BENDING STRENGTH AND STIFFNESS OF CARIBBEAN PINE FROM TRINIDAD AND TOBAGO[1]

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ABSTRACT

Small samples of Caribbean pine wood grown in Trinidad were measured for specific gravity, modulus of elasticity, and modulus of rupture in bending. Core and outer wood and samples from along the length of the tree were studied. Mechanical properties and specific gravity varied along and across the trees. Linear relationships between specific gravity and mechanical properties were better for the outer wood than for the core wood. Core wood was weaker than outer wood. The bolts varied in properties along the tree, with a maximum in the second 2-m bolt.

Keywords: Caribbean pine, *Pinus caribeae,* specific gravity, modulus of elasticity, modulus of rupture, bending, small clears, core wood, juvenile wood.

BACKGROUND

Longwood (1962) found that Caribbean pine (*Pinus caribeae* var. *hondurensis*) wood is similar to slash pine (*Pinus elliotti* Engelm.), but is slightly superior in bending strength, cleavage resistance, stiffness, and hardness and slightly inferior in shock resistance. Perusing the papers in Plumptre (1984) indicates that Caribbean pine has more variation in mechanical properties than most conifers. The fastest diameter growth rate of Caribbean pine occurs at age 25 to 30 years (Lakhan 1976). Shand (1966) defined the Caribbean pine juvenile core as the inner portion of the stem having a specific gravity less than 0.4. Such cores averaged 6-cm diameter. This is 5 to 8 year's growth (Plumptre 1984).

INTRODUCTION

The objective of this study was to measure specific gravity and bending strength of Caribbean pine wood from a Trinidad plantation.

[1] The authors gratefully acknowledge the strength testing work for this project carried out by Jonathan Phillips and Dan Wheaton.

Caribbean pine has been planted in Trinidad to replace depleted secondary forests. Plantations are typically established on poor, sandy soils in an attempt to increase carrying capacity of the site. However, few data exist on the strength of this plantation-grown wood. Hence its utility as sawtimber and its value in improving carrying capacity are poorly known. Currently, a number of similar Caribbean pine plantations are approaching maturity. Therefore data from wood of this stand will help indicate what to expect in other stands soon ready for harvest. Since it appears that silvicultural practices may have a strong influence on Caribbean pine wood quality, this study could assist in modifying thinning schedules.

EXPERIMENTAL

Five trees were cut in 1986 from a plantation established on Trinidad in 1956. Stand soil type is classified as Planosol, represented in Trinidad by the Piarco series (Hardy 1974). The plantation has a terraced soil with restricted drainage, a south-east aspect, and slopes that range from flat to gentle. The soil is sandy with a 5-cm litter layer.

Average tree height in the stand was 28 m and diameter breast height 40 cm. After felling, naturally pruned or branch-free portions of the stems were cut, and these were further cut into contiguous 2-m bolts labelled as to tree and height. The bolts were bandsawed along the grain into 6.35-cm squares. The material left over from this sawing was, where possible, sawed into 3.18-cm squares 30.5 cm long. The 6.35-cm squares were crosscut into clear, straight-grained, defect-free 1-m lengths. The radial and tangential position of each sample within each tree was diagrammed. The green wood was dipped in a borate solution to prevent sap stain and was shipped to Fredericton in rough form.

Rough samples were kiln-dried to 10% MC using a pitch-setting schedule because of the high resin content of the wood. Dried large samples were planed to 5.1 cm square and cut to 76.2 cm long. Small samples were planed to 2.54 cm square and left 30.5 cm long. All samples were inspected for defects such as grain deviations and knots, and the position of these defects and the annual rings were diagrammed. The majority of samples tested were straight-grained and knot-free, although a small percentage (especially the larger samples) had some of these defects.

An Instron Model No. 4206 testing machine was used for bending tests according to ASTM D143 (83). For the larger samples, center loading rate was 2.5 mm/min until failure on a 710-mm span. The smaller samples were loaded at 2 mm/min. The load was applied through a loading block to the sample's tangential surface nearest the pith. Load/deflection curves were plotted by the machine.

Immediately after testing, samples were cut from the test specimen for specific gravity and MC measurements. Specific gravity based on volume at 10% MC was obtained using wax coating and water immersion. Moisture content was obtained using the oven-drying method.

Modulus of elasticity (MOE) was calculated using the slope of the linear portion of the load-deflection curve. Maximum load was used to calculate modulus of rupture (MOR).

TABLE 1. *MOE and MOR test values for Trinidad-grown Caribbean pine.*

Samples	No. of samples	Mean specific gravity	Mean MOE (MPa)	Mean MOR (MPa)	MOE %CV	MOR %CV
All	237	0.62	9,502	118	19	24
Large	103	0.60	9,044	100	21	24
Small	134	0.64	9,854	132	18	23
Outer[1]	143	0.66	9,044	139	8	15
Inner[2]	80	0.54	6,857	83	22	35
First 2-m bolt[3]	86	0.65	9,162	118	21	25
Second 2-m bolt	73	0.63	9,879	121	17	24
Third 2-m bolt	61	0.61	9,696	116	19	24
Fourth 2-m bolt	19	0.53	9,044	106	11	18

[1] Beyond the first 8 rings from the pith, large and small samples combined.
[2] Inside 8 rings from the pith, large plus small samples.
[3] Large and small samples combined for bolts. CV is coefficient of variation.

RESULTS AND DISCUSSION

The static bending results are given in Table 1. The outer wood appears denser, stiffer, and stronger than the inner wood. The smaller samples had higher mechanical properties and specific gravity than the larger samples.

The mean specific gravity appears to decrease with height in the tree. The density-height pattern is consistent with the results of Goodwin-Bailey (1982) on Caribbean pine. Another worker (Ong 1978) has found a decrease in specific gravity with tree height in some Caribbean pine trees and a constant value with height in others.

Vivekanandan and Chandrarantine (1978) and Brown (1969) found that Caribbean pine tracheid length increased from the base of the tree to 30% to 50% of the tree height and then decreased. Goodwin-Bailey (1982) found greater specific strength (strength per unit specific gravity) at 15% to 45% of the tree height. The variation in mechanical properties with height in the present study seems reasonably consistent with these previous studies.

The U.S. Forest Products Laboratory (1987) reported specific gravity and MOE and MOR in bending for wood from 14 Central American Caribbean pine trees at 12% MC. The mean wood specific gravity was much higher than that in the present study (approximately 0.76) and the MOE higher (14,000 MPa), but the MOR was similar (105 MPa). Data from other studies listed in Resch and Bastendorff (1978) have a range of specific gravities from 0.36 to 0.68, with MOE values ranging from 3,720 MPa for the lower specific gravity to 13,987 MPa for the higher and MOR values ranging from 33 MPa for the lower specific gravity to 104 MPa for the higher.

All regressions of specific gravity on MOE and MOR within groups, except for inner wood, were statistically highly significant. Regression parameters for density against MOR and MOE are given in Table 2.

The regressions indicate that the specific gravity of outer wood in the Trinidad-grown material provides a better linear-model predicter of mechanical properties than the specific gravity of the inner wood. The correlations for all samples and outer wood are similar to those found by Resch and Bastendorff (1978) for Brazilian Caribbean pine, although the regression equations are different. The Resch

TABLE 2. *Regression parameters for specific gravity against bending mechanical properties of Trinidad-grown Caribbean pine.*

Samples	No. of samples	Property	Regression intercept	Slope	Correlation coefficient (r)
All	237	MOE	−18.9	15,241	0.68
	237	MOR	−30.8	237.6	0.69
Outer[1]	143	MOE	1,982	13,775	0.72
	143	MOR	−1.7	213.6	0.84
Inner	80	MOE	5,765	2,026	0.13
	80	MOR	32.2	93.5	0.31

[1] Beyond 8 rings from the pith, large and small samples combined.
[2] Inside 8 rings from the pith, large and small samples combined.

and Bastendorff trees were younger (4 to 17 years) and inner and outer wood was not separated in the analysis.

The varying results from different samplings suggests that Caribbean pine wood properties are sensitive to growing conditions.

CONCLUSIONS

A strong relationship between specific gravity and mechanical properties was found in the outer wood from a Caribbean pine plantation grown in Trinidad, in agreement with other studies. Inner wood was weaker and more variable than outer wood. Mechanical properties increased with increasing height in the tree, reached a maximum in the second 2-m bolt, and then decreased.

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