A NOTE ON THE FLEXURAL PROPERTIES OF BARK BOARD[1]

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ABSTRACT

Bending properties of particleboards made from soft maple, red oak, white oak, black cherry, beech, and yellow-poplar bark were obtained and compared with the specimen's density and thickness. Regression analyses indicated that the bending properties depend not only on species but also on density and/or specimen thickness. This dependence was not consistent among species.

Keywords: Bark board, flexural properties, density, specimen thickness.

INTRODUCTION

Bhagwat (1975) reviewed the utilization of bark residues particularly in the areas of chemistry, pulp products, soil additives, bark production, bark disposal, fuel, hardboard, particleboard, etc. Utilization of bark residue in particleboard would process large volumes of bark, and because of this possibility, some properties of bark particleboards have been reported (Blankenhorn et al. 1977; Judd 1973; Murphey and Rishel 1969). Generally the data indicate that bark boards possess high swelling and low strength values.

Previous research reported that flexural and compressive properties of red oak bark board were correlated with density (Blankenhorn et al. 1977). This correlation has not been reported for other species. Also, data relating the effects of specimen thickness on the mechanical properties have not been reported. The objective of this study was to establish whether a relationship exists between the flexural properties, density, and specimen thickness of six bark species.

EXPERIMENTAL

Bark from soft maple (*Acer* spp.), red oak (*Quercus rubra* L.), white oak (*Quercus alba* L.), black cherry (*Prunus serotina* Ehrh.), beech (*Fagus grandifolia* Ehrh.), and yellow-poplar (*Liriodendron tulipifera* L.) was obtained from a rosserhead debarker and dried in a kiln to approximately 5% moisture content (oven-

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TABLE 1. *Summary of regression equations.**

Species	MOE Y = MOE (psi); P = Density (lb/ft³); T = Thickness (inch)	R^2
Beech	MOE = 79966.4 − 645.3P − 65776.1T	0.542
Soft maple	MOE = 104141.8 − 1682.0P − 226782.3T + 5121.4PT	0.224
Black cherry	MOE = 147535.5 − 2585.5P − 354555.1T + 8127.0PT	0.184
White oak	MOE = 135104.2 − 2115.7P − 39847.9T	0.283
Red oak	MOE = 7744.6 + 74054.7T	0.125
	MOR Y = MOR (psi); P = Density (lb/ft³); T = Thickness (inch)	
Beech	MOR = 1266.9 − 1379.2T	0.655
Soft maple	MOR = 1633.4 − 15.9P − 3273.7T + 70.4PT	0.193
Black cherry	MOR = 1212.7 − 4.27P − 3922.2T + 86.3PT	0.312
White oak	MOR = 1255.7 − 6.4P + 1386.7T − 44.3PT	0.336

* Significant at the 0.05 level.

dry basis). Each species was hammermilled and all particles passing a 0.25-inch but retained on a 0.06 inch screen were used in the preparation of the molded specimens. Bark from each of the six species was tumbled, coated, and mixed with 6% by weight of powdered phenol-formaldehyde resin, and placed in rectangular molds of 0.25, 0.50, 0.75, and 1.00 inch square by selected lengths (20 times thickness). Targeted densities were 40, 50, 60, and 70 lb/ft³). The specimens were conditioned at 30% RH and 22 C prior to testing. Density measurements, based on oven-dry weight and volume, were obtained after mechanical testing, while thickness measurements were obtained on all specimens prior to testing.

Load deformation data were obtained using a Universal Tinius Olsen Testing Machine with a crosshead speed of 0.1 inch/minute in accordance with ASTM D 1037-72A.

Regression analyses for each species were conducted using the dependent variables of density, thickness, and interaction of density and thickness. Nonsignificant variables were eliminated from the general regression equation. Additional regression analyses were performed on the data at the different thicknesses (¼, ½, ¾, and 1 inch) for each species. These analyses were conducted to observe if the MOE or MOR was a function of density at different thicknesses.

RESULTS AND DISCUSSION

Table 1 is a summary of the significant regression equations produced using the general model of the flexural properties versus the density, thickness, and interaction of density and thickness. Yellow-poplar bark specimens did not produce significant equations for the variables measured. While the equations in Table 1 were significant, they generally had a low coefficient of determination. Generally, a relationship exists for the species for density and/or thickness, but it is not highly correlated. In fact, trends among species were not evident.

Table 2 lists the average flexural properties for the six species investigated. Yellow-poplar bark boards were highly fibrous, and they produced specimens with the highest average MOE, while beech bark boards were highly particulate

TABLE 2. *Average flexural properties.*

Species	MOE (10^3 psi)	MOR (psi)	Density (lb/ft^3)
Yellow-poplar	48.5	853	48.4
Red oak	48.4	819	47.6
Black cherry	31.1	966	46.4
Soft maple	29.1	838	44.8
White oak	23.5	743	42.4
Beech	19.2	600	44.8

and produced specimens with the lowest MOE and MOR. Regression analysis for average MOE versus average MOR for all species indicated that generally as the average MOE decreases the average MOR also decreases, although the correlation coefficient (r) for this relationship is only 0.51. The average densities of the specimens listed in Table 2 for each species were less than 50 lb/ft^3 indicating that the targeted densities of 40, 50, 60 and 70 lb/ft^3 were not achieved, particularly the higher targeted densities of 60 and 70 lb/ft^3.

Since the target densities were not achieved during fabrication, additional regression analyses centered around the individual molded thicknesses. Table 3 lists a summary of the regression equations that resulted in the highest coefficient of determination values (R^2) for bending properties of bark boards and the measured density at selected thicknesses after fabrication. Other thicknesses produced significant equations, but the R^2 values were lower than those given in Table 3. Additional significant equations were obtained for bending properties of the six species versus density at the following thicknesses: red oak at 1.00 and 0.25 inch for MOE and 1.00 for MOR; soft maple, 1.00, 0.75, and 0.25 inch for

TABLE 3. *Summary of regression equations* for bending properties and density.***

Species	Thickness (inch)	MOE: Y = MOE (psi); P = Density (lb/ft^3)	R^2
Yellow-poplar	0.75	Y = −275000 + 7784P	0.859
Red oak	0.75	Y = −295000 + 7477P	0.661
Soft maple	0.50	Y = 38234 − 515P	0.748
Black cherry	0.75	Y = −317000 + 7416P	0.618
White oak	0.25	Y = 162000 − 2056P	0.304
Beech	0.50	Y = 28302 − 363P	0.634
	Thickness (inch)	**MOR: Y = MOR (psi); P = Density (lb/ft^3)**	
Yellow-poplar	0.75	Y = −3639 + 100P	0.651
Red oak	0.75	Y = −1188 + 42.7P	0.630
Soft maple	1.00	Y = 2083 − 33.2P	0.654
Black cherry	0.75	Y = −4688 + 117P	0.725
White oak	0.50	Y = 192 + 3.92P	0.347
Beech		None	

* Significant at the 0.05 level.
** Density was based on oven-dry mass and volume measurements obtained after the specimens were tested in flexure.

MOE and 0.75 inch for MOR; black cherry, 0.50 and 0.25 inch for MOE; and beech, 0.25 inch for MOE. It is evident from this analysis that thickness influenced the bending properties and density relationships differently for the selected species.

Results of this study indicated that the bending properties of bark board depended on specimen density and/or thickness differently for the six species investigated. Comparisons among species were difficult. Targeted densities, particularly the higher densities, were difficult to obtain during fabrication. Significant relationships, except for yellow-poplar, were obtained with low coefficients of determination, indicating that the relationship between the bending properties and density and/or thickness exists. Subsequent regression analyses of the bending properties versus density at different thicknesses produced regression equations with higher coefficients of determination implying specimen thicknesses for each species that produce the best relationship between flexural properties and density. The thickness producing the highest correlation for each species was not generally consistent among species. This study indicates that not only specimen density but also specimen thickness must be accounted for in flexural testing of bark board specimens of different species.

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