Detailing for New England: Cold, Wet, Windy, Timber, Steel, & SIPs
The Short Version

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Foard Panel
www.foardpanel.com
Experience
Northeast, mostly New England
• Long, cold, humid winters with plenty of wind driven precipitation
• Long coastline
• Regional architecture
• High performance buildings
• Hydrophobic insulation materials
Malko's Design Theorem’s

1.) Nothing is less sustainable, less efficient, or more wasteful than that which is disposable.

2.) Design is the art of compromise

3.) Design first. Build second.
Design Issues - Holistic Design

hol·is·tic

/hōˈlistik/

adjective  PHILOSOPHY

characterized by comprehension of the parts of something as intimately interconnected and explicable only by reference to the whole.
Design Issues – Holistic Design
Systems must respect each other.

Respect is Mutual

If you don’t respect their needs and experience, they won’t respect your needs and experience.
Design Issues – Holistic Design

Systems must respect each other.
But I have always done it this way!

“Builder's intuition” is based on experience. Few have deep experience with truly high performance buildings. Therefore, applying “tradesman's intuition” to high performance buildings can be risky.

However, that doesn’t mean they don’t have valuable input for finding the “easy way” to do something.
Design Issues – Water Concentration
Design Issues – Water Concentration
Design Issues – Envelope Penetrations
Design Issues – Envelope Penetrations
Engineering

Value Engineering: Only possible if you consider it early in the design process.

True Engineering: Build for a dime what any fool can build for a dollar. However, the fool will build it for a penny and tell you how nothing he has built has ever fallen down.
Malko's Engineering Theorems

1.) Physics: one science to rule them all.

2.) Prevailing weather, exposure, architecture, materials, and use vary greatly from one building to another. The best way to learn is to look statistically.

3.) All buildings will move. Not all buildings or parts of buildings move the same way at the same time.
The Causes of Movement

1.) Deflection - creep

2.) Temperature – expansion & contractions

3) Moisture – shrinkage & cracks

Each material reacts differently to deflection, temperature, and moisture.
2 Types of Compliant Joinery

- One-time-use
- Cyclic
Temperature

1.) Metals expand in heat
2.) Water expands if it gets really cold (freeze-thaw)
3.) Some plastics melt if it gets really hot
4.) Some plastics crack if it gets really cold
5.) Masonry stable, if not wet
6.) Wood is mostly stable
7.) Not all sealants & tapes work in all temperatures

Freeze-thaw cycles destroy mountains.
1.) Deflection is a measure of how much buildings move under specific loading.

2.) Building Code defines the maximum load for which buildings should be designed. Usually the 2% weather event or 100 year storm.

3.) Code deflection limits are designed for safety not air sealing and durability.
Drifting Snow Load

FIGURE 7-8 Configuration of Snow Drifts on Lower Roofs.
Unbalanced Snow Load

Balanced

Unbalanced
W ≤ 20 ft with roof rafter system

Unbalanced Other

Note: Unbalanced loads need not be considered for θ > 30.2° (7 on 12) or for θ < 2.38° (1/2 on 12).

FIGURE 7-5 Balanced and Unbalanced Snow Loads for Hip and Gable Roofs.
Risks of Deflection
Hinge at Joints Over Rafters
Non-compliant joint design forced to comply by L/180 allowable deflection
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
  - Combined Deflection <1/8” at joints

- Stiffness usually controls
Cyclic - Moves Forever
High Allowable Deflection
Pre-Engineered Steel Frames: Very High Allowable Deflections
Moisture

1.) Metals rust
2.) Masonry absorbs water (and cracks in the cold)
3.) Concrete starts wet and dries very slowly
4.) Plastics are mostly impervious
5.) Wood starts wet and shrinks significantly as it dries.
Malko's Building Science Theorems

1.) To make wood buildings last, keep the wood dry.
2.) If wood get wets, dry it before it becomes food.
3.) Stop moisture laden air on the warm side of the assembly.
4.) Do not stop liquid water from exiting the cold side of the assembly.
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.

- Green: Quartersaw cutting
- Gray: Plainsaw cutting
3-Dimensional

- Transverse section
- Radial 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?

\[ \Delta D = \frac{D_i \left( MC_f - MC_i \right)}{30 \cdot 100 S_T} - 30 + MC_i \]

- \( \Delta D \) = 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

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

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

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

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

(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: \[0.89” = 7/8”\]
CUT/INSTALL WALL PANELS SUCH THAT THERE IS A 1\(\frac{1}{2}\)" GAP WHICH IS TO BE FILLED W/ A CONT. BEAD OF EXPANDING FOAM SEALANT.

SECURE OSB 0.131" DIA. x O.C. OR EQU.

BE W/ CONT.
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?
Wait, what about the diaphragm connections?

Bevel Blocking on Plate
Rafter / Purlin Tails
Bridging the Transition
What About Roof Diaphragm Edges?
Outside Corners
KD 2x Shrinkage Matters
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

- Avoid embedded KD
- Avoid multi-ply elements
  (Lots of EWP-sized glulam)
- Wind Bracing
- Use timber frame as much as possible
- Stiff king studs
- Don't forget reactions
- L/240 Live max. or <1/8” deflection at joint
# Foard’s Air Sealing Recommendations

<table>
<thead>
<tr>
<th>Cyclic (high deflection or temperature based)</th>
<th>One time or little movement joints (timber shrinkage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Tape (on inside)</td>
<td>1) Spray foam gaps</td>
</tr>
<tr>
<td>2) Gaskets for larger gaps</td>
<td>2) Spray foam for foam to foam joints.</td>
</tr>
<tr>
<td>3) Spray foam for thermal control only</td>
<td>3) Mastic for foam to wood or wood to wood</td>
</tr>
<tr>
<td>it will not maintain an air seal.</td>
<td>4) Tape inside for all joints with wood in them.</td>
</tr>
</tbody>
</table>
Construction:
Everyone has to give a damn.