

NONDESTRUCTIVE EVALUATION OF GREEN DEFECT-PRONE RED OAK LUMBER: A PILOT STUDY

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ABSTRACT

Honeycomb and surface checks are lumber drying defects that can go undetected and result in considerable losses during further processing of the lumber into products. This paper summarizes results of a pilot study designed to investigate use of ultrasonic nondestructive evaluation (NDE) techniques to identify sections of green lumber that would form honeycomb and surface checks during drying. A series of 1-1/4-inch- (31.75-mm-) thick, green red oak specimens were evaluated using ultrasonic through transmission NDE techniques. The specimens were then dried. A strong relationship was observed between excessively lengthy sound transmission times in the green lumber and the occurrence of honeycomb and surface checks after the lumber was dried.

a test set-up that was appropriate for use in an industrial environment at a local lumber-drying operation. This technical note summarizes the pilot study and the results obtained.

MATERIALS AND METHODS

Fifty 1-1/4-inch- (31.75 -mm-) thick red oak lumber (green) specimens were randomly selected from the Webster Lumber Company in Bangor, Wis. Width of the specimens varied (Table 1).

Lumber drying is a critical step in manufacturing hardwood lumber, especially when considering opportunities to improve recovery and reduce both de-grade and unnecessary expense. De-grade in the form of honeycomb and surface checks can be severe in oak lumber and a major source of value loss and waste. For example, the Hardwood Research Council estimates that as a result of wetwood-related drying defects in oak lumber, losses can total as much as 500×10^6 board feet (nominal 1.2×10^6 m³) per year and cost as much as \$25

million per year (John A. Pitcher, former director (now retired), Hardwood Research Council, personal communication, 1991).

The USDA Forest Service, Forest Products Laboratory, has been investigating nondestructive evaluation (NDE) techniques that might be used to identify defect-prone lumber prior to drying.^{1,2,3} Results of these studies have revealed that speed-of-sound transmission perpendicular to the grain is sensitive to the presence of defect-prone wetwood in red oak lumber. These studies focused on the development of fundamental relationships using laboratory test methods.

As a follow-up to our laboratory research, we conducted a pilot study with

Sound transmission times across the width of the specimens were measured using the prototype NDE set-up we developed to locate honeycomb in dried lumber.⁴ The set-up consists of two 84 kHz rolling transducers coupled to an ultrasonic transmitter and receiver unit. The rolling transducers were a key component of the set-up. Use of this type of sensor would be essential in a mill environment in order to use the technique on the line at production speeds. Transmission times were measured at 6-inch (152.4-mm) increments along the length of the specimens, displayed by the unit, and recorded manually.

The lumber was then dried in a commercial dry kiln using a mild schedule. After drying, 1/4-inch (6.4-mm) cross sections were cut from the specimens at

¹Ross, R. J., J.C. Ward, and A. TenWolde. 1992. Identifying bacterially infected oak by stress wave nondestructive evaluation. FPL-RP-512. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.

²Ross, R. J., J.C. Ward, and A. TenWolde. 1994. Stress wave nondestructive evaluation of wetwood. Forest Prod. J. 44(7/8):79-83.

³Verkasalo, E., R.J. Ross, A. TenWolde, and R.L. Youngs. 1993. Properties related to drying defects in red oak wetwood. FPL-RP-516. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.

⁴Fuller, J. J., R.J. Ross, and J.R. Dramm. 1995. Nondestructive evaluation of honeycomb and surface checks in red oak lumber. Forest Prod. J. 45(5):42-44.

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TABLE 1. — Width of specimens used in this study.

No. of specimens	Width (in.) ^a
18	5.5 to 6.0
7	>6.0 to 7.0
22	>7.0 to 8.0
3	>8.0 to 9.0

^a 1 inch = 25.4 mm.

points where sound transmission measurements were made. These sections were then visually examined to determine if honeycomb or surface checks were present. A comparison was then made between sound transmission times and the presence of honeycomb or surface checks. Based on previous laboratory results,² we expected that cross sections with sound transmission times of 400 microseconds/foot (1 ft. = 0.3m) or greater would tend to develop honeycomb or surface checks; those with values less than 400 microseconds/foot would not develop drying defects.

RESULTS AND DISCUSSION

A summary of sound transmission times from the green specimens and results of the visual inspection of the corresponding dry cross sections is shown in Table 2. As shown, 82 percent of the specimens having sound transmission greater than 400 microseconds/foot contained honeycomb or surface checks. Nearly 77 percent of the sections with sound transmission times less than 400 microseconds/foot were free of drying defects.

It was also enlightening to examine the sound transmission time variation along the length of an individual board and the corresponding cross sections.

TABLE 2. — Summary of results showing number of cross sections containing honeycomb or surface checks and corresponding sound wave transit times.

Sound transmission time (microseconds/foot)	Number of cross sections	
	Containing honeycomb or surface checks	Free of honeycomb or surface checks
>400	51 (82%)	11 (18%)
<400	117 (23%)	386 (77%)

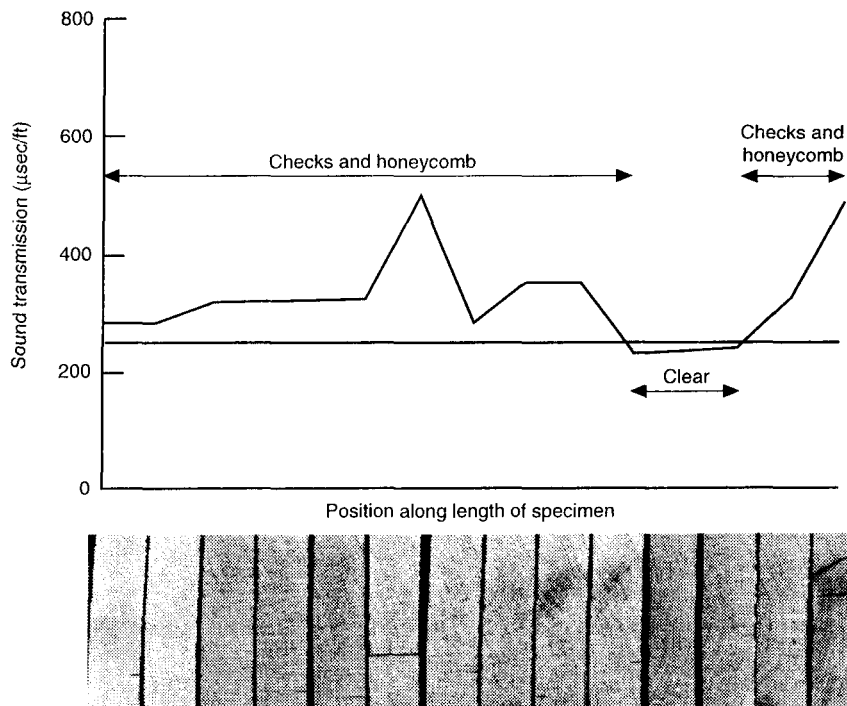


Figure 1. — Typical data obtained for a specimen.

As illustrated in Figure 1, the presence of defect-prone material resulted in a large increase in sound transmission time. Growth-related defects, such as knots, resulted in a small and localized increase in transmission time.

These results indicate that speed of sound perpendicular to the grain can be used to locate defect-prone sections of red oak lumber. Future research in this area will focus on using this technology to develop new dry kiln schedules.