Drying Stress: Fundamentals

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As wood dries, (below FSP, 30%MC), it shrinks.
But remember, wood shrinks both “as a material”, and as a “board”.
i.e.- when a “board” is at 40% MC, the “shell” is already below FSP, perhaps at 16% MC.
If shrinkage is “restrained”, because the “core” is still wet, while the “shell” is drying, stresses develop.
So, as wood dries it shrinks, as wood shrinks, stresses develop.
Wood Shrinkage Varies with Orientation, Density, and Species.
White Pine
Several “rules” about wood shrinkage:

• Dense wood shrinks more, because there is more wood material.
  – Latewood shrinks more than earlywood.
  – Maple and oak shrink more than pine.

• Shrinkage varies with orientation;
  – Longitudinal vs. transverse
  – Tangential vs. Radial
    • T/R ratio ~ 2/1
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).
Wood Shrinkage

![Graph showing wood shrinkage rates for tangential and radial directions](image)
Strength and Stiffness of wood depends primarily upon Density and Moisture Content
## 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>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>

*1,000,000 psi

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

<table>
<thead>
<tr>
<th>Wood Type</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)*
So, as wood dries it shrinks, as wood shrinks, stresses develop.
Development of Drying Stresses, Early in Drying

Diagram showing the development of stresses in wood during early drying:
- Dry shell - Tension
- Wet core - Compression
- Growth rings
- Ray tissue
Development of Drying Stresses, Later in Drying

(b)

Dry shell - Compression

Dry core - Tension
Moisture Gradient during Drying
Moisture Gradient during Drying
Stress Gradient during Drying

Maximum tension in outside

Maximum compression in center

5 days 10 days 18 days
Stress Gradient during Drying

Stress reversal in outside

Maximum tension in center

Final case-hardened state

90 days 28 days 36 days 50 days
During “Stress Relief”,

• Moisture is added to the “shell” to cause it to try to swell against the core, relieving the stresses.
Stress Relief Conditioning

• High EMC and Temperature
  – Adds moisture
  – High temperature moves moisture faster
  – High temperature means wood is not as strong so stress relieve more readily.
Thank you!
Stress Relief, Application

- Equipment
- Lumber
- Millwork