The comparative performance of woodfiber-plastic and wood-based panels

Robert H. Falk
Dan Vos
Steven M. Cramer

Abstract

In this paper, we compare woodfiber-plastic and wood-based panel products to determine if woodfiber-plastic composites might serve as substitutes for conventional wood-based panel products. This comparison is based upon tests performed according to the ASTM D 1037, "Standard methods of evaluating the properties of wood-based fiber and particle panel materials." Results indicate that woodfiber-plastic composite panels are inferior to conventional wood-based panels in bending modulus of elasticity and bending modulus of rupture. However, the composite panels performed well in thickness swell and moisture absorption.

Falk:
Research Engineer, USDA Forest Serv., Forest Prod. Lab., Madison, Wisconsin
Vos
Engineer, Berger/Abam Engineers, Inc., Federal Way, Washington
Cramer:
Professor, Dept. of Civil and Environmental Engineering, Univ. of Wisconsin, Madison, Wisconsin

Introduction

In the United States, the high cost and decreasing availability of clear lumber has driven many building products manufacturers to consider non-traditional materials. Thermoplastics reinforced with wood and other natural fibers are becoming more commonplace in building construction, especially in the outdoor decking and window products markets. The addition of woodfiber to plastic increases thermal dimensional stability The moldability of plastic allows complex product design. In addition, these composites are attractive in the environmental sense, because both waste wood and recycled thermoplastics can be used to make these products. In cooperation with the University of Wisconsin, the Wisconsin Department of Natural Resources, and North Wood Plastics Inc., the USDA Forest Service, Forest Products Laboratory developed this project to evaluate the engineering performance of panels manufactured from wood-filled thermoplastics compared to existing wood-based panel standards.

Raw material

The raw material used to manufacture the panels evaluated in this study was a standard blend, pelletized wood flour-thermoplastic feedstock produced with a twin-screw extruder by North Wood Plastics, Inc. (9). Several pellet blends were provided and ranged from 20 to 60 percent wood flour by weight (%wt). The wood flour was 40-mesh pine. Only one polymer blend was used in this study, a 50/50%wt mix of low-density polyethylene and polypropylene.

Panel preparation

The panels were manufactured at the Forest Products Laboratory and measured 20 by 20 by 1/2 inches (59 by 59 by 12 mm). The pellets were heated between platens of a 20- by 20-inch heated press using 1/2-inch stops. The pressing times and pressure varied with the amount of wood flour. The melt-flow index decreased as the percentage of added fiber increased, requiring additional pressure and pressing time to properly form the panels. In all cases, the press was heated to 200°C and cooled to approximately 60°C before the panel was removed from the press.

Tests performed

More than 2,000 test specimens were cut from the manufactured panels and they ranged in size according to the tests performed. The specimens were tested according to ASTM D 1037 (1). This standard is used to evaluate the engineering performance of wood-based panels, such as hardboard, medium density fiberboard, and particleboard. This standard was used because no standard exists for the evaluation of woodfiber-plastic panel materials.

A variety of material property and engineering tests were performed, including bending modulus of rupture (MOR), bending modulus of elasticity (MOE), tension strength, shear strength, thermal expansion, moisture absorption, hardness, and fastener withdrawal. Half the specimens were subjected to the accelerated aging exposure outlined in ASTM D 1037. These tests are detailed in Vos (11) and the results are being prepared for publication. This paper will highlight the comparative performance of selected test results to the performance of conventional panel products.

Comparison to wood-based panel products

The performance of the woodfiber-plastic panels was compared to five commonly available wood-based panel products. These include plywood, oriented strandboard, particleboard, standard hardboard, and medium density fiberboard. The wood-plastic composite panels are represented in the figures as 20%WP and 60%WP corresponding to 20 percent and 60 percent wood filler content, respectively.

The literature was searched for information on the properties of the wood-based panel products. In some cases, data were not available. In others, only industry-based performance targets were available. Also, panel products are often manufactured to produce specific material performance (e.g., particleboard is manufactured with different densities that may affect the bending MOE). For this reason, each material is shown as having a range of values denoted as minimum and maximum. Where a range of data was not available, “typical” values designate average values for the product.

The bending MOE of the composites was significantly lower than that of conventional wood products (Fig. 1). The values for panels with a high wood filler content were comparable with the lower range of values for particleboard and medium density fiberboard.

Bending MOR values of the composites were comparable with those found in the lower range of the wood-based panels (Fig. 2). The strength of the 20%WP composite panel was comparable with the range of strength of oriented strandboard, particleboard, and medium density fiberboard.

The addition of woodfiber to pure plastic significantly lowered the tensile strength of the woodfiber-plastic composite (Fig. 3). Hardness properties were higher for wood-plastic panels than other composite products (Fig. 4). Because particleboard is often used in flooring underlayment applications, this indicates that a woodfiber-plastic composite might work well in this application.

In shear, wood-plastic composite panels performed similarly to most conventional wood-based products (Fig. 5). Only hardboard had a significantly higher resistance to shear forces.

Wood-plastic composites have a high resistance to moisture absorption. The change in moisture content of the 60%WP panels was negligible compared with the wood-based panels (Fig. 6). For thickness swell, woodfiber-plastic panels exhibited extremely small changes (less than 1%) relative to the wood-based panels (which can swell up to 40% of their original thickness) (Fig. 7). Only medium density fiberboard has stability charac-

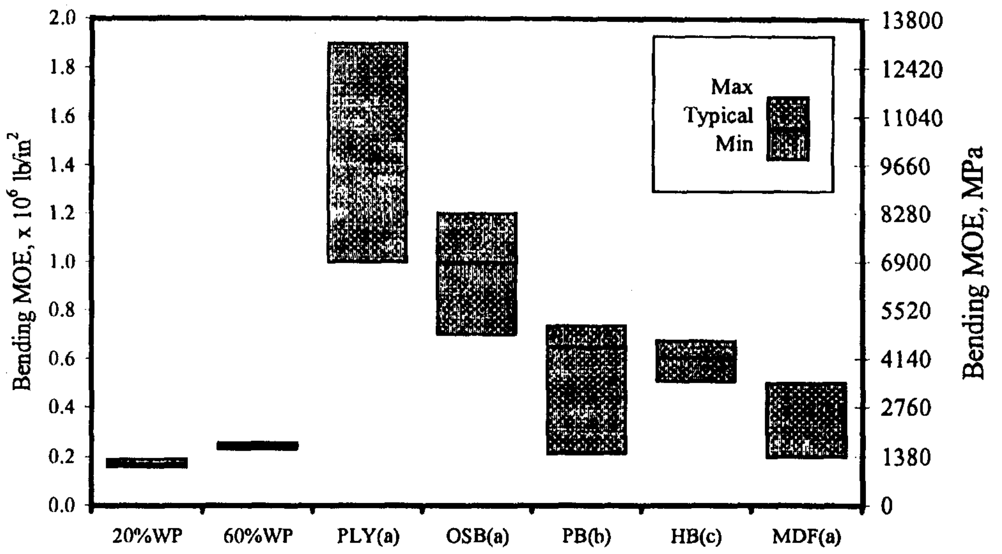

Figure 1. ~ *Bending modulus of elasticity. Sources: a = (2); b = (3,4); c = (8).*

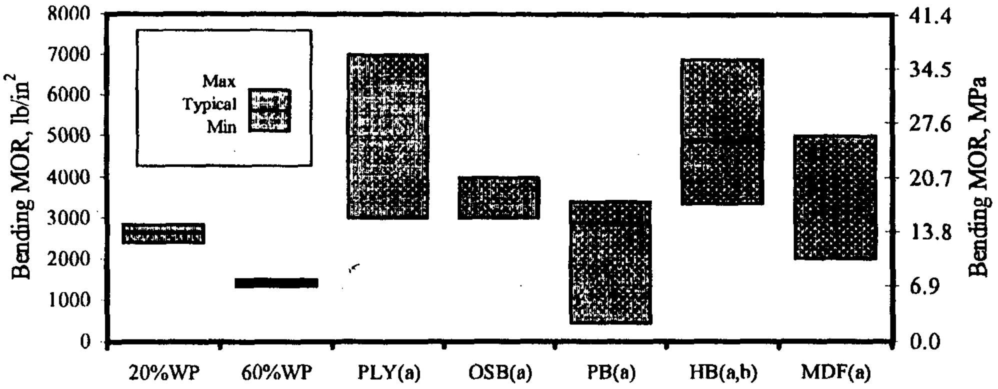

Figure 2. ~ *Bending modulus of rupture. Sources: a = (2); b = (8, 10).*

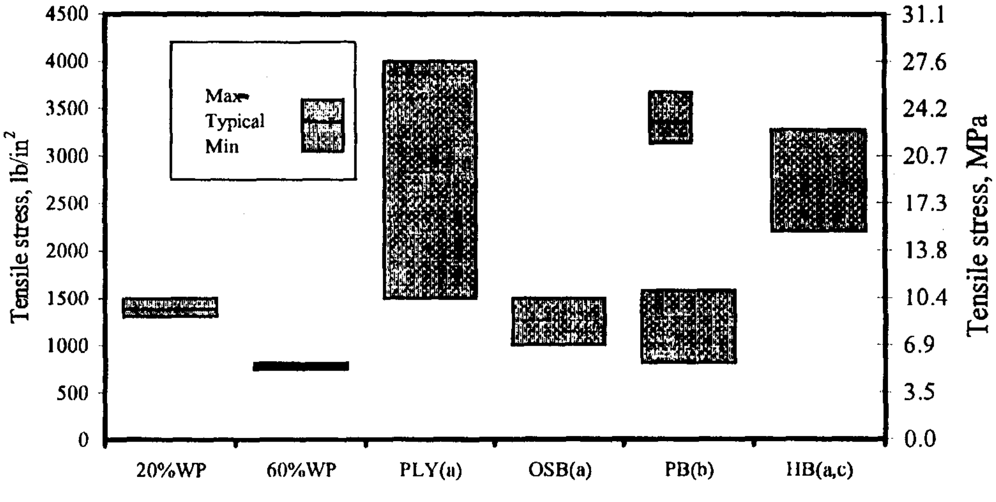

Figure 3. ~ *Tensile strength. Sources: a= (2); b = (6); c = (8).*

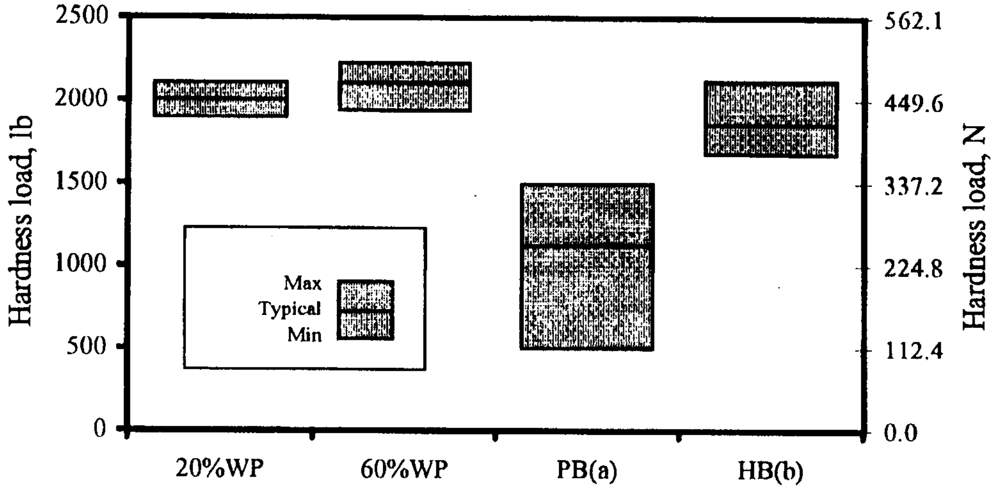

Figure 4. ~ *Hardness load. Sources: a = (2); b = (5).*

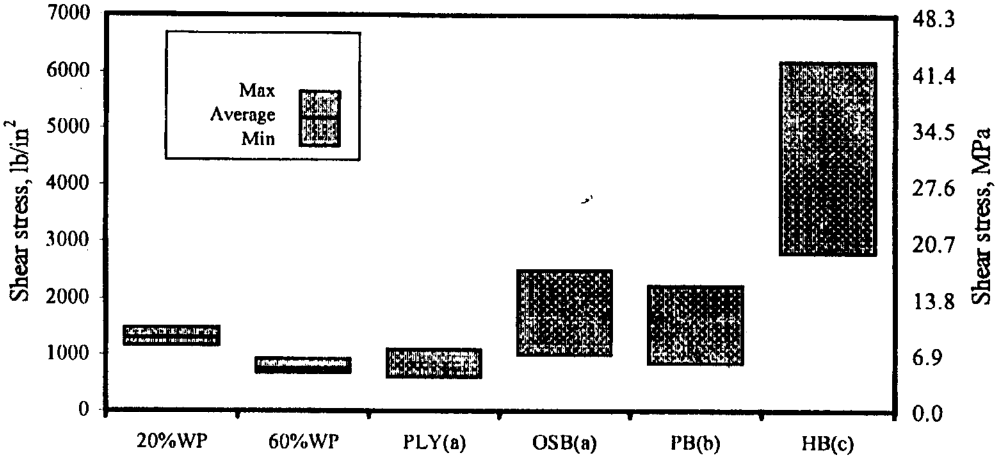

Figure 5. ~ *Edgewise shear strength. Sources: a = (2); b = (6); c = Lewis (1967, unpubl. data).*

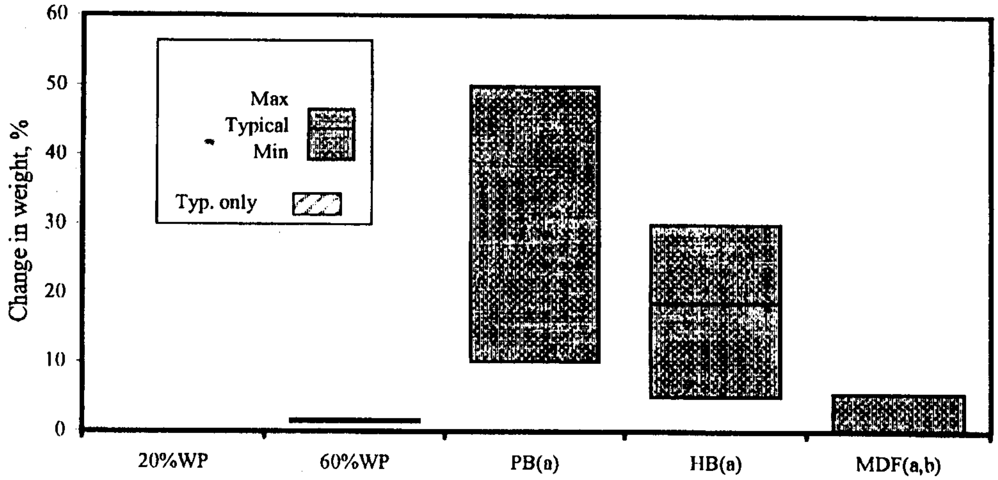

Figure 6. ~ *Percentage change in weight after 24-hour moisture exposure. Sources: a = Lewis (1967, unpubl. data); b = (8).*

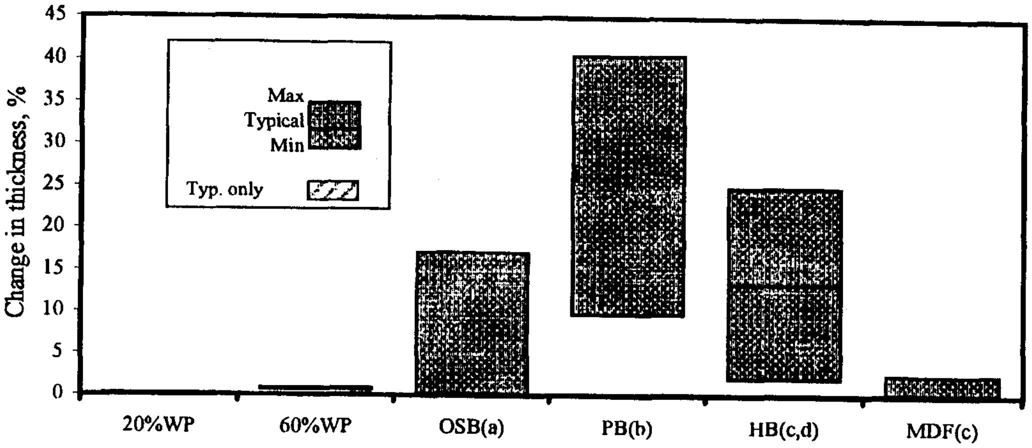

Figure 7. ~ *Thickness swell after 24-hour moisture absorption test. Sources: a = (7); b = (4); c = Lewis (1967, unpubl. data); d = (8).*

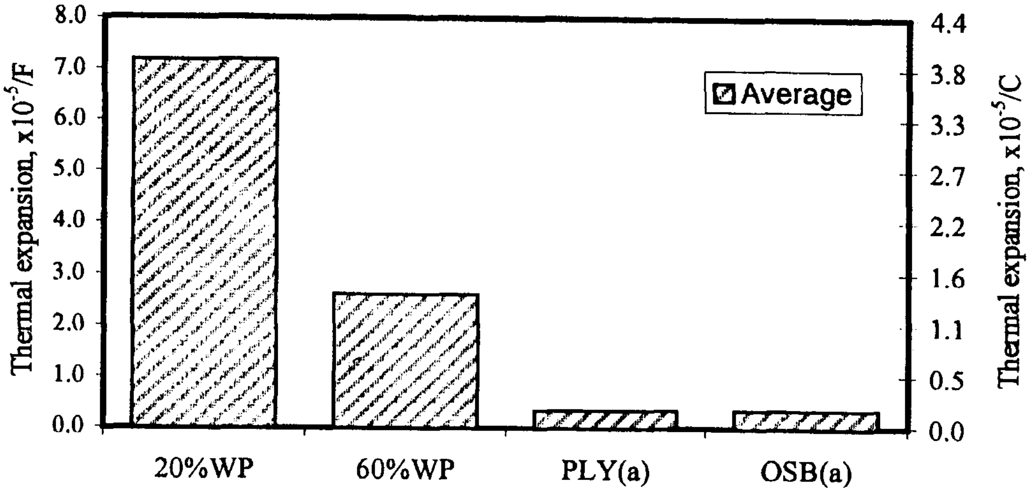

Figure 8. ~ *Coefficient of thermal expansion. Source: a = (2).*

Table 1. ~ ***General performance rating of wood-plastic composite panels relative to conventional wood-based panel products.***

Property	Inferior	Similar	Superior
Bending MOE	X		
Bending MOR	X		
Tensile strength		X	
Hardness load		X	
Edgewise shear strength		X	
Weight change for 24-hour water soak			X
Thickness swell for 24-hour water soak			X
Coefficient of thermal expansion	X		

teristics similar to those of wood-plastic composites.

A common problem often associated with plastics is their high coefficient of thermal expansion. This property is usually considered to be negligible in conventional wood-based panels. This is evident in Figure 8. The addition of woodfiber to plastic greatly reduces thermal expansion.

Conclusions

Table 1 summarizes the results of this study and provides a qualitative measure of the performance of woodfiber-plastic panels compared to conventional wood-based panel products. Table 1 indicates some of the differences between wood-plastic panels and conventional wood-based panels, even though there was a substantial amount of variation in performance between the conventional products. Classifications of "inferior" and "superior" were assigned only if the mean values for wood-plastic composite panels were lower or higher than all mean values found for the conventional wood-based panels products.

Literature cited

1. American Society for Testing and Materials. 1987. Standard methods of evaluating the properties of wood-base fiber and particle panel materials. ASTM D 1037. ASTM, Philadelphia, Pa.
2. Forest Products Laboratory. 1999. Wood Handbook: Wood as an Engineering Material. Gen. Tech. Rept. FPL-GTR-113. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
3. Geimer, R.L., B.G. Heebink, and F.V. Hefty. 1973. Weathering characteristics of particleboard. Res. Pap. FPL-RP-212. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
4. Lehmann, W.F. 1974. Properties of structural particleboard. Forest Prod. J. 24(1):19–26.
5. Lewis, W.C. 1968. Hardness modulus as an alternate measure of hardness to the standard Janka Ball for wood and wood-base materials. Res. Note FPL-RN-0189. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
6. McNatt, J.D. 1973. Basic properties of particleboard. Res. Pap. FPL-RP-206. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
7. McNatt, J.D., L. Bach, and R.W. Wellwood. 1992. Contribution of flake alignment to performance of strandboard. Forest Prod. J. 42(3):45–50.
8. McNatt, J.D. and G. Myers. 1993. Selected properties of commercial high-density hardboards. Forest Prod. J. 43(4):59–62.
9. North Wood Plastics. 1998. Product specification brochure. North Wood Plastics, Sheboygan, Wis.
10. Superfesky, M.J. and W.C. Lewis. 1974. Basic properties of three medium density hardboards. Res. Pap. FPL-RP-238. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
11. Vos, D. 1998. The engineering properties of woodfiber-plastic panels. MS thesis. Dept. of Civil and Environmental Engineering, Univ. of Wisconsin, Madison, Wis.

Fifth International Conference on Woodfiber-Plastic Composites

May 26-27, 1999
The Madison Concourse Hotel
Madison, Wisconsin

Sponsored by the USDA Forest Service in cooperation with the
American Plastics Council, the University of Wisconsin,
the University of Toronto, the Cellulose, Paper, and Textile Division
of the American Chemical Society, and the Forest Products Society

Forest Products Society
2801 Marshall Court
Madison, WI 53705-2295
phone: 608-231-1361
fax: 608-231-2152
www.forestprod.org