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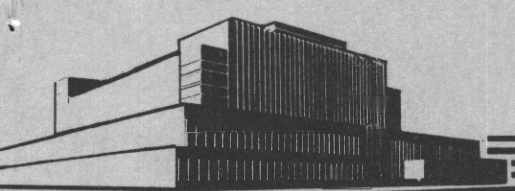

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UNITED STATES DEPARTMENT OF AGRICULTURE
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SIGNIFICANCE OF TENSION WOOD IN FURNITURE CUTTINGS OF RED OAK

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Abstract

A high percentage of the red oak lumber from southern Illinois contains some tension wood, but the occurrence of tension wood in rough lumber cannot be determined reliably by visible characteristics. Examination of furniture cuttings of red oak indicates that warping associated with tension wood does not appear to be as serious a problem as expected. These conclusions, however, apply only to red oak from southern Illinois and may not hold for other species.

Introduction

Most of the research done on tension wood has dealt with its physical and mechanical properties. For example, much evidence has been found that indicates tension wood has, in most instances, lower than average strength properties (2, 3),[2] and will shrink far more longitudinally than normal wood (1, 4, 5). Such information is valuable in determining the causes of various reactions in hardwood lumber and veneer, such as warp and machining difficulties. It does not, however, indicate the degree to which tension wood might disrupt a manufacturing process.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Underlined numbers in parentheses refer to Literature Cited at the end of this report.

For this reason, a pilot study was designed to obtain quantitative data on tension wood as a possible cause of degrade in red oak furniture cuttings. Information of this kind would be useful to industry only if tension wood could be readily and easily detected. The selection of study material was based, therefore, on the visually recognizable characteristics of tension wood.

The degrading effect of tension wood on the furniture cuttings was considered from the standpoint of warp, which reflects the high longitudinal shrinkage of tension wood.

Information was also obtained on the reliability of visual methods of detecting tension wood in rough boards and on how frequently tension wood occurs.

Characteristics of Tension Wood

Gelatinous fibers found in tension wood exaggerate the expansion and contraction of wood with changes in moisture content, particularly in the longitudinal direction. Excessively high longitudinal shrinkage (over 0.3 percent) is characteristic of tension wood. When gelatinous fibers are so located within a piece of wood that their longitudinal stresses are not restrained by surrounding areas of normal fibers, these unbalanced stresses result in warping.

In some instances, tension wood can be identified visually in lumber and veneer by areas of silvery sheen and by fuzzy surfaces. Fuzzy surfaces are caused by gelatinous fibers that have been torn and pulled rather than cut during machining. Some species, such as cottonwood, are more prone to react this way than oak.

Initial Classification Procedure

Approximately 3,200 board feet of No. 1 Common rough, four-quarter-inch red oak boards were selected from over 10,000 board feet of bright, partially air-dried, straight-grained material at a sawmill in southern Illinois. This sample was composed of five nominal width classes, 6 to 10 inches.

Each width class contained the same volume of lumber. Half of the boards displayed visible features of tension wood, and half were without visible tension wood. Board lengths were matched for each of the tension wood and normal wood categories within each width class. The visible characteristics used to classify each board were the presence or absence of bands of fibers with a silvery sheen, or fuzzy projecting fibers indicative of tension wood areas. The selected material was carefully kiln dried to a 6 percent moisture content prior to processing.

From the kiln, the tension wood areas of each board in the tension wood category were diagrammed on paper. All the boards were then skip dressed on the poor face, and furniture cuttings of nine sizes were laid out for maximum yield (fig. 1). The cuttings were clear one face and two edges and were combinations of 20-, 30-, and 40-inch lengths with 1-1/2-, 2-1/4-, and 3-inch widths. The rough cuttings were dressed to prescribed thickness and width on a moulder.

Upon completion of machining, all cuttings were examined for defects and warp. Regardless of its length, a piece was considered unacceptable if an edge crooked, or its face bowed one-sixteenth inch or more from a straight line (fig. 2). The number of warped cuttings from boards originally classified as tension wood or normal wood provided the basis for the first analysis of the effect of tension wood on warping degrade. The effect of cutting size on warping was also studied.

Analysis of First Examination

In the first examination, the ratio of warped to straight cuttings was compared for cuttings taken from boards with and without visible tension wood. On the basis of chi-square distribution tests, cuttings from boards with tension wood showed a significantly higher percentage (7 percent) of warp than did those taken from normal boards (5 percent). These classifications into tension wood and normal wood were made on the basis of the original board designation and not upon examination of the individual cuttings (table 1).

Among cuttings of several sizes, the longer, narrower cuttings, as expected, had the highest percentage of warp. The number of warped pieces increased with length of cutting from less than 1 percent of the 20-inch-long cuttings to an average of over 14 percent of the 40-inch-long cuttings (table 1). The rate of increase in warping with increasing length was approximately the same for cuttings from boards of both tension wood and normal wood. The total percentage of warped cuttings, however, was greater from tension wood boards than from boards of normal wood. Changes with increasing length are to be expected, since a 1/16-inch deviation represents much less warp in a 40-inch-long cutting than in a 20-inch long cutting.

The effect of cutting width on warp is difficult to assess. Grouping all cuttings into three width classes helps to illustrate that warping seems to change little with width. The percentage of warped pieces does increase, however, with decreasing width in the 40-inch-length class. These trends were similar in cuttings from both tension wood and normal wood.

Supplemental Classification Procedure

During the first examination of the cuttings for warp, it was noted that many of the cuttings from boards originally classified as normal wood actually contained appreciable amounts of tension wood. Therefore, four months after the first examination, the cuttings were re-examined and reclassified. The reclassification into tension wood or normal wood was made on the basis of the visible features of each cutting without regard to the original classification of the board from which it came. The data obtained from this reclassification, based on the visible features of individual cuttings, gave more realistic information about the effect of tension wood on warping. It also demonstrated the inadequacy of the original classification of rough red oak boards into normal wood or tension wood on the basis of visible surface features.

Analysis of Second Examination

The second examination revealed that most of the cuttings, including those taken from boards in the original normal wood category, contained tension wood (table 2). Almost 82 percent of all cuttings showed evidence of tension wood. In fact, only 7 boards out of the 440 selected for the study produced all cuttings free of visible indications of tension wood (table 3) (fig. 3). The basis on which the first analysis was made was therefore inadequate for about half of the boards.

Although the boards originally classed as normal wood produced more cuttings free from tension wood (27 percent) than did those classed as tension wood (10 percent), the second examination showed that the boards originally classed as normal wood contained many more cuttings with tension wood than without. When the individual cuttings were classed as either tension wood or normal wood, irrespective of the original classification of the boards, 9.65 percent of the normal wood cuttings were warped while the amount of warped tension wood cuttings was only 5.89 percent. But, it should be remembered that the percentage of warped cuttings without tension wood is based on a sample about one-fourth as large as that for tension wood.

Discussion of Results

Tension wood was much more prevalent than expected in the 10,000 board feet of lumber from which the study boards were selected. Approximately 50 percent of the boards examined had visible tension wood. From further analysis of the boards classified as normal wood, an even higher percentage occurrence of tension wood was indicated. Although the source of the sample lumber was limited, these results indicate that a very high percentage of red oak lumber from southern Illinois may contain some tension wood.

Visual inspection apparently is accurate enough to detect only the more obvious concentrations of gelatinous fibers in rough-sawn red oak boards. When indications of tension wood are visible, there is no question as to its presence, but lack of visible signs does not preclude its presence.

It is apparent from this study that present visual means of identifying tension wood in red oak lumber are inadequate from the standpoint of using them as a grading criterion.

Warping associated with tension wood does not appear to be as much of a problem as expected in red oak, since only 6 percent of the tension wood cuttings were warped. Furthermore, normal cuttings warped more, percentagewise, than did tension wood cuttings. A possible explanation for this may be the presence in cuttings classified as normal wood, of undetected gelatinous fibers that are responsible for unbalanced stresses. Since visible indications of gelatinous fibers were found in 82 percent of the cuttings (table 2), it seems plausible that there might be undetected gelatinous fibers in the 18 percent classified as normal cuttings. It may be, since tension wood was so extensively distributed, that areas of normal fibers with their low longitudinal shrinkage indirectly led to warping trouble.

The findings in this study apply only to red oak from a particular geographical area. Other species, such as cottonwood, that are known to warp violently and show surfacing defects may present a different picture. They have a much different wood structure, and tension wood is easily identified.

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Table 1.--Amounts of warped cuttings from boards classified as with or without tension wood

Cutting size	Cuttings from normal wood			Cuttings from tension wood			All cuttings		
	Total cuttings	No. warped	Percent warped	Total cuttings	No. warped	Percent warped	Grand total	No. warped	Percent warped
In.	No.			No.			No.		
1-1/2 x 40	115	17	14.78	107	22	20.56	222	39	17.57
2-1/4 x 40	190	19	10.00	159	28	17.61	349	47	13.47
3 x 40	398	46	11.56	405	64	15.80	803	110	13.70
1-1/2 x 30	113	2	1.77	119	6	5.04	232	8	3.45
2-1/4 x 30	174	7	4.02	161	10	6.21	335	17	5.07
3 x 30	302	11	3.64	346	15	4.34	648	26	4.01
1-1/2 x 20	197	0	.00	186	1	.54	383	1	.26
2-1/4 x 20	218	1	.46	183	0	.00	401	1	.25
3 x 20	284	1	.35	322	1	.31	606	2	.33
All sizes	1,991	104	5.22	1,988	147	7.39	3,979	251	6.31

Table 2.--Occurrence of warp in cuttings classified as with or without tension wood

Cutting size	Cuttings from normal wood			Cuttings from tension wood			All cuttings		
	Total cuttings	No. warped	Percent warped	Total cuttings	No. warped	Percent warped	Grand total [1]	No. warped	Percent warped
In.	No.			No.			No.		
1-1/2 x 40	55	8	14.55	136	31	22.79	191	39	20.42
2-1/4 x 40	80	16	20.00	238	31	13.03	318	47	14.78
3 x 40	167	31	18.56	557	79	14.18	724	110	15.19
1-1/2 x 30	54	2	3.70	172	6	3.49	226	8	3.54
2-1/4 x 30	61	5	8.20	262	12	4.58	323	17	5.26
3 x 30	104	7	6.73	525	19	3.62	629	26	4.13
1-1/2 x 20	69	0	.00	313	1	.32	382	1	.26
2-1/4 x 20	59	0	.00	341	1	.29	400	1	.25
3 x 20	76	1	1.32	529	1	.19	605	2	.33
All sizes	725	70	9.65	3,073	181	5.89	3,798	251	6.61

[1] Grand total excludes cuttings not acceptable because of inherent defects.

Table 3.--Tension wood in red oak boards as determined by visual examination of cuttings from the boards

Original classification of rough boards by width class	Boards with normal wood in all cuttings	Boards with tension wood in some cuttings	Boards with tension wood in all cuttings	Total boards
6-inch normal wood	3	30	22	55
6-inch tension wood	0	17	38	55
7-inch normal wood	0	34	13	47
7-inch tension wood	0	14	33	47
8-inch normal wood	3	28	17	48
8-inch tension wood	1	19	28	48
9-inch normal wood	0	29	8	37
9-inch tension wood	0	21	16	37
10-inch normal wood	0	25	8	33
10-inch tension wood	0	9	24	33
Total	7	226	207	440

Figure 1.--Laying out cuttings on poor face of red oak board.

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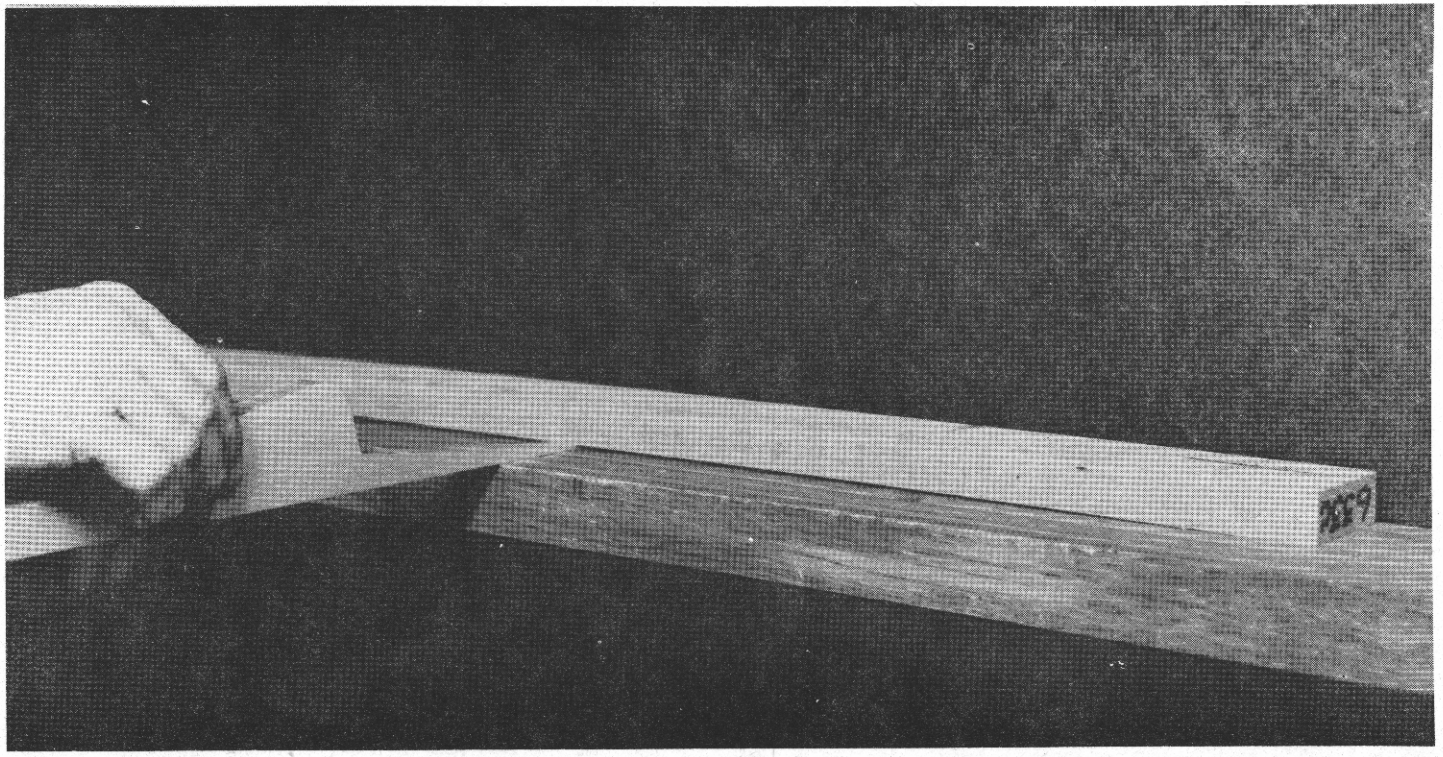

Figure 2.--Measuring warp of cutting with a taper gage.

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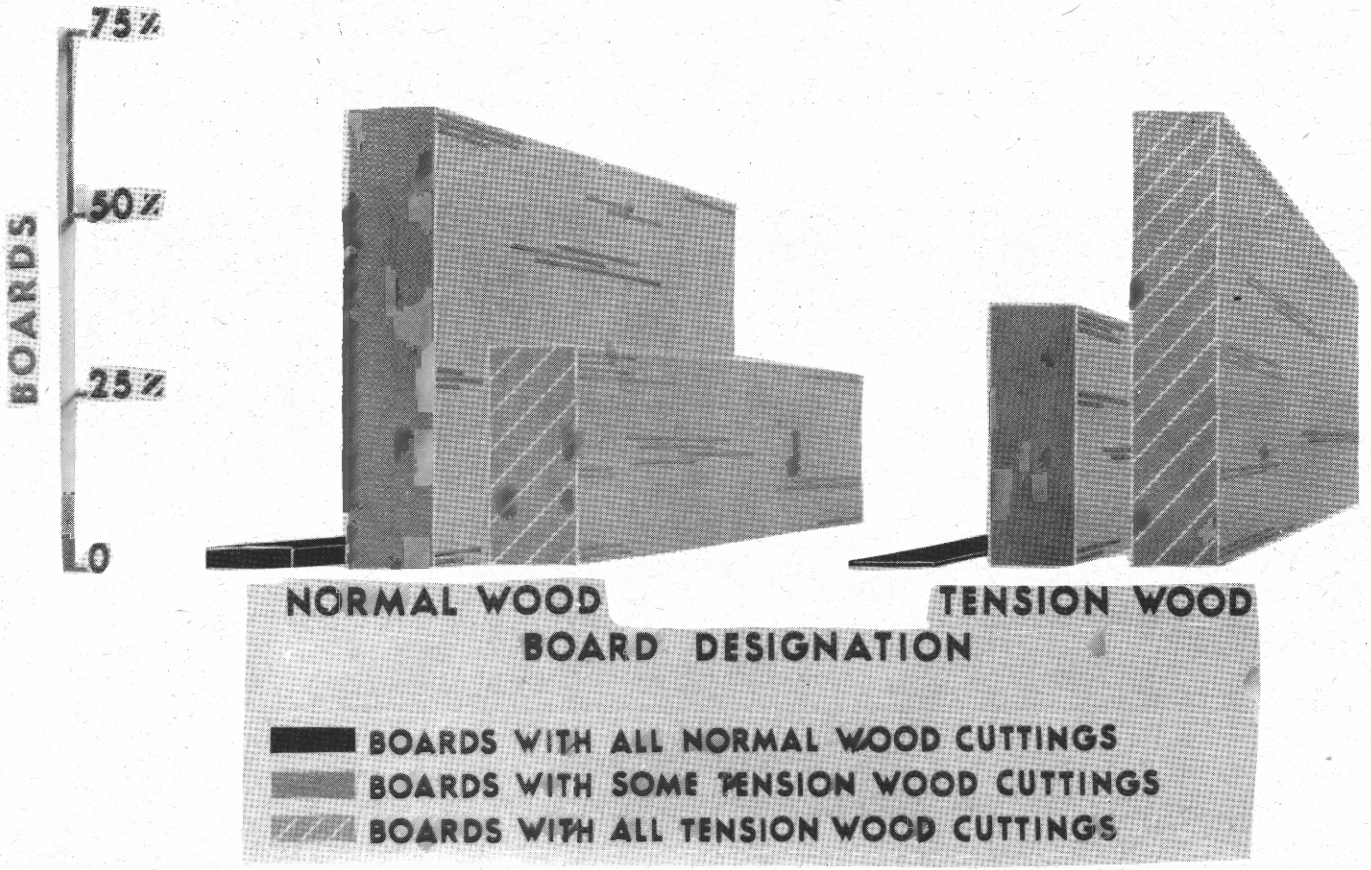

Figure 3.--Board distribution according to cutting classification.

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