Acoustic Evaluation of Warp Potential in Small-Diameter Ponderosa Pine Trees and Logs

Xiping Wang, Research Associate\textsuperscript{1,2}
William T. Simpson, Forest Products Technologist\textsuperscript{1}
Crystal L. Pilon, General Engineer\textsuperscript{1}

\textsuperscript{1} USDA Forest Service, Forest Products Laboratory, Madison, WI
\textsuperscript{2} Natural Resources Research Institute, University of Minnesota, Duluth, MN
Objective

Can stress wave analysis of trees help us predict the warp potential of lumber?

- Test trees with stress wave analysis
- Test logs with stress wave analysis
- Test lumber with stress wave analysis
- Kiln dry lumber
- Evaluate defects and measure warp of dried lumber
Site Information

Boise National Forest, Idaho

Ponderosa pine
## Kiln Drying Schedule

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Dry-bulb temperature (°F)</th>
<th>Wet-bulb temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-24</td>
<td>160</td>
<td>140</td>
</tr>
<tr>
<td>24-36</td>
<td>165</td>
<td>140</td>
</tr>
<tr>
<td>36-60</td>
<td>170</td>
<td>140</td>
</tr>
<tr>
<td>Equalize to 12% EMC</td>
<td>170</td>
<td>160</td>
</tr>
</tbody>
</table>
Warp Measurement

Bow

Crook, Twist

Crook

Twist
Comparison of stress wave speeds of trees vs. lumber and trees vs. logs (ft/s)

- Trees vs. Lumber:
  \[ y = 0.4993x + 2071.7 \]
  \[ R^2 = 0.7824 \]

- Trees vs. Logs:
  \[ y = 0.449x + 1890.6 \]
  \[ R^2 = 0.4683 \]
Results

- Separate tree and log data into different classes based on acoustic velocities
- Compare acoustic velocities to average warp measurements for that particular class
## Results

<table>
<thead>
<tr>
<th>Tree acoustic group (ft/s)</th>
<th>Number of specimens in group</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 7500</td>
<td>10</td>
</tr>
<tr>
<td>7500-8500</td>
<td>10</td>
</tr>
<tr>
<td>8500-9500</td>
<td>8</td>
</tr>
<tr>
<td>9500-10500</td>
<td>7</td>
</tr>
<tr>
<td>&gt; 10500</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42</strong></td>
</tr>
</tbody>
</table>
Comparison of warp measurements to tree measurements

- Crook
- Bow
- Twist

Tree acoustic velocity (ft/s)

Warp (in.)

- Linear (Bow)
- Linear (Crook)
- Linear (Twist)
## Results

<table>
<thead>
<tr>
<th>Log acoustic group (ft/s)</th>
<th>Number of specimens in group</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5500</td>
<td>8</td>
</tr>
<tr>
<td>5500-6500</td>
<td>24</td>
</tr>
<tr>
<td>6500-7500</td>
<td>28</td>
</tr>
<tr>
<td>&gt; 7500</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>69</strong></td>
</tr>
</tbody>
</table>
Comparison of warp measurements to log measurements

- Crook
- Bow
- Twist

Warp (in.) vs. Log acoustic velocity (ft/s)
Results

- WWPA Structural Light Framing #2
  - Western Wood Products Association
  - Did any boards lose grade because they exceeded the warp limits?
Results

Trees

Logs

Twist not evaluated because very few boards exceeded the #2 grade warp limits
Conclusions

- Good correlation between tree measurements and log measurements
- Amount of warp in the form of bow and twist decreased as velocity of trees and logs increased (crook had no strong relationships with stress wave speed)
- Analysis of standing timber and logs can possibly be used to predict warp potential of lumber
Questions?