Timber Just Needs To Move: Compliant Joinery and Timber Shrinkage

Paul Malko
Foard Panel
www.foardpanel.com
Presentation Rules

• Ask questions any time.

• This is a conversation, not a lecture.
Learning Environment

Northeast, mostly New England

• Long, cold, humid winters with plenty of wind driven precipitation
• Long coastline

Regional architecture
New & historic timber

• Cut & raised @ 30+% MC
• Standing @ 6% - 9% MC
Wood: The Perfect Building Material

- Plentiful
- Available
- Cost Effective
- Useful
- Strong
- Workable
- Sustainable
- Wood is so green, it grows on trees.
- Beautiful
Wood: The Perfect Building Material

- Variable, anisotropic properties
- Prone to fungus decay
- Grows wet/green - used dry
- Dimensionally variable with moisture content

Wood moves during and after construction.
Funny Shapes

tangential shrinkage
Wood shrinkage in a direction tangent to the growth rings, about double that of radial shrinkage.

radial shrinkage
Wood shrinkage perpendicular to the grain, across the growth rings.

longitudinal shrinkage
Wood shrinkage parallel to the grain, about 2% of radial shrinkage.

Quartersawn cutting
Plainsawn cutting
3-Dimensional

Transverse section

Radial direction

Tangential direction

Axial direction

Tangential section

Radial section
Moisture Content (MC)

As wood dries, shrinkage:

- is relatively stable above 30% MC
- continues linearly with MC
- stops when MC stabilizes

FPL “Wood Handbook”, Chapter 13
How Much Shrinkage?

$$\Delta D = \frac{D_i (MC_f - MC_i)}{30 \cdot 100} - 30 + MC_i$$

$\Delta D$ = Dimension Change
$D_i$ = Initial Dimension
$MC_f$ = Final MC
$MC_i$ = Initial MC
$S_T$ = Tangential Shrinkage Value

FPL “Wood Handbook”, Eq. 13-3
# Green/Initial MC

<table>
<thead>
<tr>
<th>Species</th>
<th>Green Sapwood MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Pine</td>
<td>148%</td>
</tr>
<tr>
<td>Doug. Fir</td>
<td>115%</td>
</tr>
<tr>
<td>White Oak</td>
<td>78%</td>
</tr>
</tbody>
</table>

FPL “Wood Handbook”, Table 4-1
Final MC - Indoor

FPL “Wood Handbook”, Figure 13-1
Air Drying Rate of Green Timber

- Location
- Time of year
- Species
- Timber size

FPL “Wood Handbook”, Ch. 13
Air Drying Rate of Green Timber

- Low density species (pine, spruce, soft maple, etc)
- Good climate, good time of year
- Green to 25%-30% MC
- 15 - 30 days for 1” THICK lumber

FPL “Wood Handbook”, Ch. 13
Air Drying Rate of Green Timber

- High density species (oak, sinker hemlock, etc)
- Northern locations, wrong time of year
- Green to 25%-30% MC
- 200 - 300 days for 1” THICK lumber

FPL “Wood Handbook”, Ch. 13
How much shrinkage?

\[ MC_i = \text{Initial MC} = 30\% \]
\[ MC_f = \text{Final MC} = 8\% \]
\[ S_T = \text{Tangential Shrinkage} \]

(Wood Handbook, Table 4-3)

<table>
<thead>
<tr>
<th>Species</th>
<th>( S_T )</th>
<th>% Shrinkage</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Pine</td>
<td>7.4</td>
<td>-5.4%</td>
</tr>
<tr>
<td>Doug. Fir</td>
<td>7.5</td>
<td>-5.5%</td>
</tr>
<tr>
<td>White Oak</td>
<td>10.5</td>
<td>-7.7%</td>
</tr>
</tbody>
</table>
KD Lumber?

\[ MC_i = \text{Initial MC} = 19\% \]
\[ MC_f = \text{Final MC} = 8\% \]
\[ S_T = \text{Tangential Shrinkage} \]

(Wood Handbook, Table 4-3)

<table>
<thead>
<tr>
<th>Species</th>
<th>( S_T )</th>
<th>% Shrinkage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spruce</td>
<td>7.3</td>
<td>-2.8%</td>
</tr>
<tr>
<td>Doug. Fir</td>
<td>7.5</td>
<td>-2.8%</td>
</tr>
<tr>
<td>Yellow Pine</td>
<td>7.5</td>
<td>-2.8%</td>
</tr>
</tbody>
</table>
Stacked Timber

- 6” heel DF rafter
- 12” DF deep plate
Stacked Timber

- Rafter
  \((5\text{”})\cos(34\ \text{deg})(5.5\%)\) = 0.23”

- Plate
  \((12\text{”})(5.5\%) = 0.66”\)

- Total: 0.89” = 7/8”
What To Do...

BE W/ CONT.
SECURE OSB
0.131" DIA. x
O.C. OR EQU.

3’ - 5 1/8”

CUT/INSTALL WALL PANELS SUCH THAT THERE IS A 1 1/2” GAP WHICH IS TO BE FILLED W/ A CONT. BEAD OF EXPANDING FOAM SEALANT.
Wait, what about the diaphragm connections?

- Uplift at rafters?
- Rolling load on rafter?
- Out of plane shear load on rafter?
Wait, what about the diaphragm connections?

Beveled Plate
Wait, what about the diaphragm connections?

Bevel Blocking on Plate
Rafter / Purlin Tails
Rafter / Purlin Tails
Rakes

Same scheme as eaves.
ATTACH ROOF PANELS TO TIMBER FRAME MEMBERS
W/ 18" LONG SIP FASTENERS @ 10" O.C.
OR 5 PER 4" PANEL WIDTH, TYPICAL UNLESS
OTHERWISE NOTED. REQUIRED - MIN. 2"
EMBEDDMENT INTO ALL TIMBERS.

EDGE W/ CONT.
AL. SECURE OSB
@ 0.131" DIA. x
1" O.C. OR EQU.

CUT/INSTALL WALL PANELS SUCH THAT
THERE IS A 1/2" GAP WHICH IS TO
BE FILLED W/ A CONT. BEAD OF
EXPANDING FOAM SEALANT.

13/8" EPS BLUEBOARD CLAD ROOF PANEL

3'-5/8"/

7/8" EPS BLUEBOARD CLAD WALL PANEL (R-23)

TIMBER FRAME MEMBER.

2 LAYERS OF 5/8" B
FASTENED TO STRU
SEE GENERAL DRYW
Rakes
Rakes
What About Roof Diaphragm Edges?

- 1 diaphragm or 2?
- Rolling or splitting load on fork?
- Maintain alignment to protect air sealing and roofing at ridge
What About Roof Diaphragm Edges?
What About Roof Diaphragm Edges?

- Rolling load on rafter?
- Strap over rafters can interfere with screws
What About Roof Diaphragm Edges?
What About Roof Diaphragm Edges?
Outside Corners
Inside Corners
KD 2x Shrinkage Matters
KD 2x Shrinkage Matters
Bridging the Transition
2 Types of Compliant Joinery

- One-time-use
- Cyclic
High Allowable Deflection
Pre-Engineered Steel Frames: Very High Allowable Deflections
Durability

• SIPs are tolerant of deflection
• Air sealed joinery (SIP or otherwise) is not.
Risks of Deflection
Risks of Deflection
Strength vs Stiffness
Drywall Cracks
“Shingle Ridging” everywhere
Span-wise Joints were OK
Hinge at Joints Over Rafters
Non-compliant joint design forced to comply by L/180 allowable deflection
Foard's Internal Design Standards

- Assume everything is flexible
- Assume all timber will shrink
- Ignore air sealing needs only on disposable buildings
- Start the planning conversations early
Foard's Internal Design Standards

- Embedded Materials
  - Avoid embedded KD
  - Avoid multi-ply elements
    (Lots of EWP-sized glulam)
- Wind Bracing
  - Use the frame as much as possible
  - Stiff king studs
  - Don't forget reactions
  - L/240 Live max.
Foard's Internal Design Standards

- Adding timber rafters at rakes is often cost effective
- Ridge connections are tricky
- Intersecting roof lines are even trickier
Foard's Internal Design Standards

- **Roof Panels:**
  - L/360 max. live
  - L/240 max. total

- **Wall Panels:**
  - L/240 max. live for mostly solid walls
  - L/360 max. live for badly perforated walls

- **Stiffness usually controls**