchsland 1973; Halligan and Schniewind 1974; Lehmann 1978; Geimer 1982). These studies were designed to investigate changes in stability and strength with changing moisture levels; effects of cyclic moisture change on panel stability and strength; and effect of moisture on panel durability. However, much of the data was collected from laboratory-made boards and/or from small-particle wood panels. As a result, there is little information on stability and strength parameters and their relationship to moisture changes in large-flake commercial OSB materials marketed.

It is well established that moisture-related thickness swelling of wood-based composites consists of two components (Halligan 1970)—swelling of the wood itself (recoverable) and release of compression stress from the pressing operation (nonrecoverable). Almost all production or processing parameters have been recognized to influence TS performance (Kelly 1977). Also, the nonrecoverable TS is usually accompanied by permanent strength loss due to degradation of adhesive bonds (Suchsland 1973). Studies of moisture effect on the strength properties of wood composites must, therefore, include the effect of TS (Halligan 1970). It is not clear, however, how the TS varies among various OSB products over a wide range of MC change within the hygroscopic range. Detailed knowledge of TS and its relationship to strength and stiffness loss for OSB products can provide valuable insight into their performance.

TABLE 1. *Panel properties for various OSBs used in the study.*

OSB Type	Panel Thickness[a] (mm)	Specific Gravity[b]	Specimen Length[c] (mm)
Southern pine OSB:			
1. Sheathing (SPS)	10.9	0.66	317.5
2. I-beam web (SPI)	10.2	0.73	292.
3. Floor underlayment (SPF)	15.2	0.66	419.
Aspen OSB:			
1. Sheathing (ASS)	10.9	0.61	317.5
2. Floor underlayment (ASF)	18.8	0.58	508.0

[a] Thickness was at 35% RH and 24°C. The thickness ratio of face-core-face was measured to be about 1:2:1 for all the products.

[b] Specific gravity was based on oven-dry weight and volume at 35% RH.

[c] Specimen width was 76.2 mm.

MATERIAL AND METHODS

Material selection

Five different commercial OSBs were selected for the study (Table 1). These included the two most widely used wood species (aspen and southern pine) and three major applications (sheathing, floor underlayment, and I-beam web) for OSB products. Among these, three southern pine OSBs were manufactured in one mill, and two aspen OSBs were made in another mill. It was known that all the OSBs were made with phenol-formaldehyde adhesive at a face-to-core weight ratio of approximately 55:45. Two panels (122- × 122-cm × thickness) of each type of OSB, cut from two separate 122- by 244-cm parent panels, were obtained directly from the manufacturers. These panels were wrapped with plastic film during transport to protect against large MC changes. Before cutting, the panels were stored in a climate-controlled room at 55% RH and 24°C. Test samples were prepared from these ten panels.

Specimen preparation

Bending specimen.—Static bending specimens (Table 1) were cut along two principal directions of each panel according to ASTM D 1037-64 (American Society for Testing and Materials 1983). Twenty-five parallel specimens and 25 perpendicular specimens from each of the five OSBs were prepared. The 25 specimens in either parallel or perpendicular direction from each OSB were randomly divided into five groups with five specimens in each group. One group of parallel specimens and one group of perpendicular specimens were randomly selected from each OSB, and they were combined to form a set of specimens. A total of five sets was prepared.

Thickness swelling specimen.—Twenty-five specimens (50.8-mm by 50.8-mm by thickness) from each of the five OSBs were prepared. Five specimens were randomly selected from each OSB, and they were numbered and combined to form a set of specimens. A total of five sets was prepared.

Testing procedure and data reduction

Both bending and TS specimens were conditioned to equilibrium under each of the five RH conditions: 35, 55, 75, 85, 95% at 24°C. The procedures of testing and data reduction are as follows.

Bending test.—For each specified RH level, a set of bending specimens was randomly selected. They were stacked in a climate-controlled chamber and conditioned for eight weeks. The specimens were then removed from the conditioner, and their weight and size (i.e., length, width, and thickness) were measured. Bending tests were conducted on a Model 4260 INSTRON machine with computer-controlled data acquisition system. To calculate the flexural properties, thickness measured after RH exposure and a fixed span for all the RH levels were used. Each specimen was reweighed immediately after breaking. All specimens were then oven-dried for 24 hours at 104°C, and their oven-dry (OD) weight was determined. The MC of each specimen was calculated on the OD basis. The specific gravity of each specimen was calculated based on the OD weight and volume at 35% RH.

A stepwise regression procedure using SAS (SAS Institute Inc. 1994) was used to correlate MOE and MOR to MC and specific gravity for each of the five OSBs. Initially, linear, quadratic, and cubic terms for both variables were included in the analysis. However, for a given OSB, all models except the one with a linear MC term were either rejected or showed little improvement in terms of the correlation coefficient. Thus only a linear model with MC, %, was considered:

$$Y = A + B\ MC \qquad (1)$$

where Y is the property (MOE or MOR), MPa; A is regression constant, MPa; B is regression constant, MPa/%MC.

Reduction in the property Y, RY (%), from the reference MC level was defined as:

$$RY = \frac{(Y - Y_o)}{Y_o} \times 100\% \qquad (2)$$

The reference MC level corresponded to 35% RH. Regression equation (Eq. 1) was used to calculate Y and Y_O in Eq. (2).

Thickness swelling test.—At each specified RH, twenty-five TS (five from each OSB) specimens were selected. They were first oven-dried, and their OD weight and thickness were measured. The specimens were conditioned in a chamber similar to the method used for the bending specimens. At the end of each RH level exposure, the specimens were removed from the chamber, and their weight and thickness were measured. The weight and thickness were measured again after oven-drying. The total thickness swelling (TTS) for a given specimen was calculated as:

$$TTS = \frac{(T_A - T_{OB})}{T_{OB}} \times 100\% \qquad (3)$$

TABLE 2. *Summary of bending results*[a].

	Parallel				Perpendicular				
OSB	MC (%)	Specific Gravity[b]	MOE (MPa)	MOR (MPa)	MC (%)	Specific Gravity	MOE (MPa)	MOR (MPa)	MOE Ratio[c]
SPS	5.1 (0.1)	0.64 (0.02)	5,206 (487)	32.9 (4.9)	5.3 (0.2)	0.68 (0.02)	2,116 (238)	22.1 (3.9)	2.46
	8.3 (0.1)	0.67 (0.04)	4,993 (627)	36.4 (3.7)	7.6 (0.1)	0.65 (0.02)	1,507 (136)	16.3 (1.7)	3.31
	11.6 (0.3)	0.67 (0.02)	4,191 (388)	27.7 (4.8)	12.5 (0.2)	0.68 (0.01)	1,430 (115)	15.9 (2.8)	2.93
	14.0 (0.3)	0.67 (0.01)	3,542 (664)	24.1 (4.6)	14.0 (0.6)	0.65 (0.01)	1,195 (160)	15.1 (1.4)	2.96
	22.1 (0.4)	0.62 (0.04)	2,299 (409)	17.6 (1.3)	20.8 (0.2)	0.64 (0.04)	841 (102)	10.8 (1.7)	2.73
SPI	5.3 (0.1)	0.69 (0.01)	5,714 (758)	45.4 (6.4)	5.3 (0.1)	0.73 (0.02)	2,348 (331)	26.1 (5.2)	2.43
	8.3 (0.4)	0.71 (0.01)	5,373 (518)	43.2 (2.9)	8.3 (0.4)	0.74 (0.01)	2,162 (306)	31.2 (3.6)	2.48
	11.5 (0.2)	0.74 (0.03)	4,473 (434)	37.1 (2.8)	11.9 (0.3)	0.73 (0.03)	1.958 (192)	27.8 (2.5)	2.28
	13.9 (0.3)	0.72 (0.03)	3,902 (654)	35.4 (6.1)	14.1 (0.2)	0.74 (0.02)	1,399 (112)	19.1 (1.1)	2.79
	19.5 (0.5)	0.71 (0.02)	3,184 (229)	27.5 (2.9)	20.9 (0.4)	0.74 (0.02)	1,040 (164)	16.4 (1.9)	3.06
SPF	5.3 (0.1)	0.63 (0.01)	5,583 (429)	29.6 (3.6)	5.2 (0.1)	0.65 (0.02)	2,152 (134)	19.9 (3.3)	2.59
	8.9 (0.5)	0.66 (0.02)	5,163 (439)	29.8 (3.4)	8.7 (0.5)	0.63 (0.04)	1,895 (126)	20.5 (2.7)	2.72
	13.1 (0.3)	0.69 (0.03)	4,131 (106)	28.5 (3.3)	12.7 (0.2)	0.65 (0.02)	1,400 (110)	16.3 (1.1)	2.95
	14.0 (0.1)	0.64 (0.01)	3.957 (298)	27.4 (2.6)	14.2 (0.2)	0.72 (0.01)	1,019 (312)	12.3 (4.5)	3.88
	19.6 (0.5)	0.65 (0.01)	2,863 (265)	21.8 (2.2)	20.5 (0.3)	0.66 (0.02)	809 (71.9)	12.4 (1.1)	3.54
ASS	4.6 (0.1)	0.59 (0.04)	5,914 (184)	32.4 (4.2)	4.5 (0.1)	0.62 (0.02)	2,774 (378)	24.2 (2.2)	2.13
	7.2 (0.1)	0.61 (0.02)	5,348 (397)	30.9 (3.4)	8.1 (0.3)	0.64 (0.04)	1,728 (288)	15.3 (2.4)	3.09
	13.1 (0.5)	0.61 (0.02)	3,497 (352)	22.6 (5.6)	11.1 (0.2)	0.58 (0.04)	1,713 (405)	16.7 (2.1)	2.04
	14.2 (0.2)	0.62 (0.02)	3,359 (240)	21.4 (1.4)	14.3 (0.2)	0.59 (0.02)	1,182 (252)	11.1 (2.3)	2.84
	19.7 (0.4)	0.63 (0.03)	1,979 (327)	14.3 (3.1)	19.9 (0.3)	0.64 (0.04)	793 (118)	8.3 (0.7)	2.49
ASF	4.4 (0.1)	0.57 (0.01)	6,138 (605)	29.3 (1.2)	4.4 (0.1)	0.59 (0.01)	2,088 (204)	16.6 (0.8)	2.94
	7.3 (0.4)	0.58 (0.02)	5,430 (489)	26.3 (4.4)	8.9 (0.4)	0.54 (0.02)	1,462 (207)	12.1 (1.5)	3.71
	12.8 (0.5)	0.58 (0.04)	3,351 (418)	18.3 (1.6)	11.5 (0.4)	0.55 (0.04)	1,207 (91)	10.0 (1.9)	2.78
	14.1 (0.4)	0.57 (0.01)	3,751 (318)	18.7 (2.4)	14.0 (0.2)	0.57 (0.02)	953 (152)	9.4 (0.9)	3.94
	21.1 (0.3)	0.59 (0.03)	2,242 (405)	13.1 (2.5)	19.9 (0.4)	0.55 (0.06)	659 (94)	6.1 (1.5)	3.40

[a] Value listed in parentheses is the standard deviation based on five specimens.

[b] Specific gravity was based on oven-dry weight and volume at 35% RH.

[c] MOE ratio between parallel and perpendicular direction.

where TTS is expressed in %, mm/mm; T_A is the specimen thickness after conditioning, mm; T_{OB} is the specimen thickness before conditioning at the OD condition, mm.

A quadratic polynomial was used to fit TTS and MC data:

$$TTS = C + D\ MC + E\ MC^2 \qquad (4)$$

where C, D, and E are the regression constants.

The recoverable thickness swelling (RTS) was calculated as:

$$RTS = \frac{(T_A - T_{OA})}{T_{OB}} \times 100\% \qquad (5)$$

where RTS is expressed in %, mm/mm; T_{OA} is the specimen thickness after conditioning at the OD condition, mm.

A linear function was used to fit RTS and MC data:

$$RTS = F + G\ MC \qquad (6)$$

where F and G are regression constants.

The nonrecoverable thickness swelling (NTS) was the difference between total thickness swelling and recoverable thickness swelling (i.e., NTS = TTS − RTS). Finally, Eqs. (2) and (4) were used to examine the relationship between strength and stiffness loss and TS over a specified MC range.

RESULTS AND DISCUSSION

MOE/MOR and MC relation

Table 2 summarizes the mean value and standard deviation of MC, SG, bending MOE, and MOR for each of the five OSBs in two

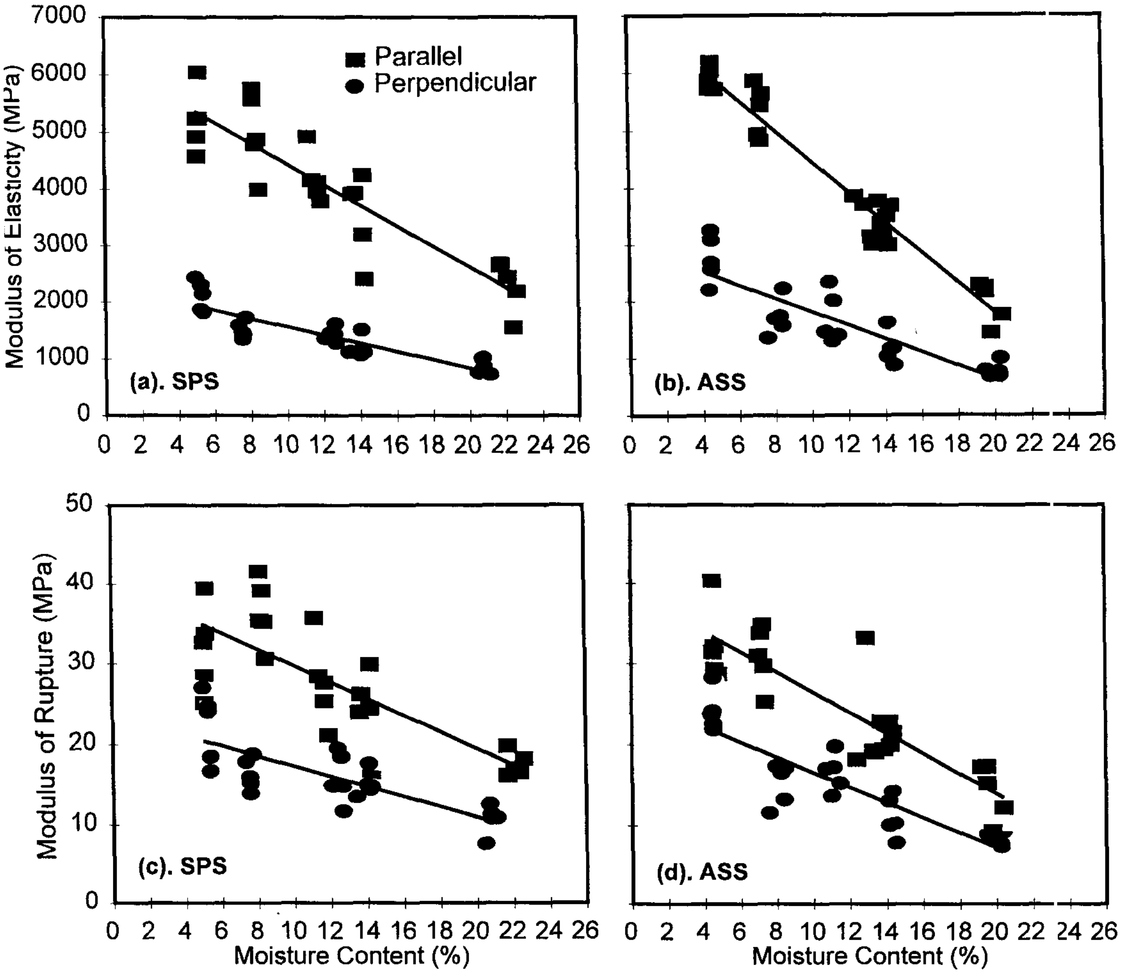

FIG. 1. Typical plots showing MOE (a: SPS, c: ASS) and MOR (b: SPS, d: ASS) as a function of MC. Lines show the linear fit of the data.

principal directions. Also, shown in Table 2 are the MOE ratios between parallel and perpendicular direction at the five MC levels. For a given OSB, mean specific gravity (SG) varied slightly among specimens at different MC levels and between two directions. SPI had the highest SG and was possibly made with a higher resin content for its application as the I-beam web material, which led to considerably higher MOR values in both directions. ASF had the lowest SG and the smallest MOR values. MOE and MOR in both directions of a given OSB decreased with increases in board by Halligan and Schniewind (1974) for their laboratory-made particleboards. There seemed to be no particular trend to the variation in the MOE ratio with MC increases. The mean MOE ratio was 2.88, 2.61, 3.14, 2.52, and 3.35 for SPS, SPI, SPF, ASS, and ASF, respectively. These values compared with an MOE ratio of 2.85 listed in the Siempelkamp promotion literature (Anonymous 1993) at a face-to-core weight ratio of 60:40.

Typical plots of MOE and MOR in both directions as a function of MC are shown in Fig. 1. Both MOE and MOR followed a linear

TABLE 3. *Summary of regression results on MOE and MOR.*

OSB	Parallel A (MPa)	 B (MPa/%MC)	 r^{2a}	Perpendicular A (MPa)	 B (MPa/%MC)	 r^2
			MOE			
SPS	6,281.97	−182.85	0.80	2,289.71	−72.53	0.77
SPI	6,740.29	−188.78	0.73	2,842.21	−87.74	0.76
SPF	6,749.62	−198.27	0.90	2,615.52	−94.82	0.84
ASS	7,170.22	−267.99	0.96	3,012.21	−118.49	0.73
ASF	6,997.13	−235.72	0.85	2,336.02	−90.69	0.86
			MOR			
SPS	40.09	−1.03	0.61	23.45	−0.62	0.58
SPI	52.80	−1.29	0.65	34.19	−0.83	0.49
SPF	34.15	−0.55	0.40	23.68	−0.61	0.48
ASS	39.03	−1.25	0.76	26.13	−0.95	0.76
ASF	32.89	−0.99	0.80	18.48	−0.65	0.83

[a] Correlation coefficient between MOR or MOR and MC.

(Fig. 1 and Table 3). The correlation coefficients varied from 0.73 to 0.96 for the MOE data and 0.4 to 0.83 for the MOR data. Halligan and Schniewind (1974) showed a maximum in either MOE or MOR value between 3 to 6% MC in particleboards. Some of our MOR data showed a decrease of the value at 4 to 5% MC compared to the value at 7 to 9% (e.g., MOR in the parallel direction for SPS as shown in Table 1). However, variations among different specimens and range of MC change at the lower end used in this study did not allow establishment of such a maximum in either MOE or MOR for those OSB products.

Predicted percentages of reduction in MOE and MOR using Eq. (2) are shown in Fig. 2 as a function of MC. For an MC change from 4 to 24%, the average MOE loss for the five OSBs was 72% in the parallel direction and 83% in the perpendicular direction. The average MOR loss was 58% in the parallel direction and 67% in the perpendicular direction. The average MOE loss and MOR loss along the grain from 12% MC to green are, respectively, 22%, and 42% for both aspen and southern pine lumber (USDA Forest Service, 1987). Pu et al. (1992) measured the bending creep and strength of six commercial OSB Sturd-I-Floor products. They subjected the specimens to an RH change from 65% to 95% under a constant load for a period of 30 days and determined the bending MOE and MOR after the creep test. They observed an average of 50% loss in bending MOE and 40% loss in the MOR after the creep test. A considerably larger MC change was involved in this study, and thus a larger MOE/MOR loss was expected. Hiziroglu (1989) demonstrated that a significant portion of stiffness and strength losses (both in bending and tension) in OSB, particleboard, and waferboard after being exposed at higher RH conditions was not recovered when the products were redried to the dry state. Therefore, protection of OSB products from moisture uptake before and during use has an important practical significance in maintaining the quality and performance of commercial OSBs.

Over the same range of MC change, the two aspen products had greater losses of both MOE and MOR in both directions as compared to the southern pine OSB products. Pu et al. (1992) also reported that aspen OSB fabricated with power phenol-formaldehyde had poor creep resistance at high humidity compared with southern pine OSB. In addition to the species difference, the larger TS of the aspen products, as discussed in the next section, might have played an important role in causing those losses. Since the same MC change was applied to all the OSBs in Fig. 2, large variations in the amount of MOE and MOR

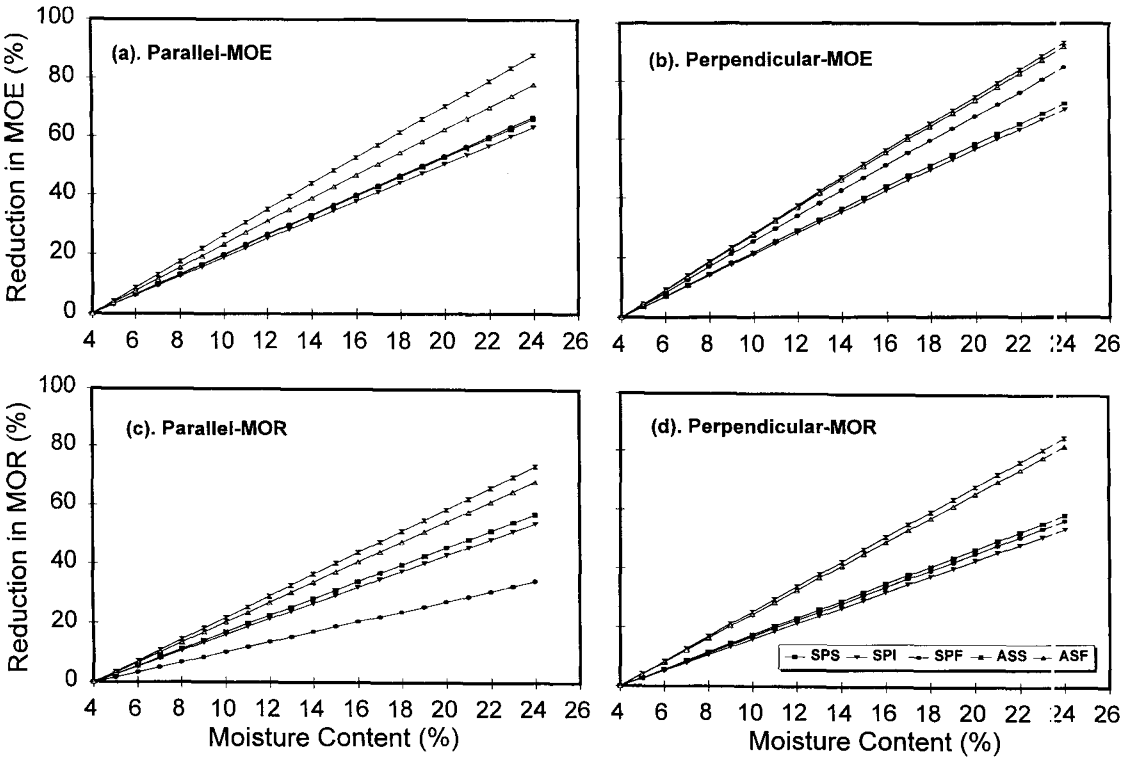

FIG. 2. Reduction in MOE (a: parallel, b: perpendicular) and MOR (c: parallel, d: perpendicular) as a function of MC for all five OSBs.

losses among different OSBs suggest that the relationship between MOE/MOR loss and MC change is very product-dependent. Thus, a common relationship with MC change is not adequate in describing losses in the strength properties of different OSB products.

Thickness swelling and MC relation

Table 4 lists TS data. The total thickness swelling, TTS (%), was divided into two separate components: recoverable, RTS (%), and nonrecoverable, NTS (%). Also shown in Table 4 are the corresponding MC and SG data. There were some variations in final MC among various OSBs and in SG among different groups for a given OSB, similar to the data from the bending test (Table 2).

TTS (both components) increased with increases in MC (Table 4 and Fig. 3). For MC change up to about the 5% level, very little NTS developed so that data points for TTS and RTS overlap. As MC increased further, however, NTS developed gradually up to 8 to 10% MC, and then increased quickly with further increases in MC. The average MC change from OD to equilibrium at 95% RH was 20.6% among all OSBs. The average total TS with the MC change was about 19.9%, in which 7.4% was RTS and 12.5% was NTS. This TTS value of 19.9% compares with an average TS value of 24.5% from OD to vacuum pressure soaked condition for six commercial OSBs reported by Pu et al. (1992). ASS had the largest TTS (25.6% over a 20.6% MC change), while SPI had the smallest TTS (15.8% over a 20.6% MC change).

Increased board density and/or resin content had a great influence on thickness swelling, especially on the NTS component as indicated by the SPI data. SPI had the largest RTS due to its higher density, but its NTS was significantly smaller than those of other OSBs. In

TABLE 4. *Summary of thickness swelling test results*

OSB	MC (%)	Specific Gravity[b]	TTS (%)	RTS (%)	NTS (%)
SPS	5.0 (0.4)	0.64 (0.02)	1.3 (0.1)	1.2 (0.2)	0.1 (0.1)
	8.9 (0.4)	0.66 (0.01)	4.3 (0.9)	3.3 (0.4)	1.0 (0.7)
	12.6 (0.5)	0.68 (0.03)	8.4 (1.2)	4.8 (0.6)	3.7 (1.5)
	15.2 (0.8)	0.65 (0.04)	12.3 (1.1)	5.3 (0.7)	7.0 (1.5)
	21.3 (0.6)	0.66 (0.02)	21.6 (2.2)	6.6 (0.9)	14.9 (2.8)
SPI	5.1 (0.1)	0.74 (0.05)	1.3 (0.1)	1.2 (0.2)	0.1 (0.1)
	8.8 (0.4)	0.71 (0.07)	4.0 (0.4)	3.7 (0.5)	0.3 (0.2)
	12.3 (0.6)	0.74 (0.04)	7.6 (0.7)	4.9 (0.3)	2.6 (0.9)
	13.9 (0.6)	0.74 (0.04)	10.2 (1.6)	6.0 (0.7)	4.1 (1.6)
	20.6 (0.6)	0.75 (0.05)	15.8 (2.7)	8.5 (0.7)	7.3 (3.2)
SPF	5.3 (0.1)	0.62 (0.02)	1.2 (0.1)	1.1 (0.2)	0.1 (0.1)
	8.6 (0.4)	0.65 (0.04)	3.4 (0.6)	3.0 (0.5)	0.4 (0.2)
	12.3 (0.7)	0.63 (0.02)	6.7 (1.0)	5.0 (0.6)	1.7 (0.5)
	14.3 (0.6)	0.65 (0.03)	9.4 (1.1)	5.8 (0.5)	3.7 (0.9)
	19.7 (0.5)	0.68 (0.03)	16.5 (1.1)	7.4 (0.4)	9.2 (1.3)
ASS	4.2 (0.1)	0.64 (0.05)	1.3 (0.2)	1.3 (0.1)	0.1 (0.1)
	7.8 (0.5)	0.63 (0.05)	4.7 (0.8)	2.5 (1.1)	2.2 (1.3)
	11.9 (0.6)	0.59 (0.02)	9.7 (2.2)	4.0 (0.6)	5.7 (2.5)
	14.1 (0.8)	0.62 (0.03)	13.4 (2.8)	4.8 (0.7)	8.6 (2.5)
	20.7 (0.6)	0.64 (0.04)	25.6 (5.6)	7.9 (0.9)	17.9 (5.5)
ASF	4.2 (0.1)	0.55 (0.03)	1.2 (0.1)	1.1 (0.1)	0.1 (0.1)
	8.0 (0.5)	0.58 (0.02)	4.8 (0.4)	3.1 (0.2)	1.8 (0.3)
	12.1 (0.7)	0.57 (0.03)	9.3 (1.2)	4.2 (0.6)	5.1 (1.2)
	14.3 (0.7)	0.59 (0.01)	13.8 (1.6)	5.9 (0.6)	7.9 (1.4)
	20.6 (0.5)	0.58 (0.02)	19.8 (2.6)	6.6 (0.9)	13.2 (2.9)

[a] Value listed in parentheses is the standard deviation based on five specimens.

[b] Specific gravity was based on oven-dry weight and volume at 35% RH.

particular, NTS for ASS and SPS was more than twice as large as that of SPI. The effect of a large NTS component for ASS on board quality was reflected in a considerably larger reduction in both MOE and MOR. Thus, efforts should be made to reduce this nonrecoverable TS during manufacturing to maintain the board quality at higher MC levels. The quadratic relation for TTS and linear relation for RTS with MC change appeared to fit the data well (Table 5 and Fig. 3).

Relation between reduction in MOE/MOR and TS

The reductions in MOE/MOR and TTS over an MC change from 4 to 24% were calculated using Eqs. (2) and (4), respectively, for each of the five OSBs. The data (MOE loss or MOR loss) were plotted as a function of TTS to show the interrelationship between MOE/MOR loss and thickness swelling among the five OSBs (Fig. 4). Similar to the relationship between MOE/MOR loss and MC change, MOE loss (Fig. 4a and b) and MOR loss (Fig. 4c and d) increased with increased thickness swelling. Unlike the MOE/MOR loss-MC relation, however, data from all five OSBs in both parallel and perpendicular directions are crowded in a narrow range, despite differences in wood species and manufacturing variables among the OSBs. One set of MOR data in the parallel direction (Fig. 4c), which was from SPF specimens, deviated from the rest of the data in the graph. This was due to the poor fit of the MOR data using the linear relation with MC change as shown in Table 3 ($r^2 = 0.40$).

The small variation in MOE or MOR loss among the five OSBs over a given amount of thickness swelling suggests that all the OSBs had in common a very similar relationship be-

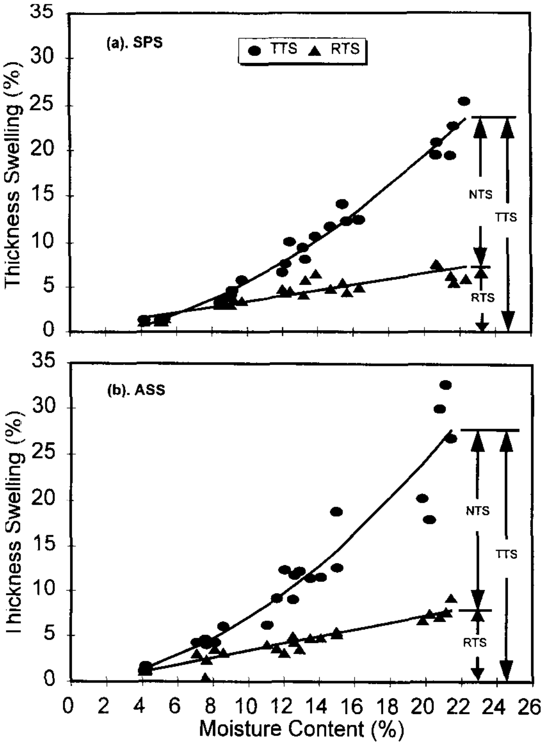

FIG. 3. Thickness swelling as a function of MC. (a): SPS, (b): ASS.

tween MOE or MOR loss and TTS. This is in contrast with a large variation of MOE or MOR loss among the OSBs for a given MC change (Fig. 2). Thus, stiffness and strength losses in OSBs are more closely related to thickness swelling than MC increase; and thickness swelling would be a better predictor for both strength and stiffness of these OSBs.

A linear fit between MOE loss and TTS for all five OSBs led to the following relationships:

$$RMOE_{\parallel} = 4.979 + 2.825*TTS \quad r^2 = 0.97$$

$$RMOE_{\perp} = 6.327 + 3.173*TTS \quad r^2 = 0.95 \tag{7}$$

where, $RMOE_{\parallel}$ (%) and $RMOE_{\perp}$ (%) are the MOE losses in parallel and perpendicular directions, respectively. The relationships between MOR loss and TS are:

$$RMOR_{\parallel} = 3.310 + 2.309*TTS \quad r^2 = 0.90$$

$$RMOR_{\perp} = 3.976 + 2.695*TTS \quad r^2 = 0.94 \tag{8}$$

where, $RMOR_{\parallel}$ (%) and $RMOR_{\perp}$ (%) are the MOR losses in parallel and perpendicular directions, respectively. The relationships defined by Eqs. (7) and (8) apply to all the OSBs used in the study. These relationships can be conveniently used to indicate current strength and safety margins in field use of OSBs.

SUMMARY AND CONCLUSIONS

Bending stiffness and strength loss in structural OSB occurred as a result of moisture content increase and thickness swelling within the hygroscopic range. Due to nonrecoverable thickness swelling, a significant portion of the loss will not be recovered when the products are redried to the dry state. These permanent stiffness and strength losses will subsequently affect the performance of the products during service. The study described in this paper investigates the bending MOE and MOR, and TS of five commercial OSBs at various levels of MC and examines their relationships to moisture changes.

It was shown that both MOE and MOR de-

TABLE 5. *Summary of regression results on thickness swelling.*

	TTS (%)				RTS (%)		
OSB	C	D	E	r^{2a}	F	G	r^2
SPS	−1.430	0.364	0.0336	0.98	0.288	0.314	0.83
SPI	−3.314	0.859	0.0037	0.91	−0.629	0.454	0.93
SPF	−1.354	0.297	0.0309	0.92	−0.823	0.438	0.95
ASS	−0.578	0.273	0.0488	0.92	−0.530	0.391	0.92
ASF	−4.637	1.293	−0.0051	0.93	0.066	0.345	0.87

[a] Correlation coefficient between thickness swelling and MC.

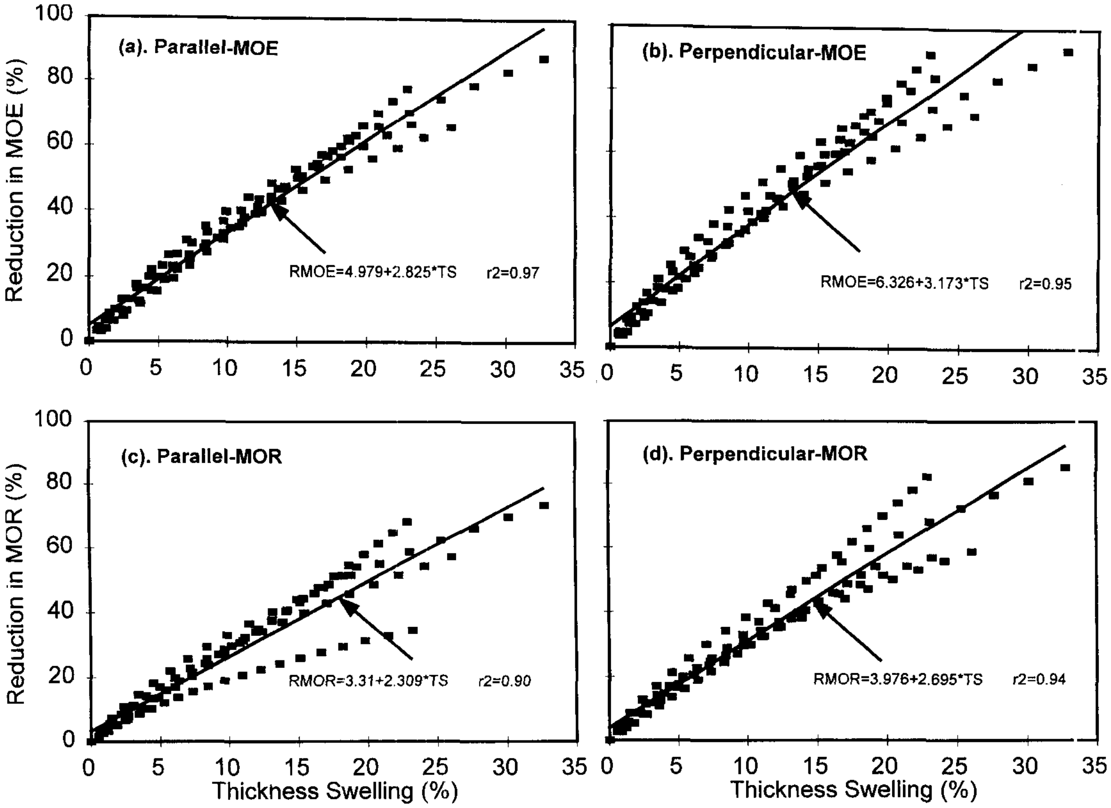

FIG. 4. Reduction in MOE (a: parallel, b: perpendicular) and MOR (c: parallel, d: perpendicular) as a function of thickness swelling. The corresponding MC change was from 4 to 24%.

creased with increases in board MC. The change in both MOE and MOR followed a linear relationship with MC over the given MC change. It was also shown that thickness swelling of these OSBs had a large nonrecoverable component, which mainly occurred with MC increases above the 8 to 10% level. For an MC change from 4 to 24%, the combined effect of increased MC and TS led to an average MOE loss of 72% in the parallel direction and 83% in the perpendicular direction and to an average MOR loss of 58% in the parallel direction and 67% in the perpendicular direction.

The study has generated sets of regression equations describing MOE/MOR and thickness swelling as functions of MC and MOE/MOR loss as a function of thickness swelling. These equations are useful for developing correction factors for the moisture effect on the flexural properties of commercial OSB products.

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A PLEA FOR PROMPTNESS

Wood and Fiber Science continues to provide an effective medium for professional papers of interest to workers in the field. This is a plea for help in keeping it that way by maintaining the number and qualtity of papers as well as the timeliness of their publication.

We need more papers. The number of papers and pages in the journal has been declining this year, from 13 papers and 144 pages in the January issue to 8 papers and 107 pages in the October issue. This reflects a decline in the number of papers submitted as well as delays in the review, revision, and galley proof return phases of publication.

Review and revision of manuscripts as well as return of galley proofs need to move more quickly. Reviewers are asked to return their comments to me within three weeks after they receive the manuscript. No deadline has been set for revision by the author, but normally this could be done within a month. Galleys should be reviewed and returned immediately. Above all, keep all of these out of the bottom layer of the "IN" box.

Thanks to all who have helped in this process as we try to publish new developments in wood and fiber science as promptly as possible. Timely publication is a contribution both to the profession and to our stature in it, as well as to the more effective use of the wood and fiber resource—our ultimate objective.

Bob Youngs, *Editor*