

# **A stress-wave-based approach to nondestructive evaluation of logs for assessing potential veneer quality using small-diameter ponderosa pine**

*Robert J. Ross*

*Susan W. Willits*

*William von Segen*

*Terry Black*

*Brian K. Brashaw*

*Roy F. Pellerin*

## **Abstract**

Longitudinal stress-wave nondestructive evaluation techniques have been used in a variety of applications in the forest products industry. Recently it has been shown that they can significantly aid in the assessment of log quality, particularly when used to predict performance of structural lumber obtained from a log.

The purpose of the research described in this report was to investigate the use of stress-wave-

based techniques for assessing the potential quality of veneer obtained from logs. Several ponderosa pine logs were nondestructively evaluated using longitudinal stress-wave techniques. They were then rotary peeled, and the resulting veneer dried and ultrasonically graded using commercially available grading equipment. The quality of the veneer, as determined by ultrasonic grading, was then compared with the nondestructive measurements of the logs from which they came. A strong relationship was found to exist between log and veneer non-destructive assessments.

## **Introduction**

Historically, the wood products community has used nondestructive evaluation (NDE) techniques almost exclusively to sort or grade structural products. Two excellent examples of the use of nonvisual NDE techniques are machine

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### **Ross:**

USDA Forest Serv., Forest Prod. Lab., Madison, Wisconsin.

### **Willits, von Segen, Black:**

USDA Forest Serv., Washington, D.C.

### **Brashaw:**

Univ. of Minnesota, Duluth, Minnesota.

### **Pellerin:**

Washington State Univ., Pullman, Washington.

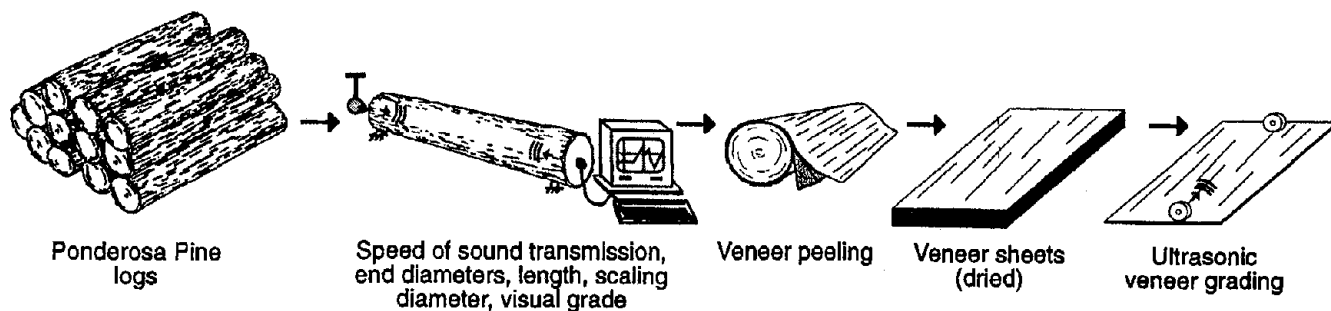


Figure 1.—Schematic of phases of the study.

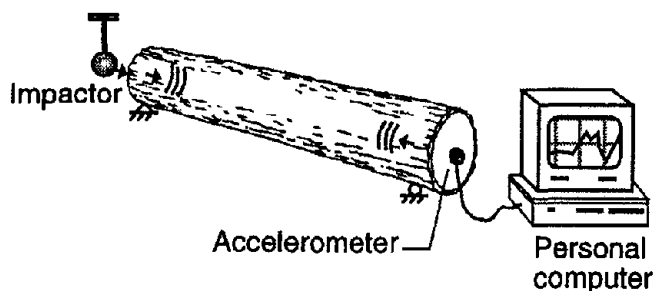


Figure 2.—Experimental test setup.

stress rating (MSR) of lumber and ultrasonic veneer grading in laminated veneer material production. As currently practiced in North America, MSR couples visual sorting criteria with nondestructive measurements of the stiffness of a piece of lumber to assign it to an established grade (3). Similarly, laminated veneer lumber production facilities use stress wave NDE techniques to sort incoming veneer into strength categories, which are established through empirical relationships between stress wave velocity and strength (8).

A series of studies has been conducted to investigate the use of longitudinal stress-wave NDE techniques to aid in log quality assessment. Aratake et al. (1) utilized longitudinal vibration characteristics to estimate the quality of lumber obtained from a small sample of Sugi logs. Galligan et al. (2) conducted a similar study with six Douglas-fir logs and were able to rank the lumber obtained from the logs, with reasonable accuracy, based on the log NDE information. Ross et al. (6) examined the relationship between log NDE measurements and the quality of lumber obtained from balsam fir and eastern spruce logs. They observed useful relationships,

with that for eastern spruce logs being exceptionally strong. Green and Ross (4) described the results from a series of studies using the same technique with Douglas-fir, western hemlock, and southern pine logs in which comparable results were obtained.

The objective of the research reported herein was to investigate the use of longitudinal stress-wave NDE techniques to evaluate log quality based on the potential structural quality obtained from them. Specific objectives were to:

- determine if a relationship exists between log NDE measurements and the quality of veneer obtained from them; and
- examine the strength of that relationship.

### Materials and methods

A schematic outlining our experiment is shown in Figure 1. Twenty-two tree-length ponderosa pine logs were evaluated at a mill yard. These logs came from trees that were growing in natural stands in southwest Oregon that were well stocked (not overly dense), with a mean tree age of 37 years. The small-end diameters of the logs ranged from 8 to 14 inches (203 to 356 mm). For each log, the longitudinal speed of sound transmission was determined using the setup shown in Figure 2. The setup consisted of an accelerometer fixed to one end of the log. A stress wave was introduced to the specimen through a hammer impact on the opposite end, and the resulting stress wave was recorded using a personal computer. A detailed description of the instrumentation and analysis procedures is given by Ross et al. (5), and a discussion of its application to large wood specimens is included in Schad et al. (7).

The tree length logs were then bucked into 8.5-foot- (2.59-m-) long veneer blocks. Stress-wave NDE data was taken on each of the 62

short logs. End diameter, length, and scaling diameter were determined for each log. The logs were then rotary peeled into 0.1-inch- (2.54-mm-) thick veneer, which was then dried. Special care was taken to ensure that individual veneer sheets could be traced to the log from which they were peeled. Each full veneer sheet was then evaluated nondestructively in a commercially available veneer grader. Average veneer NDE values for each log were then compared with log NDE values. Specifically, we compared the speed at which a stress wave traveled in a log with speeds from corresponding veneer sheets.

### Results and discussion

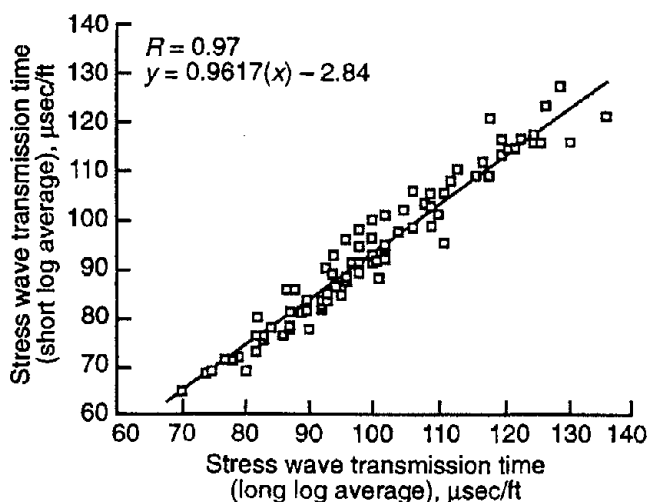
Moisture content values for the logs ranged from 46 to 190 percent. The average moisture content for the logs was 110 percent.

Statistical analyses were conducted to compare NDE values for tree length logs, short logs, and corresponding veneer NDE values. Specifically, sound transmission times (calculated on a per length basis) were compared for tree length and short logs, tree length logs and veneer, and short logs and veneer. Results obtained from those analyses are summarized in Table 1. Note the strong relationship between tree length and short log NDE measurements. More importantly, note that strong relationships were observed between either log NDE measurement or those NDE measurements for veneer obtained from the logs. This reveals that it would be possible to utilize log NDE assessments to accurately estimate the potential quality of veneer that would be obtained from a given log. Figures 3 through 5 illustrate the relationships we obtained.

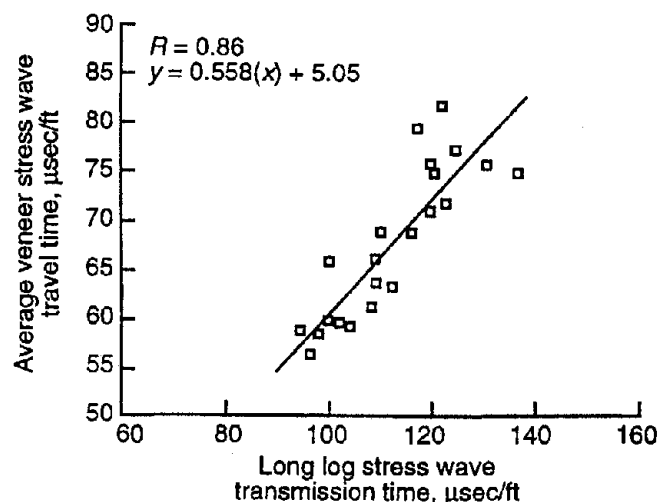
**Table 1.**—Results of statistical analyses.<sup>a</sup>

Comparison	Regression equation	Correlation coefficient ( <i>r</i> )	Coefficient of determination ( <i>r</i> <sup>2</sup> )
Short log average transmission time ( <i>SL</i> ) compared with long log transmission time ( <i>LL</i> )	$SL = 0.9617(LL) - 2.84$	0.97	0.94
Average veneer transmission time ( <i>VN</i> ) compared with long log transmission time ( <i>LL</i> )	$VN = 0.558(LL) + 5.05$	0.86	0.74
Average veneer transmission time ( <i>VN</i> ) compared with short log transmission time ( <i>SL</i> )	$VN = 0.708(SL) - 7.45$	0.87	0.76

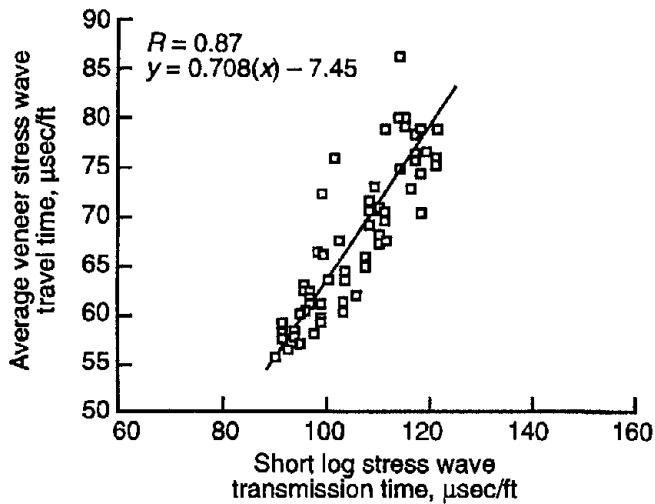
<sup>a</sup> All transmission times are expressed as  $\mu\text{sec./ft.}$



**Figure 3.**—Comparison of tree length and short log NDE measurements.



**Figure 4.**—Comparison of NDE measurements made on tree length logs and veneer obtained from them.



**Figure 5.**—Comparison of NDE measurements made on short logs and veneer obtained from them.

### Conclusions

1. For ponderosa pine logs, an excellent relationship exists between NDE measurements made on tree length logs and NDE measurements made on short logs obtained from them.
2. Sound transmission times obtained from both tree length and short logs strongly correlate to comparable measurements made on veneer obtained from the logs.

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