PERMEABILITY OF OSB. PART I. THE EFFECTS OF CORE FINES CONTENT AND MAT DENSITY ON TRANSVERSE PERMEABILITY

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ABSTRACT

This paper reports on the effects of density and core fines content on the transverse permeability, *K*, of oriented strandboard (OSB), with the aim of using fines generated during the log stranding process to improve mat permeability and possibly press efficiency. Forty-five OSB panels were made in the laboratory containing five levels of fines content (0, 25, 50, 75, and 100%) and compressed to three target density levels (low—450, medium—550, and high—650 kg/m^3). Both density and fines content and their interaction significantly influenced K_{core}, which increased exponentially with fines content at each density level. Above 75% fines, density level no longer had any significant effect on K_{core}, indicating that as the mat is compressed, the presence of fines maintains a more interconnected void system through which gas can pass. The rate of heat transfer to the core was affected by board thickness but contrary to expectations, not by fines content. Fines content did, however, affect the accumulation of gas pressure in the high target density heavily compressed boards; maximum core gas pressure was significantly reduced if core fines content was greater than 50%.

Keywords: Wood composites, OSB, transverse permeability, fines content, core density.

INTRODUCTION

Oriented strandboard (OSB) competes strongly with plywood in the residential construction market and is forecast to increase to 63% of market share for North America's entire structural panel (plywood and OSB) consumption (RISI 2002; Wood Markets 2002). Increasing wood costs translates into OSB manufacturers' wanting to increase the utilization of fines in their panels to improve resource and pressing efficiency. Fines are small wood elements generated from the log stranding process and are mostly used as boiler fuel. It is generally recommended that the fines content in OSB furnish be no more than about 5% for blending purposes since fines increase the resin usage; however, some manufacturers blend furnish containing up to 15% or 20% fines (Coil 2005). The total proportion of fines material passing through a ¼-in. rotary screen in a plant can be 30% to 40% of total furnish mass. Using only 5% fines results in considerable waste, and there is a strong need to improve resource efficiency by utilizing more fines in board production. Wood is the highest cost component of OSB manufacture, and it is

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estimated by Spelter and Wang (1996), based on a wood cost of \$55/m^3, that annual furnish costs for a plant producing 400 million ft^2/yr on a 3/8-in. basis (0.35 million m^3) could be reduced by around \$1 million if the use of waste fines content in panels could be increased by 5%.

The permeability of wood composite panels is relevant to preservative treatment of the composite (Muin et al. 2003) and moisture absorption/desorption in service (Beldi and Szabo 1986; Sekino 1994). Permeability also critically affects heat and mass transfer processes during the hot-pressing of composite mats (Zombori et al. 2003; Dai and Yu 2004). Studies including Hata (1993), Haas (1998), Haas et al. (1998), D'Onofrio (1994), Hood (2004), and Dai et al. (2005) have focused on measuring mat permeability to aid the development of hot-pressing models. These studies show that the permeability of particleboard and OSB mats is strongly influenced by wood element length, width, thickness, and mat density. The thermal conductivity and permeability of the mat in the transverse and in-plane directions control the vapor transport processes during hot-pressing, influencing the heating rate of the core, resin cure, board densification, and gas venting (Zombori et al. 2004; Pichelin et al. 2001).

The effects of increased fines content on OSB mat structure and its permeability and heat and mass transfer dynamics during pressing require investigation. Data from Fakhri (2005) show that the permeability of the core of commercial OSB is lower and much more variable than that of particleboard or MDF, despite being of lower density. Since gas flow in wood composite mats is primarily around the wood elements rather than through them (Zombori et al. 2001; Dai et al. 2005), these results led to speculation that the wood element size distribution in OSB may be manipulated to control void space connectivity and thus the permeability of OSB. Increasing the proportion of smaller wood elements in the core could increase the permeability of OSB mats during pressing, possibly resulting in more efficient heating and curing, and shorter degas times.

This study helps address a general shortage of experimental data on OSB mat permeability. The objective was to measure the effect of increasing the compaction and the fines content of the core layer on the transverse permeability, density, and IB of laboratory-made OSB. The effects of compaction and fines content on mat heating rate and gas pressure build-up during hot-pressing were also measured. The underlying hypothesis is that by manipulating wood element size mixture in the core of OSB mats, the permeability could be controlled and modeled. In Part II of this series, the permeability data are used to verify a proposed rule of mixtures-based model to describe the transverse permeability of OSB for any given density and fines content.

MATERIALS AND METHODS

Furnish collection and preparation

Dried, unscreened, and unresinated commercial OSB furnish was collected from the production line at Ainsworth Lumber Co. Ltd., 100 Mile House, BC, Canada, for use in this study. Furnish was collected from the conveyor in 6 batches of 20 kg each at approximately 1-h intervals. Typical furnish composition was around 60% aspen, 30% pine, and 10% birch and was 4% moisture content (MC) at the time of collection.

Each batch was screened separately into four size classes using a mechanical shaker. The furnish retained on a 14.29-mm (9/16-in.) square mesh screen was designated as strands, that retained on a 7.76-mm (3/16-in.) mesh as intermediates, that on a 3.17-mm (1/8-in.) mesh as fines, and that which passed through the 3.17-mm screen as dust. After screening to establish the size classification for each batch, the strands from batches 1 and 2, 3 and 4, and 5 and 6 were combined to provide sufficient material to make three replicates of each board type. The same was done for the fines. The intermediates and dust were not used for the manufacture of boards in this study. The total weight proportion of strands and fines in each furnish group was measured, indicating that the frequency distributions of wood element sizes did not differ significantly between the three groups of furnish used to make each replicate of the fines content/density combinations. In a sample of 300 pieces each of strands and fines, the mean strand length was 85 mm, mean width 12 mm, and mean thickness 0.72 mm; the mean length of the fines was 23 mm, mean width 2.8 mm, and mean thickness 0.62 mm. The size frequency and weight distributions of strands and fines are shown in Fig. 1a and b, respectively.

Experimental design and board manufacture

A set of 45 laboratory-scale OSB boards measuring 30 × 30 cm square of three different thicknesses (19.0, 22.45, and 27.44 mm), containing uni-directionally oriented strands in the surface layers and a controlled mixture of randomly oriented strands and fines in the core were manufactured by hand. Three replicate boards of each of 15 combinations of three target densities and five fines contents were manufactured from furnish that had been conditioned to 4% MC prior to blending. The three target densities were 450 (low), 550 (medium), and >650 kg/m^3 (high), and the five fines contents were 0, 25, 50, 75, and 100% by weight. The fixed and variable board manufacture parameters are given in Table 1.

The strands and fines for each board were blended separately to avoid the confounding effect of preferential resin distribution onto the fines if they are blended with the strands. Boards were manufactured in nine runs of 5 boards each, and for each run, sufficient surface and core furnish to make the 5 boards were blended separately in a 1.5-m diameter by 0.61-m deep blender rotating at 34-rpm. The resin was liquid PF-resin (GP F-59M, Borden Chemical: solids content = 59%) at 5% of furnish dry weight. This was atomized using compressed air and sprayed into the blender over a period of approximately 10 min. Furnish was tumbled for a further 10 min to ensure adequate mixing.

The mats were constructed in three layers. The bottom layer was laid down first and oriented by placing strands lengthwise into a 30-cm × 30-cm × 10-cm high orienter divided into 7 parallel cells. The core layer, which comprised

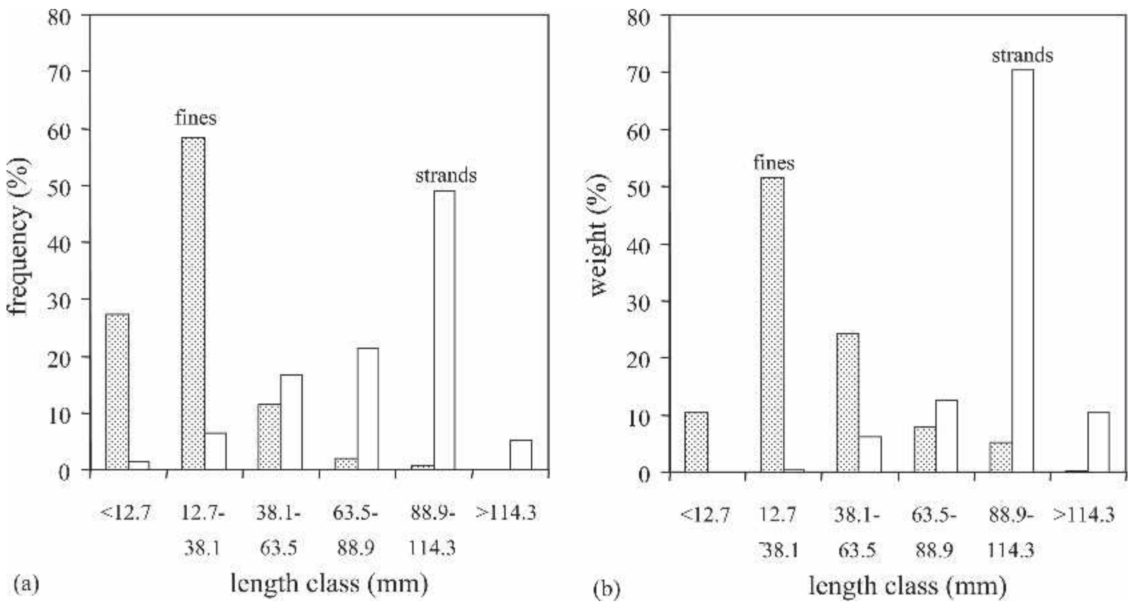

FIG. 1. The (*a*) frequency distribution and (*b*) weight distribution of strands and fines by wood element length class.

TABLE 1. *Fixed and variable factors for manufacture of OSB in the laboratory.*

Constants	
Board area	30 × 30 xm
Furnish oven-dry weight	1.06 kg
Resinated furnish weight	1.21 kg
Surface/core ratio by mass	65%/45%
Press platen temp.	185°C
Press closure to target thickness	9 steps over 76 s
Cooking time at target thickness	1664 s
De-gas time	60 s
Variables	
Target thickness (mm)	27.44, 22.45, 19.0
Core fines content (%)	0, 25, 50, 75, 100
Replicates	3

45% of the total board mass, was distributed randomly. The top layer was then laid down in the same manner as the bottom layer. The assembled mats were pressed to three different thicknesses at 185°C between two sheets of wax paper and two aluminum caul plates using a 304-mm × 304-mm Wabash press. The press cycles, including core temperature, mat pressure, and gas pressure, were monitored using the PressMAN press control system. The press cycles were relatively long (30 min) to ensure that gas pressure had fully dissipated prior to press opening and the resin fully cured. The goal when pressing the thickest boards, 27.44 mm, was to produce a low-density board with sufficient compression that intact samples could be prepared and their permeability measured. Once cooled, the outer 50 mm from each edge was trimmed off and the surfaces were lightly sanded on a wide belt sander to remove the wax paper.

Sample preparation

From each board 9 samples were cut: 1 for transverse permeability through the full board thickness, 2 for transverse permeability of the top and bottom layers, 4 for transverse permeability of the core layer, and 2 for vertical density profile (VDP) and IB tests. The cylindrical permeability specimens were cut using a plug saw mounted on a drill press to measure 51 mm in diameter and the VDP/IB pieces were cut square to measure 51 × 51 mm. The positions of each sample type on each board were assigned randomly. To isolate the desired 5-mm layer of top, bottom, or middle zone, the unwanted portions of the sample were sanded away using a belt sander. All prepared permeability and VDP specimens were placed in a conditioning chamber maintained at 20°C and 65% humidity for three weeks to equilibrate to an equilibrium moisture content (EMC) of 12%.

Measurement of layer density and IB

The VDP of the samples was measured using an X-ray density profiler (Quintek Measurement Systems Inc, model QDP-01X). IB strength was measured in accord with ASTM D1037 (2000) using a Sintech 40D Universal Testing Machine.

Measurement of transverse gas permeability

Superficial gas permeability, k_g, was measured using the falling water displacement method designed for specimens of high to very high permeability (Siau 1995). Darcy's Law was used to calculate permeability since viscous flow is almost certainly the only kind of flow encountered during conventional hot-pressing of wood composite mats (Bolton and Humphrey 1988). Three falling water rate measurements were made for each specimen and the average k_g was computed. The calculated superficial gas permeability values were multiplied by the viscosity of air, $K = k_g \cdot \mu_a$, $\mu_a = 1.846 \times 10^{-5}$ Pa·s, for the calculation of specific permeability in units of m^3/m, which is independent of measuring fluid and solely a function of the material itself.

Statistical analysis

Two-factor ANOVA analyses for the effects of fines content, target density, and their interactions on mat heating rates, board density, transverse permeability, and IB were performed. Since the mat heating rate and the permeability data were not normally distributed, the values were transformed ($\log_{10}$) prior to statistical analysis, after which the transformed data were found to be normally distributed. No transformation was required for the density data. ANOVA analyses were performed using JMP statistical software. Tukey-Kramer multiple range tests were used to determine significant differences at the 95% confidence level. Significant results are presented graphically with a least significant difference (LSD) bar to represent significant differences between means.

RESULTS AND DISCUSSION

Density

From Table 2 the density of the core layer was significantly affected ($p < 0.001$) by the known factors of target density and fines content, as well as a possible unknown source of variation arising from nonuniform furnish distribution from the hand formation of mats. Typical examples of VDPs of boards in each density class are given in Fig. 2 for 25% fines content and are close to a typical fines content found in commercial OSB. The heterogeneity of density within and between boards can also be seen. The average density and CoV of the boards and their surface and core layers in each target density class are given in Table 3, in which mean board densities were 527, 637, and 733 kg/m^3, respectively, for low, medium, and high target densities, while CoV was less than 10%. Note that average board densities were 13% to 18% higher than their specified target density. Core layer densities were 461, 503, and 586 kg/m^3, respectively; compared to the average core density of a comparison commercial ¾-inch-thick OSB, which is approximately 540 kg/m^3 (Fahkri 2005), i.e., in the mid- to upper range of density used here.

TABLE 2. *Summary of ANOVA results for density and fines content effects on core and whole board density, and IB.*

Factor	Density		IB
	Core	Whole board	Core
Density	$p < 0.0001$	$p < 0.001$	$p = 0.02$
Fines content	$p = 0.0002$	ns	ns
Density × fines content	$p = 0.006$	ns	ns

ns = not significant at $p \leq 0.05$.

The average board density with fines content of the core layer of boards in each target density class is shown in Fig. 3. There was no significant effect of fines content on the density of the core layer of the low and medium target density boards, but there was a decline in density with increasing fines content in the high target density boards. Differences in final mat density can be expected since the size and shape of wood elements in a composite mat affect the platen pressure required to achieve a specific final density (Suschland 1959; D'Onofrio 1994). Reducing the size of the wood elements results in more efficient packing, i.e., mat void space is more effectively filled during compression, and this reduces the degree of compaction of wood elements in the core, resulting in a reduced mat compaction ratio during hot-pressing.

Internal bond strength

IB was significantly affected by target density, but there were no statistically significant effects of fines content (Table 2). Mean IB for each density class are given in Table 3, increasing significantly, by 35%, between low and medium density classes, with a slight, but not significant, decrease between medium and high density boards. Increasing mat compression increases IB only to a certain extent, beyond which the effect of gas pressure is believed to compromise bond strength. Work by Smith (1982) showed that compressing waferboards to higher density greatly reduced the lateral mat permeability due to higher gas pressure and reduced ease of venting, and this was accompanied by reduced IB. Bond development can also be hampered by interactions between mat moisture and pressure, which can cause resin to retreat into the wood elements during pressing (Brady and Kamke 1988).

The IB of commercial OSB should be no less than 0.345 MPa (CSA O437.0–93). The variation in IB values was high relative to that of density, with CoV values between 24% and 55%. Approximately 60% of the IB samples

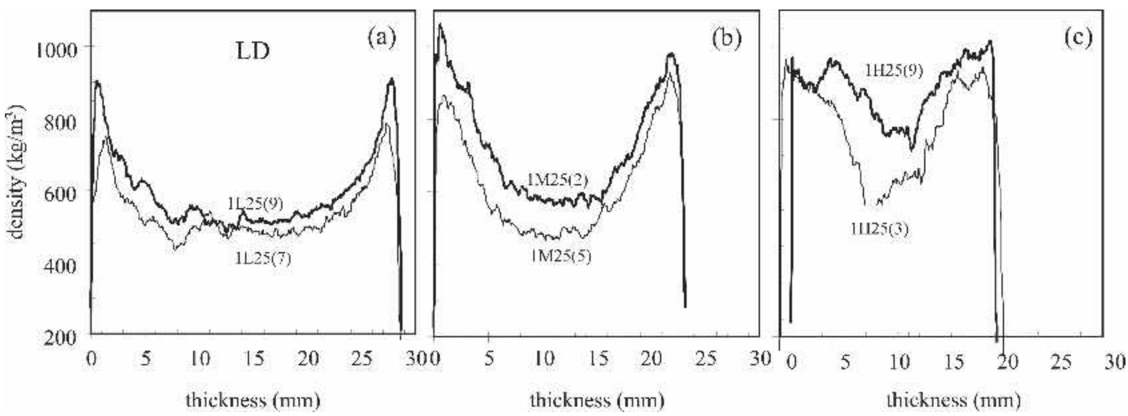

FIG. 2. Example vertical density profiles (VDPs) for low, medium, and high target density boards containing 25% fines.

TABLE 3. *Average density and IB of boards and layers for each target density class. CoV given in parentheses.*

Layer	Density (kg/m^3) Low	Medium	High
Full thickness	526.8 (9.3%)	636.9 (7.9%)	732.6 (6.5%)
Core	460.7 (7.5%)	503.1 (7.0%)	586.4 (9.6%)
Face	609.9 (5.9%)	744.3 (6.7%)	806.1 (7.3%)
	Internal bond (MPa)		
Core only	0.27 (33.2%)	0.36 (23.4%)	0.31 (54.9%)

were below 0.345 MPa. The blending of flakes may not have been as even as desired and hand-manufacture of small OSB boards inevitably introduces higher variation into IB. A much larger sample size would be required to elucidate the true effect of fines content on IB, particularly for the lower density boards.

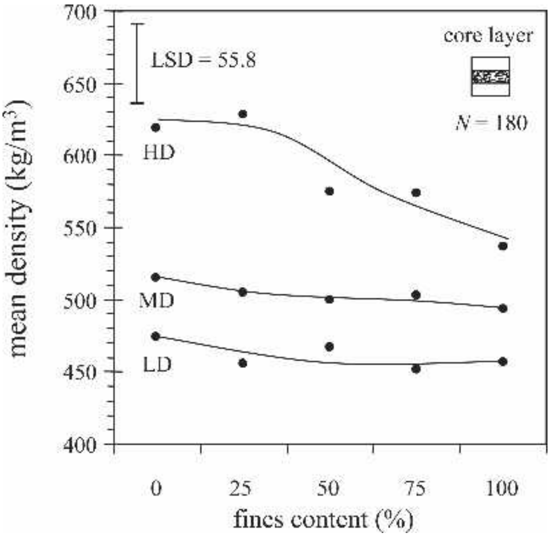

FIG. 3. Mean core density as a function of fines content for each board target density class. Least significant difference (LSD) bar shown for comparison of means.

Effects of density and fines content on transverse permeability

Mat density exerts a major effect on permeability of wood composites (Sokunbi 1978; Humphrey and Bolton 1989). A summary of the results from the ANOVA tests showing significant effects on surface, core, and board permeability is given in Table 4. The effects of density, fines content, and their interaction on the permeability of the core layer were highly significant ($p < 0.001$). In contrast to the core layer on its own, the significance of effect of fines content on the permeability of the boards through the full thickness was lower ($p < 0.043$), with no significant interaction between fines content and density. These effects were probably ‘masked’ by the presence of the two low permeability face layers.

The average permeability of the face and core layers, and the full thickness samples, are given in Table 5, in which the very high variation in permeability is evident from the CoV values. Despite this, there were significant differences in permeability. Board surfaces decreased significantly from 3.14×10^{-13} to 0.53×10^{-13}

TABLE 4. *Summary of ANOVA results for density and fines content effects on transverse permeability of surfaces, core, and full board thickness, and mat heating rate.*

	Permeability				Mat heating rate
	Layer			Full thickness	
Factor	Top	Bottom	Core		Core
Density	ns	ns	$p < 0.0001$	$p < 0.001$	$p = 0.002$
Fines content	ns	ns	$p < 0.0001$	$p = 0.043$	ns
Density × Fines content	ns	ns	$p < 0.0001$	ns	ns

ns = not significant at $p \leq 0.05$.

TABLE 5. *Average permeability of boards and layers for each target density class. CoV shown in parentheses.*

	Permeability ($\times 10^{13} m^3/m$)		
Layer	Low	Medium	High
Full thickness	5.1 (58.0%)	1.0 (106.6%)	0.4 (67.8%)
Core	65.1 (57.9%)	44.2 (66.6%)	33.3 (84.3%)
Face	3.1 (145.0%)	0.5 (77.5%)	0.5 (211.6%)

m^3/m as the composite was compressed to the medium target density, after which there was no significant change in mean permeability of the face layers. The face layers were comprised of large strands only and permeability therefore controlled by density only.

From Table 5, average K_{core} decreased steadily with increasing compaction, in accord with previous findings (Humphrey and Bolton 1989; Haas et al. 1998; Hood 2004). Previous research on permeability of partially consolidated particleboard mats during pressing (Denisov et al. 1975) shows that mat permeability is strongly dependent on both compaction ratio and the size and shape of particles. Nketiah (1982) found the relationship between transverse permeability and density of different layers of particleboard to be strongly confounded by the changes in particle size distribution through the thickness of the board. It is expected that the rate of decrease in permeability with densification of the composite would be less if smaller discrete wood elements are used.

In accord with these previous observations, the interacting effect of fines content heavily confounded the relationship between permeability of the core layer, K_{core}, and layer density, as shown in Fig. 4a. Note from the figure and from Table 5 the increasing variability in K_{core} with increasing density, which is consistent with previous findings for OSB mats of Hood (2004), who found that increasing the mat compaction ratio led to greatly increased variability in the permeability of his samples. This suggests that within the higher density ranges, the effect of variation in mat density and wood element packing on permeability is much more accentuated. The other contributor is the observed decrease in density of the high target density boards containing high fines content shown previously in Fig 3. This likely also contributed to the higher permeability of the core containing 75% or 100% fines. Because of the inversely exponential relationship between OSB mat density and permeability observed here and by Haas et al. (1998), the wood element size and the density of the parent wood can have a critical effect on mat permeability through their influence on mat compaction ratio (Hood 2004). Low density parent wood increases the compaction ratio for a particular board target density, resulting in reduced mat permeability.

Mean K_{core} and CoV for each density/fines content combination are given in Table 6. Note the large increase in K_{core} between 75% and 100% fines content, which is consistent with recent mat porosity and permeability models by Dai et al. (2005) which predict that mat porosity and permeability are much more sensitive to changes in average strand dimensions (as affected by fines content) when average wood element size is small (i.e. high fines contents). The variability (CoV) generally increased with density class and decreased with fines content. Plotting log K_{core} with fines content at each density

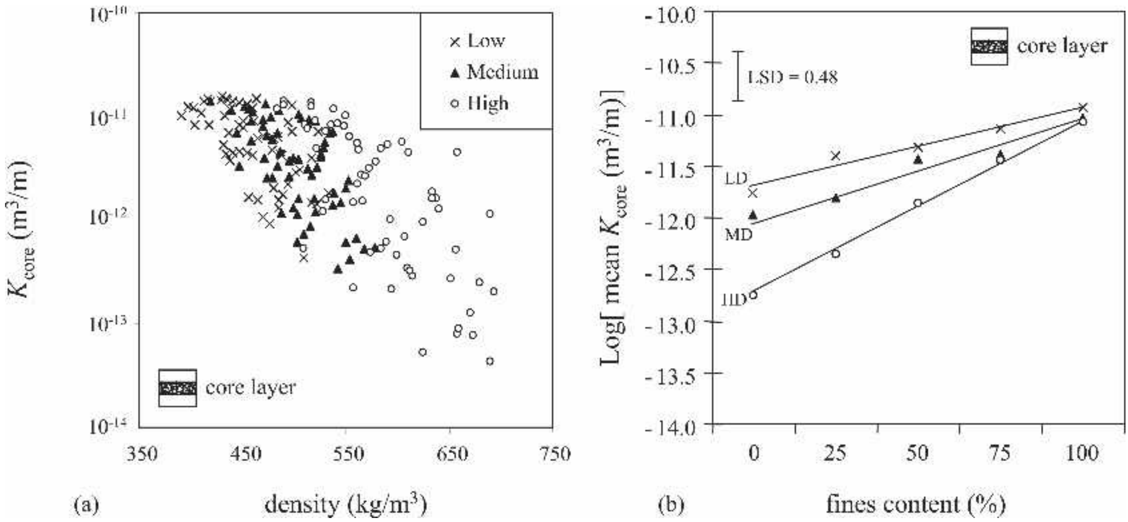

FIG. 4. The (*a*) permeability of core layer specimens as a function of density, and (*b*) log-linear fits to mean core permeability as a function of fines content. Least significant difference (LSD) bar shown for comparison of means.

TABLE 6. *K_{core} (× 10^{13} m^3/m) for each combination of target density and fines content. (CoV shown in parentheses).*

Density class	Fines content				
	0%	25%	50%	75%	100%
Low	34.0 (101.5%)	51.5 (70.5%)	54.3 (55.5%)	76.3 (41.3%)	119.0 (20.7%)
Medium	14.7 (107.8%)	21.7 (98.3%)	38.9 (39.6%)	53.4 (64.2%)	92.4 (23.0%)
High	3.4 (121.1%)	7.4 (118.5%)	22.4 (94.5%)	43.0 (54.4%)	90.5 (33.1%)

level in Fig. 4b indicates that the rates of increase in permeability with fines content were similar for the low and medium target density levels, but higher for the high density level, indicating an interaction between density and fines content. This was also consistent with the Dai et al. (2005) models in which strand dimensions have a diminished effect on permeability in the lower range of mat density. There was a minimal effect of density on log K_{core} when it was comprised of 100% fines, where the average permeability was highest; around 10^{-11} m^3/m. The same effect is evident from Fig. 5a, but Fig. 5b for the full board thickness shows that the core fines content effect has been heavily masked by the presence of the surface layers.

The results indicate that compaction had the greatest effect on transverse permeability when fines content was low, whereas at higher fines contents, core permeability remained high even when the composite was compacted to higher density. In addition to the density contribution noted earlier, there is also the effect of geometric differences between the strands and fines and how this impacts on the number and connectivity of flow paths as the composite is compressed. Previous investigations by D'Onofrio (1994), Bolton and Humphrey (1994), Hata (1993), and Dai et al. (2005) all demonstrate how composite permeability decreases when it contains longer, wider elements (i.e., strands). The already long and tortuous flow paths are easily sealed off as the mat is compressed and strand surfaces contact one another. In contrast, a mat containing short and narrow splinters (i.e., fines) forms a system of polygonal voids with a network of connecting flow paths that are shorter and more frequent. Some of the fines may also orient vertically, creating parallel flow paths in the transverse direction. This configuration of voids and connecting paths is less easily sealed off during mat compaction and likely explains why com-

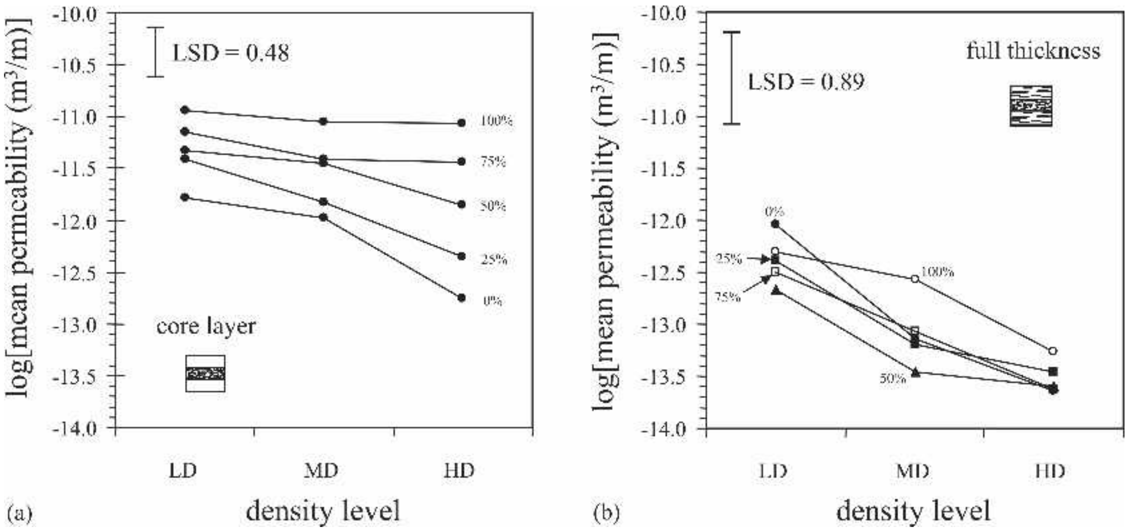

FIG. 5. Average log K_{core} as a function of board target density for (*a*) core layer specimens and (*b*) full thickness specimens. Least significant difference (LSD) bar shown for comparison of means.

posite permeability remains high regardless of density.

Transverse permeability and heat and mass transfer during hot-pressing

The main mechanism of heat transfer during early stages of pressing of wood composite mats such as particleboard and OSB is convection (Strickler 1959; Bolton and Humphrey 1988; Zombori et al. 2003). During the early stages of mat compression, moisture in the surface strands is vaporized by heat from the platens and carries heat into the core along a vapor pressure gradient. As the vapor condenses, it releases its latent heat, which increases the core furnish temperature and accelerates resin cure. The transverse gas permeability of the mat in the very early stages of compression plays a greater role in controlling the rate of convective heat and mass transfer from the surface layers into the core (Dai et al. 2005). However, large flake composites such as OSB have much lower transverse permeability, but higher in-plane permeability, and therefore rates of convective moisture and heat transfer from surface to core are lower (Geimer et al. 1975; Kamke and Casey 1988).

The permeability of uncompressed, uncured mats was unable to be measured; however, transverse permeability of the core of boards increased steadily with fines content up to about 75% with a greater increase above 75% fines content, suggesting that replacing strands with fines in the core of OSB may enhance convective heat transfer to the core. To test this theory, the temperature increase between 25°C and 95°C was measured for all press runs (3 per density/fines content combination). An example of a typical press run for a medium target density board is shown in Fig. 6a, and the average heating rates between 25 and 95°C of the boards in each target density and fines content are shown in Fig. 6b. The rate of temperature rise in the core was significantly affected by board density (Table 4) whereby heat transfer to the core was slower for the low density boards due to their greater furnish bulk (board thickness = 27.4-mm compared with 19.0- and 22.4-mm for the high and medium density boards). However, contrary to expectations, the fines content had no significant effect on heating rate of the core.

This may relate back to the reduced effect of fines content on permeability in less compacted boards, suggesting that fines may have even less effect on air circulation in unconsolidated mats containing more and better connected void

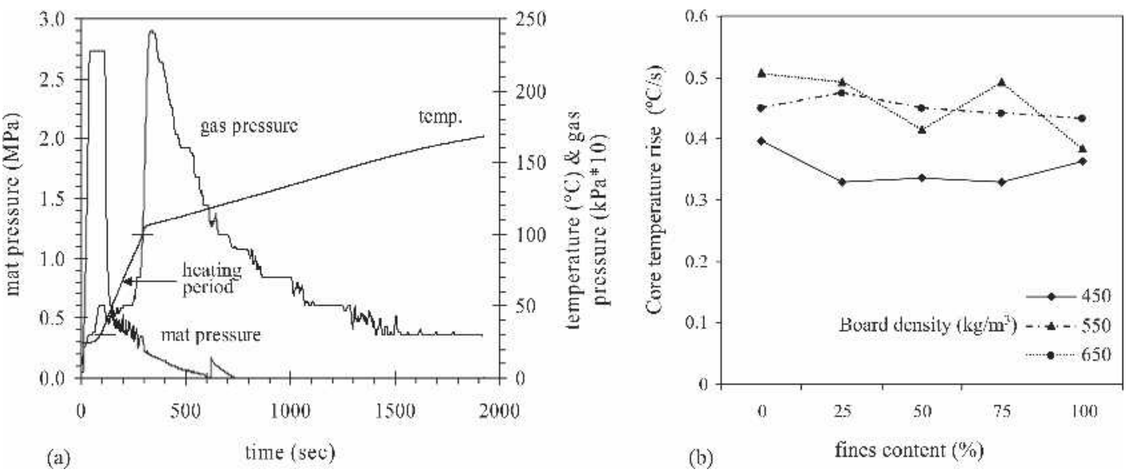

FIG. 6. The (*a*) typical pressing history for a board of 550 kg/m^3 target density and 50% fines content, and (*b*) average increase in mat core temperature for boards in each fines content and board target density group.

space. Heat transfer to the core takes place during the early stages of consolidation when the mat is more porous and the density profile is still being formed, and in this stage the permeability is governed much more by density than strand dimensions (Dai et al. 2005). In contrast, the permeability measurements were made on fully cured, consolidated boards in which flow paths are more restricted. Other important differences between the steady-state measurement of consolidated permeability specimens and the dynamic conditions inside the mat as it is hot-pressed include the liquid to gas phase changes and translocation through the mat, temperature, and pressure gradients that develop in the mat, and mat moisture content, all of which are closely linked to the permeability and conductivity of the mat (Dai and Yu 2004). It highlights some of the great difficulties in directly relating board permeability measurements to the hot-pressing process. A fines content effect on heating rate (if present) will be further confounded by mat moisture content effects on core heating rate and permeability (D'Onofrio 1994). This is because heating of the core of the mat is delayed by the condensation of steam carried in from the surfaces and it is not until this free moisture vaporizes and escapes from the mat that the core can reach maximum temperature (Maku et al. 1959; Kamke and Casey 1988; Wang and Dai 2004). The fines content effect on in-plane permeability of the mat is unknown at this time.

As the air and void space are squeezed out of the mat in the later stages of compaction, conduction becomes the predominant heat transfer mode, and increases as the surface flakes compress and void space in both the mat and the flakes reduces (Kamke and Zylkowski 1989; Zombori et al. 2003; Hood 2004). Towards the end of the press cycle, the gas pressure and the ease with which this pressure equalizes after the mat has reached final thickness becomes critical, and is related to compressed mat in-plane permeability (Smith 1982; Kamke and Casey 1988; D'Onofrio 1994; Hood 2004). The venting period of the press cycle enables the mat to expand under restraint, increasing its permeability, and reducing the risk of delamination after press opening. Any remaining trapped gas expands after press opening, potentially causing localized delaminations or full-scale blows. Because venting mainly involves the in-plane movement of gas, subsequent investigation of the effects of fines content on in-plane permeability of OSB mats is required.

While in-plane permeability was unable to be measured here, information on internal gas pressure in the core was available from the PressMAN files, and average maximum gas pressure measured in the boards in each density class and fines content is shown in Fig. 7. Gas pressure was lowest for the low target density boards, with little increase in the case of the medium target density boards. In both these cases, increasing fines content had little effect on the accumulated gas pressure until strands were replaced entirely with fines, in which case gas build-up was reduced. However, when boards were compressed to high density, replacing strands with fines greatly reduced the gas pressure in those boards. At low fines content, 0 and 25%, the maximum gas pressure was over 20 times higher than that of the medium target density boards. This finding seems to be consistent with strand dimension models for hot-pressing parameters (maximum core temperature, gas pressure, and moisture content) by Dai et al. (2005), which predict that longer, wider flakes lead to higher maximum gas pressures.

The follow-up to this work (Part II) examines the relationship between composite permeability and the ratio of strands to fines. A conceptual framework for permeability of OSB based on an electrical analogy of series and parallel conduction is examined. The effect of fines content is modeled according to the possible spatial arrangements of the two wood element types in the mat using a rule of mixtures approach whereby the permeability of OSB containing strands and fines in either series or parallel configurations form the limiting conditions.

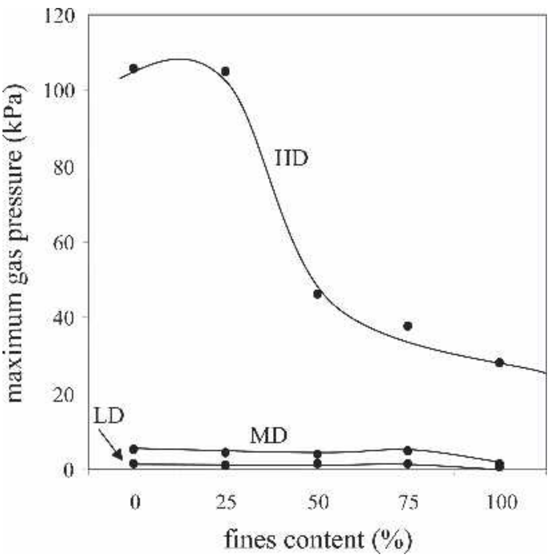

FIG. 7. Maximum gas pressures recorded in boards of each fines content and board target density group.

CONCLUSIONS

1. IB strength was significantly affected by board densification but not by fines content.
2. Board and layer density strongly affected transverse permeability and there was a significant interaction between density and fines content influencing K_{core}.
3. There was a log-linear increase in K_{core} with increasing fines content at each density level. The fines content effect on K_{core} was greatest in the high target density boards. At high fines contents, i.e., 75% and 100%, there was a less pronounced effect of mat compaction on transverse permeability.
4. The positive effect of core fines content on K_{core} of pressed boards did not translate into any observed increase in heating rate of the mat during pressing. This may be due to the marked differences in mat conditions (compaction and density, temperature, pressure gradients, etc) between specimens during permeability measurement and during actual hot-pressing.
5. Core fines content significantly affected the gas pressure build-up in the high density boards only. The higher gas pressures generated in the high density boards during pressing were significantly reduced when core fines content was increased to 50% or more. These findings need to be related to subsequent measurement of in-plane permeability of OSB core material.

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