Fundamentals of Wood Anatomy: How Wood Dries

Bill Smith
SUNY ESF Syracuse
What is wood?

- Tree?
- Log?
- Boards?
- Wood as a Material?
- ???
What is wood?

- Tree?
- Log?
- Boards?
- Wood as a Material?
- **ALL OF THE ABOVE!**
Why do we dry wood?

- Remove moisture?
- Cause controlled shrinkage?
- Avoid mold and other biodeterioration?
- Reduce weight?
Why do we dry wood?

• Remove moisture?
• Cause controlled shrinkage?
• Avoid mold and other biodeterioration?
• Reduce weight?
• ALL OF THE ABOVE!
What make wood special?

• It is an anisotropic material -
  – Its characteristics and properties differ with orientation!
    • Strength, Stiffness, Shrinkage
    • Longitudinal, Tangential, Radial

• It is an hygroscopic material -
  – Dry wood has an affinity to adsorb and absorb water!
What make wood special?

• It is an heterogeneous material -
  – Different species
  – Hardwoods vs. Softwoods
  – Heartwood vs. Sapwood
  – Earlywood vs. Latewood
    • (Springwood vs. Summerwood)
  – Cell Type, Anatomy, Structure
    • fibers, tracheids, vessels, rays.
  – Density, Porosity
  – Permeability
  – WOOD ANATOMY !!
Figure 1-6—Annual growth rings. Quartersawn board (left) shows edge of annual rings on its broad face; flatsawn board (right) shows side of rings. (M 554)
Transverse Sections

Ray cell size
Tyloses in vessels

Red Oak

White Oak
Tangential Sections

Red Oak

White Oak

Ray cell size
Tyloses in vessels
What makes wood special?

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  – Density, Porosity
  – Permeability
  – **WOOD ANATOMY !!**
Several “rules” about wood:

• Dense wood shrinks more, because there is more wood material.
  – Latewood shrinks more than earlywood.

• Permeability varies with orientation; wood dries faster where permeability is greatest.
  – Longitudinal vs. transverse
  – Maple and oak shrink more than pine.
  – Radial vs. Tangential
Figure 1-5—Pit cross sections. (a) Bordered pit (with torus in softwoods); (b) simple pit; and (c) half-bordered pit. (ML88 5569)
Red Oak
Hard Maple
Red Pine
Several “rules” about wood:

• Wet wood, with “free water” present (above fiber saturation, \(~30\%MC\)) is susceptible to mold, fungi and insect attack.
• Wood (as a material) shrinks as “bound water” evaporates.
• Lumber shrinks its wood (as a material) shrinks.
**Equilibrium Moisture Content and Relative Humidity**

<table>
<thead>
<tr>
<th>RH %</th>
<th>EMC %</th>
</tr>
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<tbody>
<tr>
<td>–90</td>
<td>–20</td>
</tr>
<tr>
<td>–80</td>
<td>–16</td>
</tr>
<tr>
<td>–65</td>
<td>–12</td>
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<tr>
<td>–50</td>
<td>–9</td>
</tr>
<tr>
<td>–30</td>
<td>–6</td>
</tr>
<tr>
<td>–0</td>
<td>–0</td>
</tr>
</tbody>
</table>
RH and EMC “sorption isotherm”
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• Dense wood shrinks more, because there is more wood material.
  – Latewood shrinks more than earlywood.
  – Maple and oak shrink more than pine.

• Permeability varies with orientation; wood dries faster where permeability is greatest.
  – Longitudinal vs. transverse
  – Radial vs. Tangential
### Shrinkage - Green to 6%

<table>
<thead>
<tr>
<th></th>
<th>S.G.grn</th>
<th>Tangential</th>
<th>Radial</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Pine</td>
<td>0.34</td>
<td>4.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>0.56</td>
<td>7.9</td>
<td>3.8</td>
</tr>
</tbody>
</table>

*S.G.grn = dry weight (oven dry) / volume (green)*
A good “general rule” about tangential shrinkage

- **Softwoods**, such as white pine shrink about 5 - 6 % from green to 0% -
  – ~ 1 % / 5.5% MC change

- **Hardwoods**, such as maple and oak shrink about 8 % from green to 0% -
  – ~ 1 % / 4% MC change
Longitudinal shrinkage of wood is very small, 0.1%

- Except for juvenile wood and reaction wood (compression and tension wood)
Longitudinal shrinkage of boards is very small.

- Except for -
  - boards with juvenile wood and reaction wood (compression and tension wood)
  - boards with sloped grain (which means there is a transverse component to the longitudinal orientation.

- This is the cause of twist, bow and crook warpage!
Oval

Diamond

Cup

Point of greatest deflection
**Stiffness (bending // to grain)**

<table>
<thead>
<tr>
<th></th>
<th>S.G.grn</th>
<th>Green</th>
<th>12%MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>1,000,000 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Pine</td>
<td>0.34</td>
<td>0.99</td>
<td>1.25</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>0.56</td>
<td>1.55</td>
<td>1.83</td>
</tr>
</tbody>
</table>

*S.G.grn = dry weight (oven dry) / volume (green)*
**Strength (bending // to grain)**

<table>
<thead>
<tr>
<th>Material</th>
<th>S.G.grn</th>
<th>Green</th>
<th>12%MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Pine</td>
<td>0.34</td>
<td>4,900</td>
<td>8,600</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>0.56</td>
<td>9,400</td>
<td>15,800</td>
</tr>
</tbody>
</table>

*S.G.grn = dry weight (oven dry) / volume (green)*
## Electrical Resistance (maple)

<table>
<thead>
<tr>
<th>• MC %</th>
<th>• MegOhms</th>
</tr>
</thead>
<tbody>
<tr>
<td>– 25</td>
<td>– 0.60</td>
</tr>
<tr>
<td>– 22</td>
<td>– 1.23</td>
</tr>
<tr>
<td>– 19</td>
<td>– 3.16</td>
</tr>
<tr>
<td>– 15</td>
<td>– 16.6</td>
</tr>
<tr>
<td>– 12</td>
<td>– 105</td>
</tr>
<tr>
<td>– 10</td>
<td>– 690</td>
</tr>
<tr>
<td>– 8</td>
<td>– 13,800</td>
</tr>
<tr>
<td>– 7</td>
<td>– 72,400</td>
</tr>
</tbody>
</table>
As wood dries it shrinks,
as wood shrinks,
stresses develop.

If stresses exceed wood strength,
failures occur.
Checks, cracks, splits, honeycomb!
“Green” wood, at the beginning of drying

“Dry” wood, at the end of drying
Wood is Good!

• Strong
• Attractive
• Useful
• Economical
• But, .........
  – for almost every purpose and use, it must be dried properly!
  – That is what we do.