New Wood Quality Tools
To Effectively Segregate
Logs and Lumber

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Contents

• Tools for stiffness in forest, yard and mill
• How the tools work
• Results and values
• Conclusions

New tools for measuring stiffness

• Full range of tools now available to measure stiffness
• Manage quality from forest to MSG, VSG, or LVL product
Hand tools for field application

New development – processor head tool
Monitor LM600 – automated log tool

- Test 100% of logs
- Longitudinal or transverse chain
- Continuous operation
- Sort logs for batch processing
- Alter processing to maximise MSG or veneer out-turn

SM400 – new automated board tool

- Combination of acoustic velocity and green density
HM200, LM600, SM400 – how they work

- Stiffness = density x (velocity)^2
- Velocity is derived from resonant frequency (2nd harmonic) and length
- Sensor/microphone detects frequency from hammer blow
- Green density is relatively constant

Director ST300, and PH330 – how they work

- ’Time of flight’ outerwood velocity measure – higher than log measure
- Ruggedised, waterproof, wireless, auto-distance, audible and visual output, interface to PDA
- Velocity correlates strongly with log velocity at stand level
Results

- Tools progressively developed and released
- Many trials undertaken in NZ, Australia and North America
- Tools predict stiffness (MoE) across all species tested
- Measured and managed process improves MSG yields

Results

- Excellent prediction of high strength LVL yields
Results

- High level of interest in other properties
  - Strong correlations with microfibril angle, longitudinal shrinkage, and distortion

Verified Visual Grading

- Consultation and introduction in 2006
- Director Index offers a guide to absolute stiffness (E value) from standing trees or green log velocity measures
- Stiffness = density x (velocity)²
- Adjustments required for
  - Green density and moisture content
  - Increase in stiffness from 30% moisture content to ‘dry’
- DI-8 is indicative of VSG8 production and would require
  - Average log velocity 2.8km/sec (allowing 0.1 for SE of mean)
  - Green density 1000kg/m³
  - Moisture content 150%
- DI-8 target velocity could vary 2.60 - 2.90
- Sample of boards must meet grade specs
Revision to Standards

Characteristic stresses for visually graded timber (GPa)

1. Moisture condition – Dry (m/c = 16%).

<table>
<thead>
<tr>
<th>Species</th>
<th>Grade</th>
<th>Bending Strength $f_b$</th>
<th>Compression Strength $f_c$</th>
<th>Tension Strength $f_t$</th>
<th>Modulus of Elasticity $E$ (GPa)</th>
<th>Lower Bound Modulus of Elasticity $E_{lb}$ (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiata Pine &amp; Douglas Fir</td>
<td>VSG10</td>
<td>20.0</td>
<td>20.0</td>
<td>8.0</td>
<td>10.0</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>VSG8</td>
<td>14.0</td>
<td>18.0</td>
<td>6.0</td>
<td>8.0</td>
<td>5.4</td>
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<tr>
<td></td>
<td>No.1 Framing</td>
<td>10.0</td>
<td>15.0</td>
<td>4.0</td>
<td>6.5</td>
<td>4.0</td>
</tr>
</tbody>
</table>

2. Moisture condition – Green (m/c = 25%)

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<tr>
<th>Species</th>
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<tbody>
<tr>
<td>Radiata Pine &amp; Douglas Fir</td>
<td>VSG10'</td>
<td>11.7</td>
<td>12.0</td>
<td>4.0</td>
<td>6.5</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>VSG8'</td>
<td>11.7</td>
<td>12.0</td>
<td>4.0</td>
<td>6.5</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>No.1 Framing</td>
<td>7.5</td>
<td>11.0</td>
<td>3.0</td>
<td>4.8</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Buying based on velocity delivers profit

- At NZ$100 price differential between ‘VSG8’ and ‘No.2’, extra value ranges $10 - $30/t log (for structural proportion sawn 20-70%)
  - If all stands will not make VSG8, but 60% of stands will, selecting only DI-8 stands will benefit $0.45m/annum
  - If insufficient DI-8 stands available, but 70% of logs within stands are DI-8, benefit for sorting is $0.73m/annum (50,000 t mill)
Results – effect of temperature on velocity

In general
• Acoustic velocity increases with lower temperature
But
• Rate of change not well defined
• Moisture content changes may compensate on logs, but not in trees

Results – boards and beams

• Acoustic velocity on green or dry boards also correlates well with dry board MoE
• Addition of density improves radiata pine correlation from 0.92 to 0.98, and D fir from 0.86 to 0.96
• SM400 tool segregates green boards
Results – log velocity within stem – butt to top

- Acoustic velocity varies from butt to top although greatest variation is between stems
- Highest velocity logs are in mid section of stem
- Variation follows pattern of microfibril angle

Source: X Wang et al, University of Minnesota

Results – log velocity within stem – pith to bark

Average stiffness of lumber cut from some 60 trees. Note the low stiffness at the base of the tree, in the butt logs.

Why not cut a short, 2.5 m butt log?

Average stiffness of wood in boards up the stems

Ping Xu, 2002
Results – velocity and MoE correlate with age

In general
- Acoustic velocity increases with increasing age

But
- Other factors affect velocity and MoE
- Wide range of velocities within stands
- Strategy - harvest highest V rather than oldest age (extra 0.06km/sec)

Standing tree sampling – single trees

- Measure is a single sample of outerwood velocity
- Sampling procedure and intensity must match need
- Single tree - intensive sampling
  - Variation around stem
  - Knot location
  - Transverse
  - Compression wood
  - Hit variability
- 3 sets of 3 hits, in each of 2-4 locations around stem
- High productivity (>60 sample sets/hour) – faster than density coring
Standing tree sampling – single trees

- Eyrewell study – radiata pine, age 28
- Correlation between standing tree and log velocity improves as sample intensity increases

<table>
<thead>
<tr>
<th>Location/s on tree</th>
<th>taps</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper side</td>
<td>3</td>
<td>0.44</td>
</tr>
<tr>
<td>Upper side</td>
<td>3</td>
<td>0.48</td>
</tr>
<tr>
<td>Upper side</td>
<td>3</td>
<td>0.43</td>
</tr>
<tr>
<td>Upper side (A)</td>
<td>9</td>
<td>0.50</td>
</tr>
<tr>
<td>Lower side (B)</td>
<td>9</td>
<td>0.45</td>
</tr>
<tr>
<td>Random side (D)</td>
<td>9</td>
<td>0.60</td>
</tr>
<tr>
<td>Mean A+B</td>
<td>18</td>
<td>0.61</td>
</tr>
<tr>
<td>Mean A+D</td>
<td>18</td>
<td>0.62</td>
</tr>
<tr>
<td>Mean A+B+D</td>
<td>27</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Standing tree sampling - stands

- More extensive sampling procedure to match need
- Stand average measure
  - Link sampling to pre-harvest assessment
  - Cover the stand – plots of 5+ trees
  - Cover diameter range
  - Variability between trees > within
  - Sample as many trees as possible in least time
- 1 set of 3 hits/tree on 35+ trees/stand
- Productivity dependent upon terrain and vegetation
Standing tree velocity

- Correlation with log measures good
- Absolute conversion varies primarily with velocity

**Data Bank - Director HM200 vs ST300 Velocities**

- Linear regression equation: \( y = 0.7965x + 469.14 \)
- \( R^2 = 0.92 \)

**Standing tree velocity**

- Green density adjustment of log measure appears useful

**Data Bank - Director HM200 (Green Density Adjusted) vs ST300 Velocities**

- Linear regression equation: \( y = 0.5887x + 2570.4 \)
- \( R^2 = 0.9624 \)
Results – sales/business benefits

• Capability to measure quality early in manufacture
  – On green boards
  – On log supply
  – On harvest planned
  – On stumpage purchased
• Capability to forecast actual mill MSG outturn (currently unknown)
• Improved ability to reliably fulfill sales orders
• Potential to lower MSG or G1 & G2 veneer costs
• Customer satisfaction and improved profitability

Conclusions

• New tools available for use in forest, yard, and mill
• Improved ability to meet orders, with higher grade out-turn and profit
• Opportunities for research and teaching across a range of disciplines – from tree breeding to wood processing
• For tools and information
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  www.fibre-gen.com