Stephen F. Austin State University
SFA ScholarWorks

Texas Forestry Papers, No. 1-29, 1970-1976 Journals

4-1974

Texas Forestry Paper No. 25

Leonard F. Burkart
Stephen F. Austin State University

Jorge Cano-Capri
Stephen F. Austin State University

TEXAS FORESTRY PAPER

No. 25 APRIL 1974

SCHOOL OF FORESTRY

STEPHEN F. AUSTIN STATE UNIVERSITY

Nacogdoches, Texas

Tension Wood In Southern Red Oak *Quercus falcata* Michx.

by
Leonard F. Burkart[1]
and Jorge Cano-Capri[2]

Tension wood, which causes degrade in hardwood lumber and veneers, c not be readily identified in the log once a tree is cut. A basis for estimating tens wood content in standing trees could help sawmill and plywood operators pro their logs for maximum yield and quality. To establish if easily measu parameters can be used for such predictions, we have determined the amount location of tension wood in red oak trees having varying degrees of lean.

A leaning tree or a straight tree that has a one-sided or eccentric crown ca ed by prevailing winds, injury, competition or some other reason is stressed gravity and has a natural tendency to fall. To offset or react against such stres trees produce a chemically, physically, and anatomically abnormal type wood c ed "reaction wood." Tension wood, the form of reaction wood produced hardwood trees, is characterized by cells (gelatinuous fibers), with thickened walls and lower lignin-to-cellulose ratio than normal cells, that tend to pull aga the disrupting stress (8). In conifers, on the other hand, reaction to stress conditi produces compression wood, which tends to push against the stress. Compress wood is located primarily on the lower side of the lean while tension wood tend concentrate in the upper or tension side (8).

The presence of tension wood in lumber is often associated with longitud shrinkage, warping, collapse, splitting, rough or fuzzy planing, and low resista to shock. Equally deleterious effects occur in veneers and pulps. Gelatinous fiber tension wood can occur singly, in isolated groups, or in broad bands or patc within a growth ring (11).

As a rule, tension wood cannot be recognized with certainty by visual insp tion of the ends of logs. Wahlgren (11), Lassen (7), Hale (4), Koch (6), and ot

---

[1] Associate Professor, School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

[2] Former Graduate Student, School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

point out that growth ring eccentricity is an unreliable indicator of the presence of reaction wood. Sorensen and Wilson (9) found maximum tension wood on the upper side of the lean regardless of eccentricity.

Kaiser and Pillow (5) found higher concentrations of gelatinous fibers on the upper side of leaning cottonwood trees. Frequency of gelatinous fibers was highly correlated with degree of lean. Goeble (3) on the other hand, reported more tension wood in a non-leaning hickory than in the leaning trees he examined. Zanker (12) and Terrel (10), working with poplar and aspen respectively, found that frequency of gelatinous fibers increased with height in the tree.

MATERIALS AND METHODS

A 23-acre plot of typical upland mixed pine-hardwood forest in the Stephen F. Austin Experimental Forest, Nacogdoches County, Texas, was selected for the field work. All southern red oaks seven inches or greater dbh with at least sixteen feet of defect-free log below major branching were assigned to lean classes as follows: Class I, 0°-2.5°; Class II, 3.0°-6.0°; Class III, 7.0°-10.0°; and Class IV, 11.0° and greater. The degree of lean was read to the nearest 0.5° with a simple instrument consisting of a protractor with an attached plumb bob. Table 1 shows distribution of trees among these classes.

Table 1. Number and classification of red oak trees on a 23-acre plot of mixed pine-hardwood forest in East Texas.

Class	Lean (Degrees)	Trees (Number)	Percent
I	0.0- 2.5	114	53.0
II	3.0- 6.0	79	36.7
III	7.0-10.0	15	7.0
IV	11.0-greater	7	3.3

Three trees were randomly selected from each lean class and prepared for laboratory examination. The lower side of the lean was marked and the degree and direction of lean at selected heights along the trunk were recorded.

The selected trees were felled and 2-inch thick disks were cut from just above butt swell, just below major branching, and midway between these two points. The disks were stored in a freezer until examined. Each disk was measured for stem eccentricity and then divided into four quadrants relative to the lean (Fig. 1). Enough three-quarter-inch squares were randomly located and marked on each quadrant to occupy approximately 10 percent of the total cross-sectional area. The squares were then cut from the sections and prepared for microtomy.

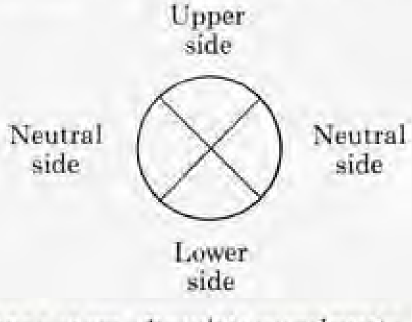

Figure 1. Cross section of tree stem showing quadrants, as related to lean direction.

Squares were softened for microtome sectioning by the triethylene glycol method described by Burkart (2). An AO Spencer 860 sliding microtome was used to cut cross sections 30 microns thick for microscope examination. The sections were stained with a 1:9 solution of Safranin-0 in water, followed by counter-staining with a four percent alcoholic solution of Fast Green. This treatment stains normal fibers bright red and gelatinous fibers blue-green.

A Leitz Orthoplan microscope fitted with a photograming eyepiece was used to define 60 observation areas on each microscope slide. Under 160x magnification, the percentage of gelatinous fibers was determined as an index to tension wood occurence in sampled tree segments.

RESULTS

Table 2 summarizes the relative frequencies of gelatinous and normal cells. Contrary to the findings of Arganbright and Bensend (1) who found the largest number of gelatinous fibers concentrated in the earlywood portions of soft maples, our study of southern red oaks found such fibers confined almost exclusively to the latewood portion of the growth rings with greatest amounts usually in the wider growth increments. No gelatinous fibers were found in the last row of latewood cells within any growth ring.

Table 2. Frequency of gelatinous fibers in relation to total fibers.

		Location with respect to lean [a,c]		
Class	Total [a,b] cross section	Upper quadrant	Neutral quadrant	Lower quadrant
	percent			
I	11.16	18.74**	11.35	3.38
II	12.04	18.71	12.05	5.37**
III	14.62	29.31**	14.21**	0.33**
IV	15.63	34.88**	12.01**	0.00**
Mean	13.36	25.41**	12.41**	2.27**

a. Averages for 3 trees and all heights within the trees.

b. Total cross section was analyzed separately. No significant difference was found between total cross sectional averages.

c. Figures not underscored by the same line were significantly different at the 5% level

** Significantly different at the 1% level. Horizontal comparisons.

Within individual growth rings, gelatinous fibers were found scattered individually, in isolated groups, in narrow and broad tangential or radial bands, and in solid patches. Bands and patches of gelatinous fibers occured most frequently in the upper sides of Class III and IV trees, although a number of solid patches were found in one Class I tree which showed an exceptionally large amount of tension wood. Individual gelatinous fibers were usually scattered more or less evenly throughout the sample section. Bands were found as tangential or radial rows of cells, often confined between the broad rays. In some extensive patches, considerable amounts of collapse were observed.

Frequency of gelatinous fibers tended to increase with increased lean, but standard "t" tests showed no significant differences between class means at the 5% level. As the degree of lean increased, the concentration and aggregation of gelatinous fibers increased in the upper quadrant and in the lower quadrant. Conversely, with decreasing lean, the distribution of such fibers became uniformly scattered throughout the entire tree cross section. Though the total number of gelatinous fibers did not significantly increase with increasing lean, the concentration in the upper side increased and that in the lower side decreased significantly. No significant differences were found between means of the neutral sides.

CONCLUSIONS

Only 10 percent of the red oak trees on the study area fell into Classes III or IV, the upper sides of which contained 29 to 34 percent tension wood fibers. Such leaning trees are usually not harvested or if harvested produce lumber, furniture blanks, or veneer of low or cull grade. Trees in Classes I and II, in which gelatinous fibers are more uniformly distributed, contain few concentrations of tension wood that would degrade lumber or other products.

Grading standing southern red oak trees according to lean class and marking lean class and upper side of lean on each log should aid lumber and veneer mill operators to maximize product quality by reducing degrade due to tension wood. Class I and II logs can be processed normally for high quality products. Class III and IV logs should not be used for rotary cut veneers. The neutral and lower sides of such logs contain relatively small amounts of tension wood and could be sawn for grade in the usual manner. Lumber from the upper portion should probably be marked and segregated at the green chain for use in pallets or other products not requiring kiln drying or planing.

LITERATURE CITED

1. Arganbright, D.G. and D.W. Bensend. 1968. *Relationship of gelatinous fiber development to tree lean in soft maple.* Wood Sci. 1(1):37-40.
2. Burkart, L.F. 1968. *Triethylene glycol as a woody tissue softener in preparation for microtome sectioning.* Stain Technology. 41(5).
3. Goeble, N.B. 1960. *Tension wood and its relation to splitting in Hickory.* S.C. Agr. Exp. Sta. Bul. 480. 21 pp.
4. Hale, J.D. 1961. *Importance of compression wood and tension wood in appraising wood quality.* Can. Dept. of For. Bul. 0-186. 7 pp.
5. Kaiser, M. and M.Y. Pillow. 1955. *Tension wood in eastern cottonwood.* Central States For. Exp. Sta. Tech. Paper No. 149.
6. Koch, C.B. 1968. *The nature of tension wood in black cherry.* W.V. Univ. Agr. Exp. Sta. Bul. 561. 14 pp.
7. Lassen, L.E. 1959. *Tension wood in cottonwood.* For. Prod. Jour. 9(3):116-120.
8. Pahshin, A.J. and C. deZeeuw. 1964. *Textbook of wood technology.* McGraw-Hill Book Co., Inc., New York. pp. 300-306.
9. Sorensen, W.S. and B.F. Wilson. 1964. *The position of eccentric stem growth and tension wood in leaning red oak trees.* Harvard For. Paper No. 12.
10. Terrell, B.Z. 1952. *Distribution of tension wood and its relation to longitudinal shrinkage in aspen.* U.S.D.A., For. Serv. Bul. R-1917. 25 pp.
11. Wahlgren, H.E. 1957. *Effect of tension wood in a leaning eastern cottonwood.* For. Prod. Jour. 7(6):4.
12. Zenker, R. 1968. *Tension wood percent and fiber length in the stemwood of different poplar varieties.* Translated from Faserforshung und Textiltechnik, Vol. 19.