A STRESS WAVE BASED APPROACH TO NDE OF LOGS FOR ASSESSING POTENTIAL VENEER QUALITY. PART 1. SMALL-DIAMETER PONDEROSA PINE

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ABSTRACT

Longitudinal stress wave nondestructive evaluation (NDE) 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 they are 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. Sixty-two ponderosa pine veneer blocks from 22 tree-length logs were nondestructively evaluated using longitudinal stress wave techniques. Stress wave transmission times were measured on both tree-length logs and veneer blocks. They were then rotary peeled, and the resulting veneer was 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 nondestructive assessments.

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 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 or stiffness (8).

A series of studies has been conducted to investigate use of longitudinal stress wave NDE techniques to aid in log quality assessment. Perhaps the earliest reported results were those by Galligan et al. (2). They 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. The pace of the research has accelerated in recent years. Aratake et al. (1) utilized longitudinal vibration characteristics to estimate the quality of lumber obtained from a small sample of Sugi logs. 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 the relationship being exceptionally strong for eastern spruce logs. Green and Ross (4) described the results from a series of studies using the same technique with Douglas-fir, western hemlock, and southern pine

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TABLE 1. – Results of statistical analyses.[a]

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

[a] All transmission times are expressed as µsec./ft.: 1 µsec./ft. = 3.28 µsec./m.

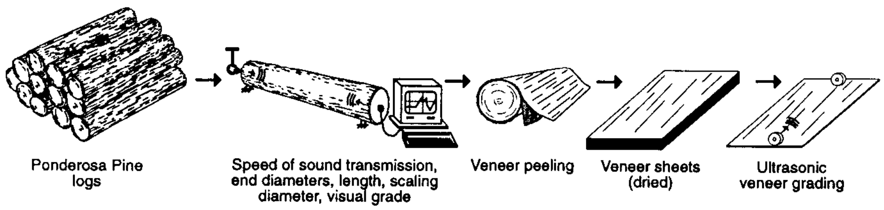

Figure 1. – Flowchart of study.

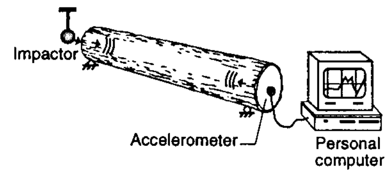

Figure 2. – Experimental test setup.

logs. Note that all these studies yielded similar results.

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 the log. Specific objectives were to 1) determine if a relationship exists between log NDE measurements and the quality of veneer obtained from the log; and 2) 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 203 to 356 mm (8 to 14 in.). For each log, longitudinal speed of sound transmission was determined using the setup shown in **Figure 2.** An accelerometer was 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 can be found in a previous article (5) and a discussion of its application to large wood specimens is included in a publication by Schad et al. (7).

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

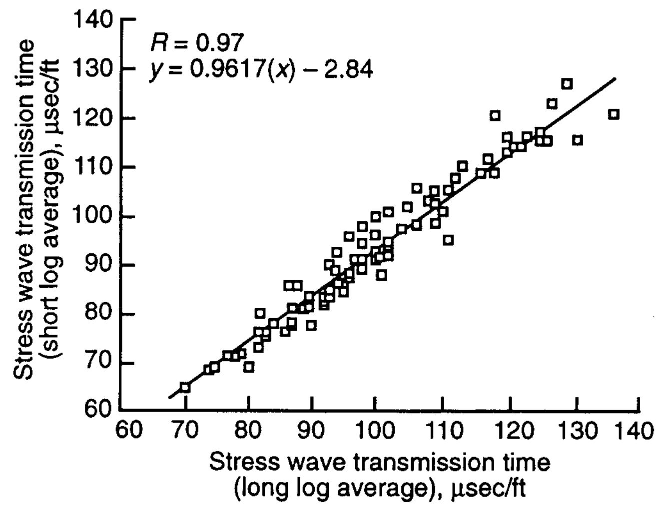

Figure 3. – Comparison of tree-length and short log stress wave transmission times.

length, and scaling diameter were determined for each log. No attempt was made to analyze the anatomical characteristics of the logs. Note that because we focused on investigating the relationship between transmission times in logs and the veneer obtained from them, we did not weigh the logs. In addition, no adjustments were made for moisture content (MC) of the logs. The logs were then rotary peeled into 2.54-mm- (0.1-in.-) 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. In these machines, individual veneer sheets are fed through opposing ultrasonic rolling transducers that send and receive a wave that travels through the veneer along its length. The time it takes the wave to travel between the transducers is then determined. Average veneer transmission times for each log were then compared with corresponding log values.

RESULTS AND DISCUSSION

MC values for the logs ranged from 46 to 190 percent. The average MC for the logs was 110 percent.

Regression 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-

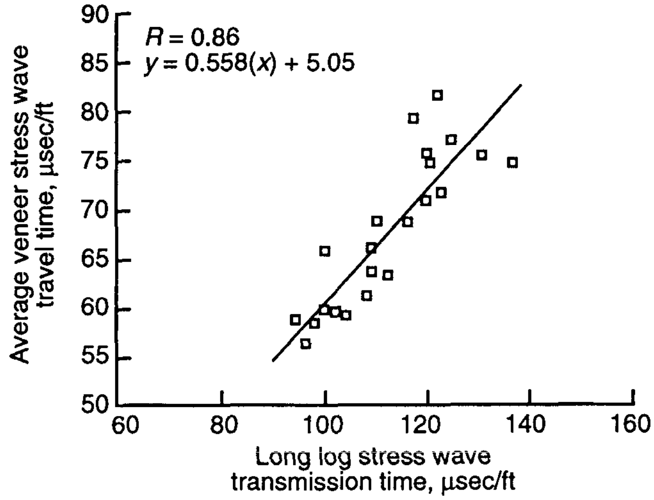

Figure 4. – Comparison of stress wave transmission times for tree-length logs and those for the veneer obtained from them.

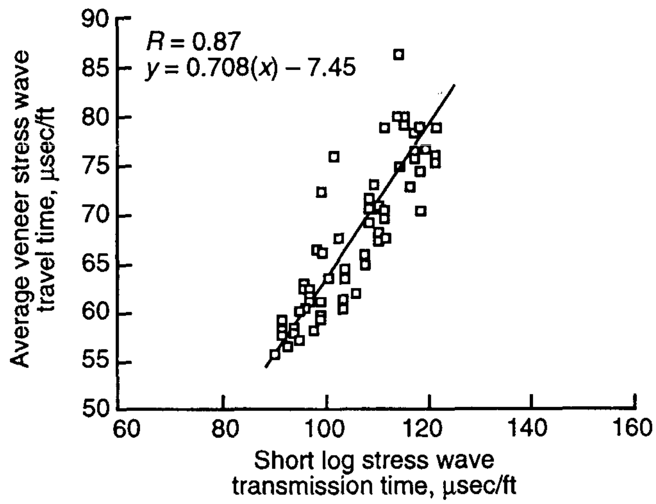

Figure 5. – Comparison of stress wave transmission times for short logs and those for the veneer obtained from them.

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 that was found between tree-length and short log transmission times. More importantly, note that strong relationships were observed between either log transmission times and those for veneer obtained from the logs. This reveals that it would be possible to utilize log transmission times 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.

These results are encouraging. Although not discussed in this report, we collected data on the quality of veneer as a function of position within the stem and cross section. For this report, we made no attempt to isolate or quantify the relative volume of veneer, and its corresponding transmission times, and its relationship to log stress wave transmission time. As a consequence, we expect that stronger correlative relationships might be found if a volume weighting by sector of the log was employed. We believe that these results do, however, indicate that a measurement of the transmission time in a log would be useful as a sorting tool for logs that are to be used for producing structural products, including laminated veneer lumber.

Future work will be aimed at refining our analysis procedures and examining relationships between gross anatomical characteristics, stress wave transmission behavior, and veneer quality.

CONCLUSIONS

Based on our results, we conclude the following:

- For ponderosa pine logs, an excellent relationship exists between stress wave transmission times in tree-length logs and corresponding times observed for short logs obtained from them.
- Stress wave 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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