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

The Short Version

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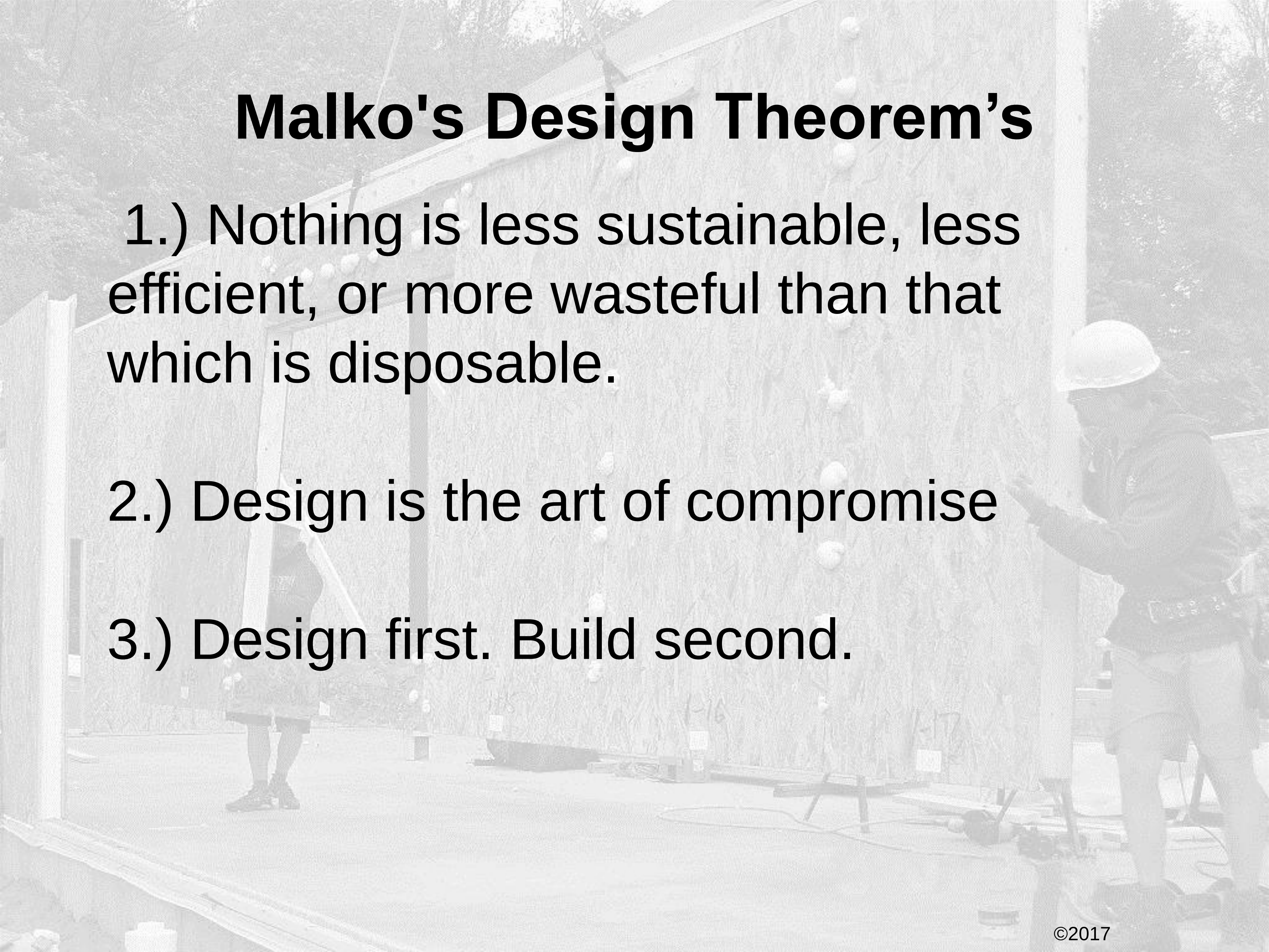
www.foardpanel.com

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

ho·lis·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!

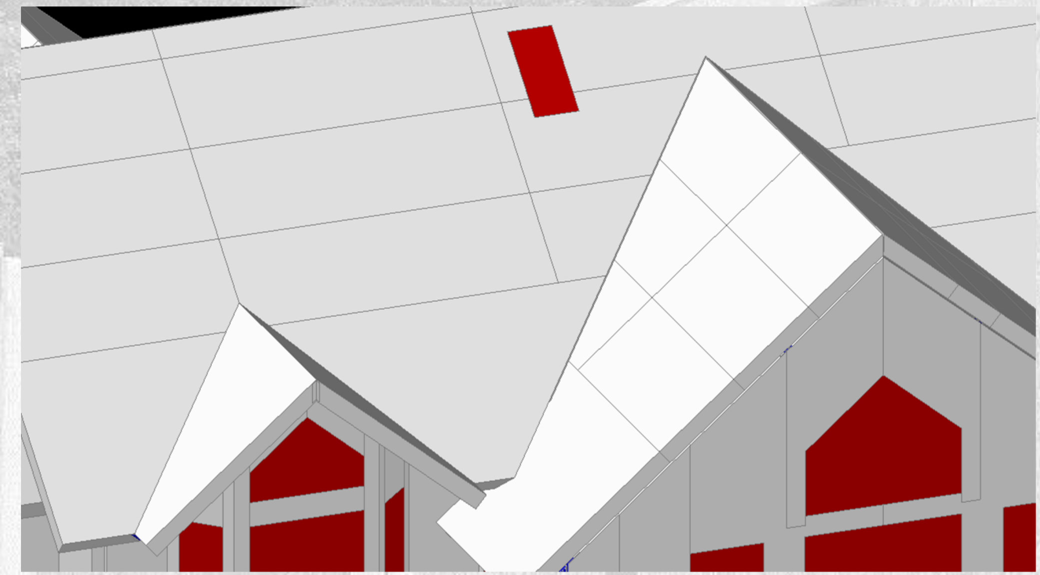
“Builder's intuition” is based on experience.

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.

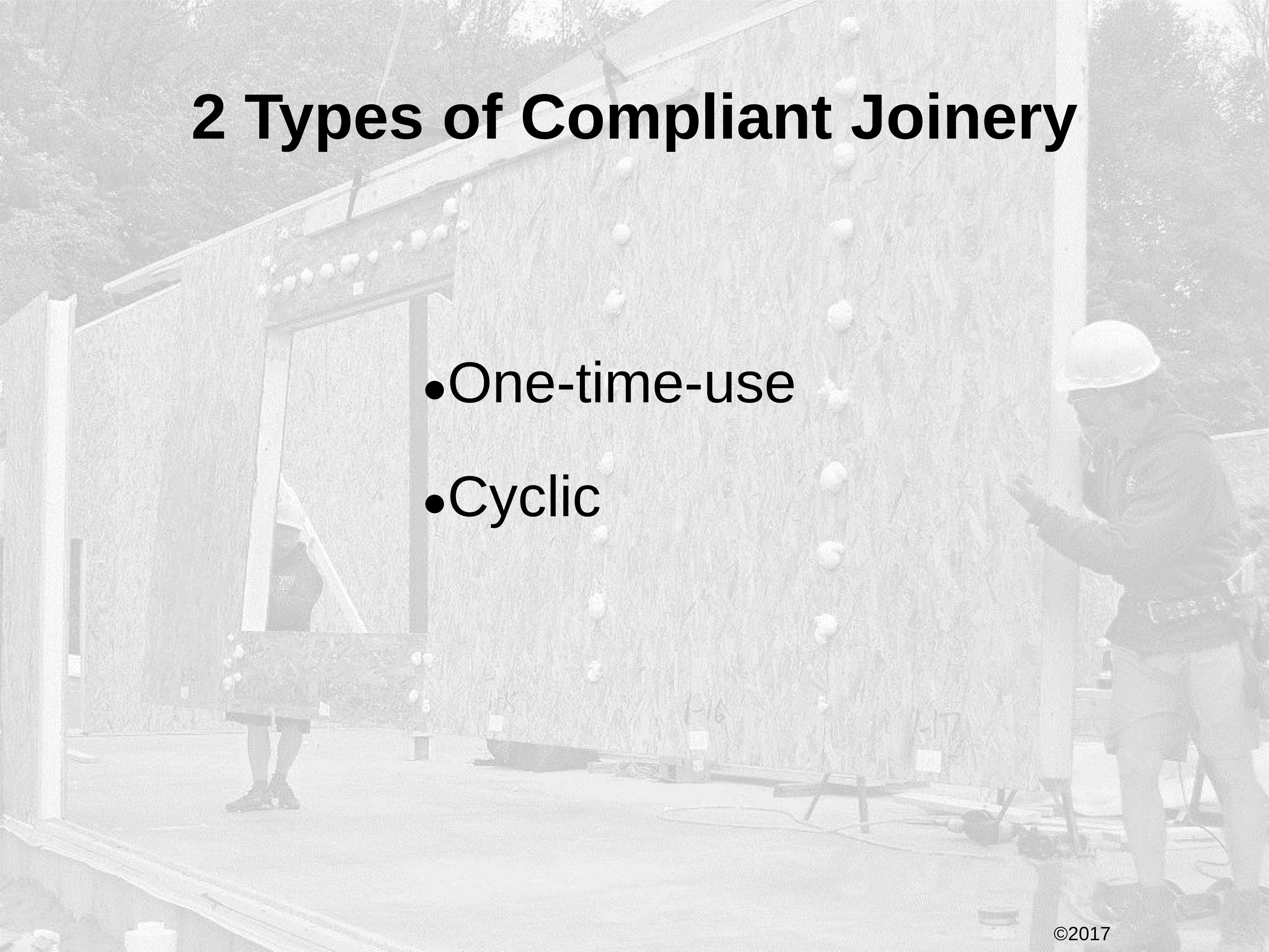
The Causes of Movement

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.

Deflection

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

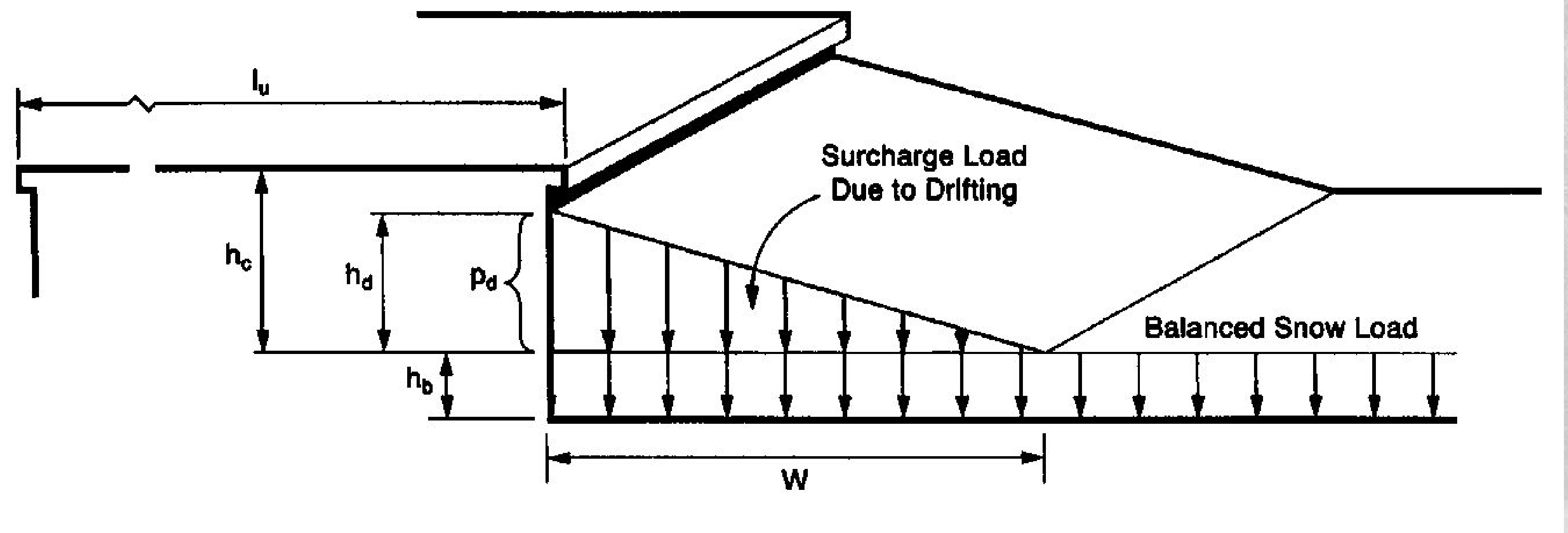


FIGURE 7-8 Configuration of Snow Drifts on Lower Roofs.

Unbalanced Snow Load

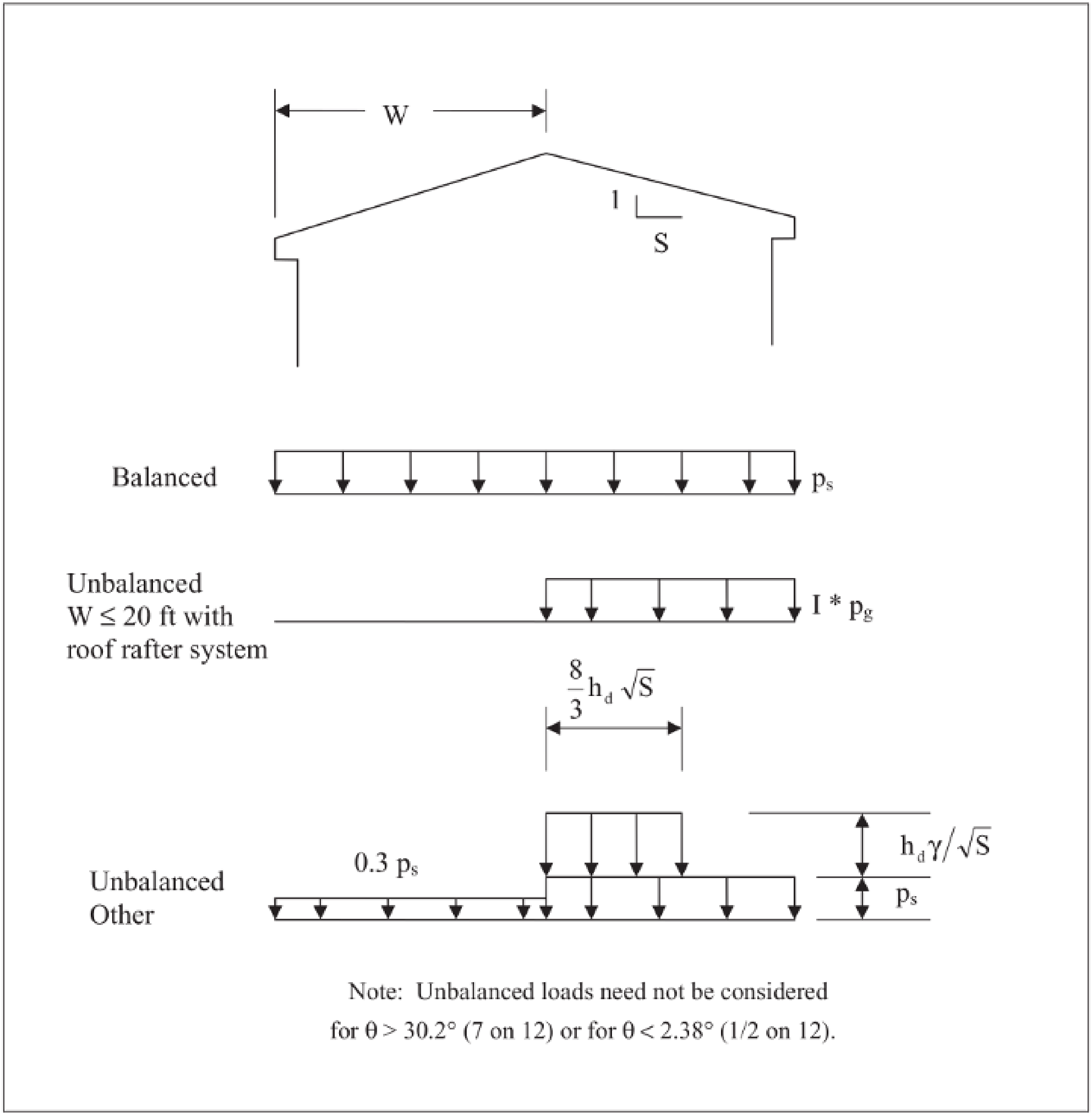


FIGURE 7-5 Balanced and Unbalanced Snow Loads for Hip and Gable Roofs.

Risks of Deflection

Hinge at Joints Over Rafters

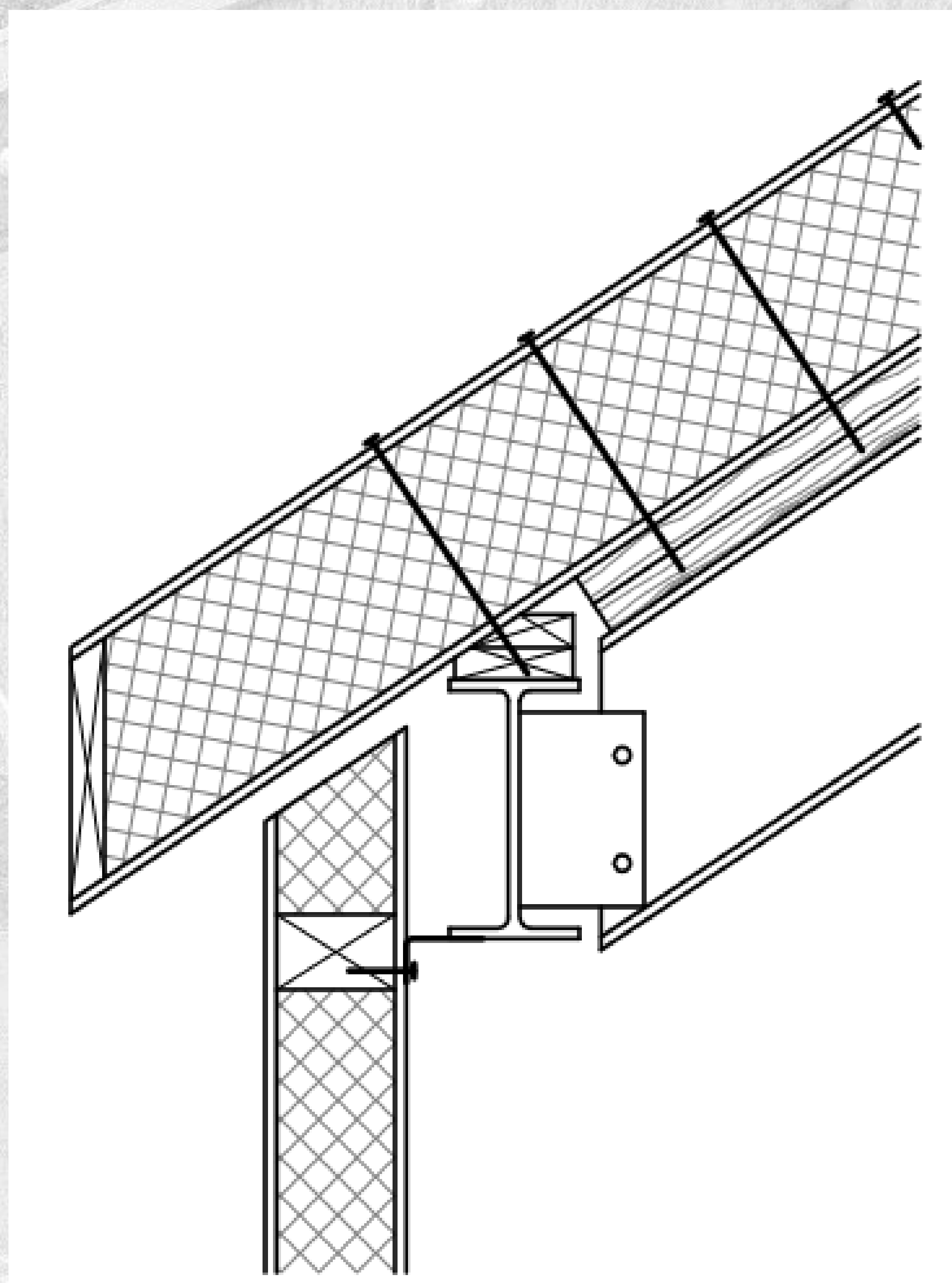
Non-compliant joint design forced to comply by L/180 allowable deflection

Foard's Internal Design Standards

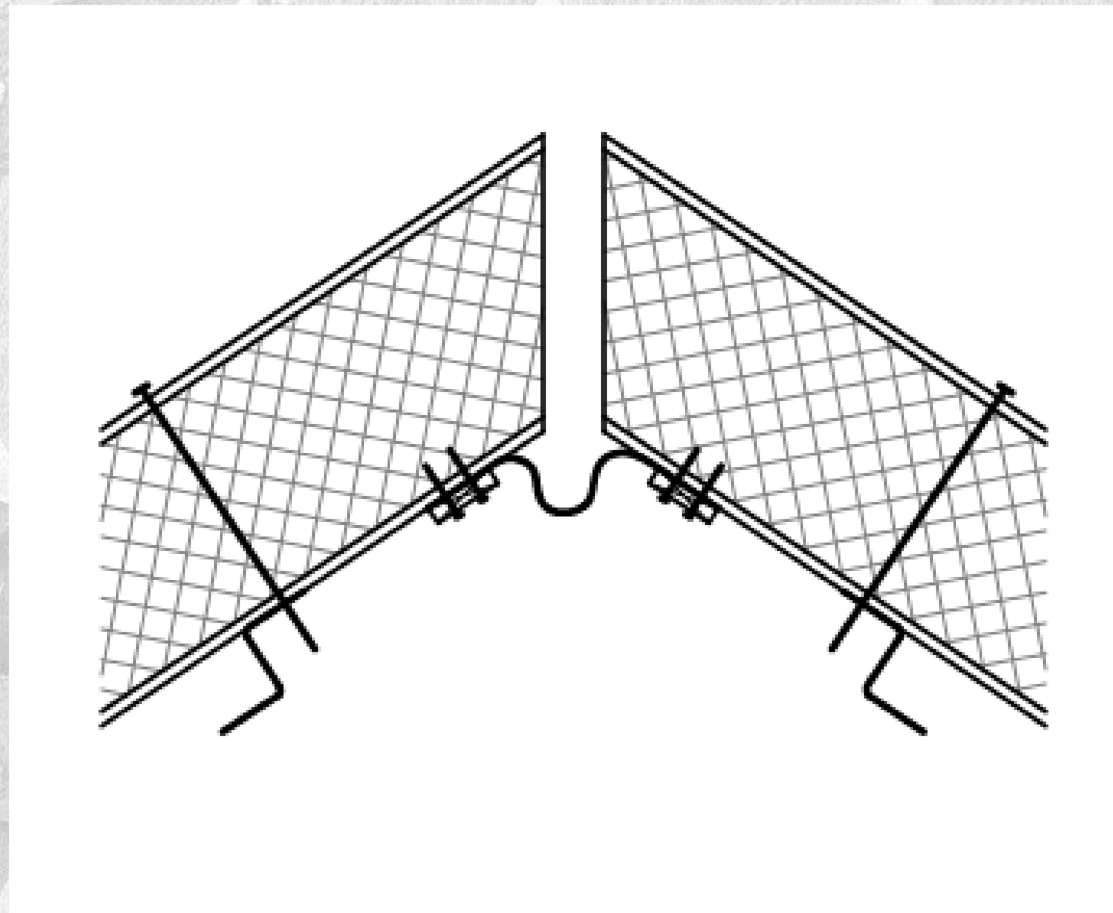
- Roof Panels:
- L/360 max. live
- L/240 max. total
- Wall Panels:
- L/240 max. live for mostly solid walls
- L/360 max. live for badly perforated walls
- Combined Deflection <1/8” at joints
- **Stiffness usually controls**

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

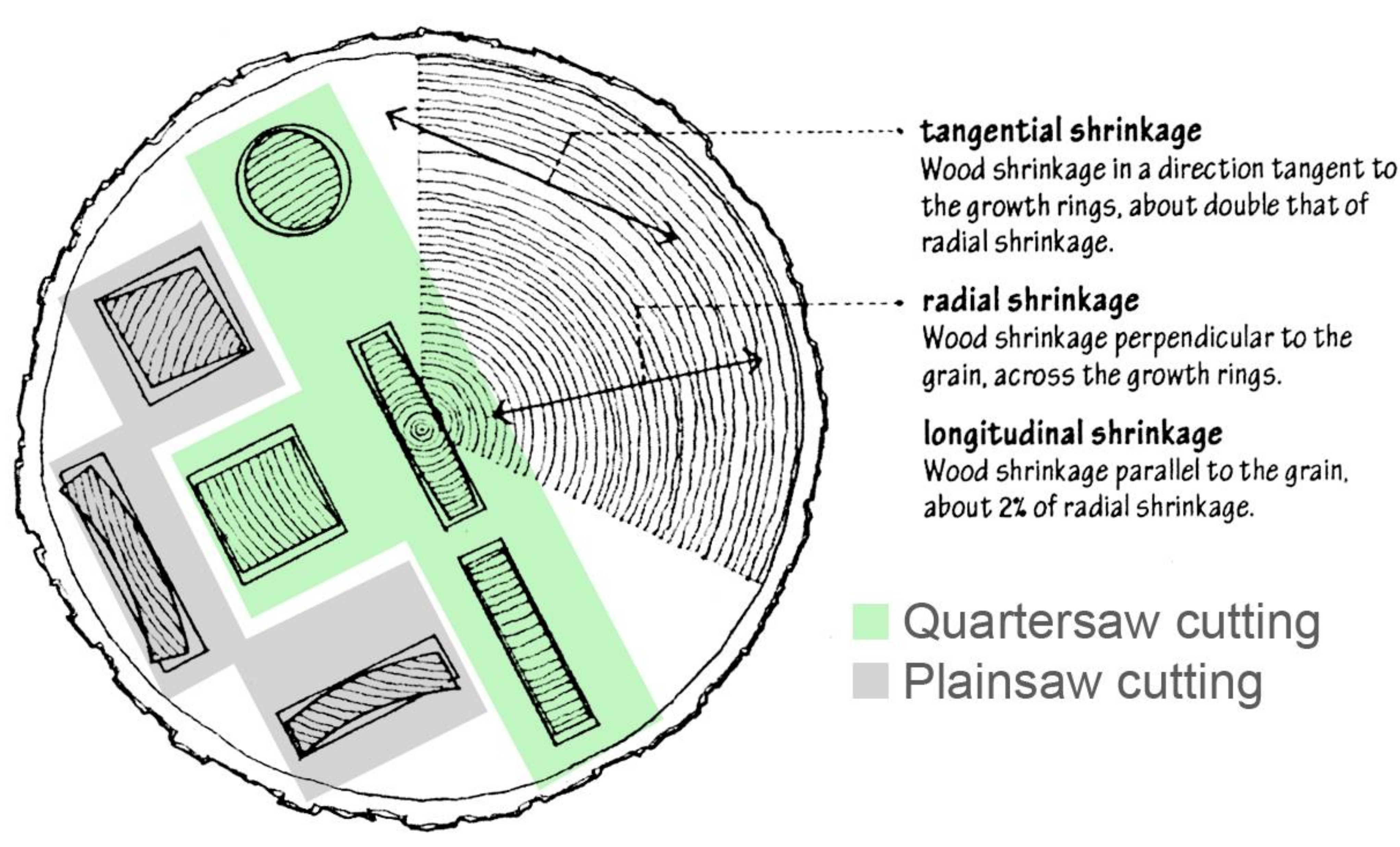
1.) To make wood buildings last, keep the wood dry.

2.) If wood get wets, dry it before it becomes food.

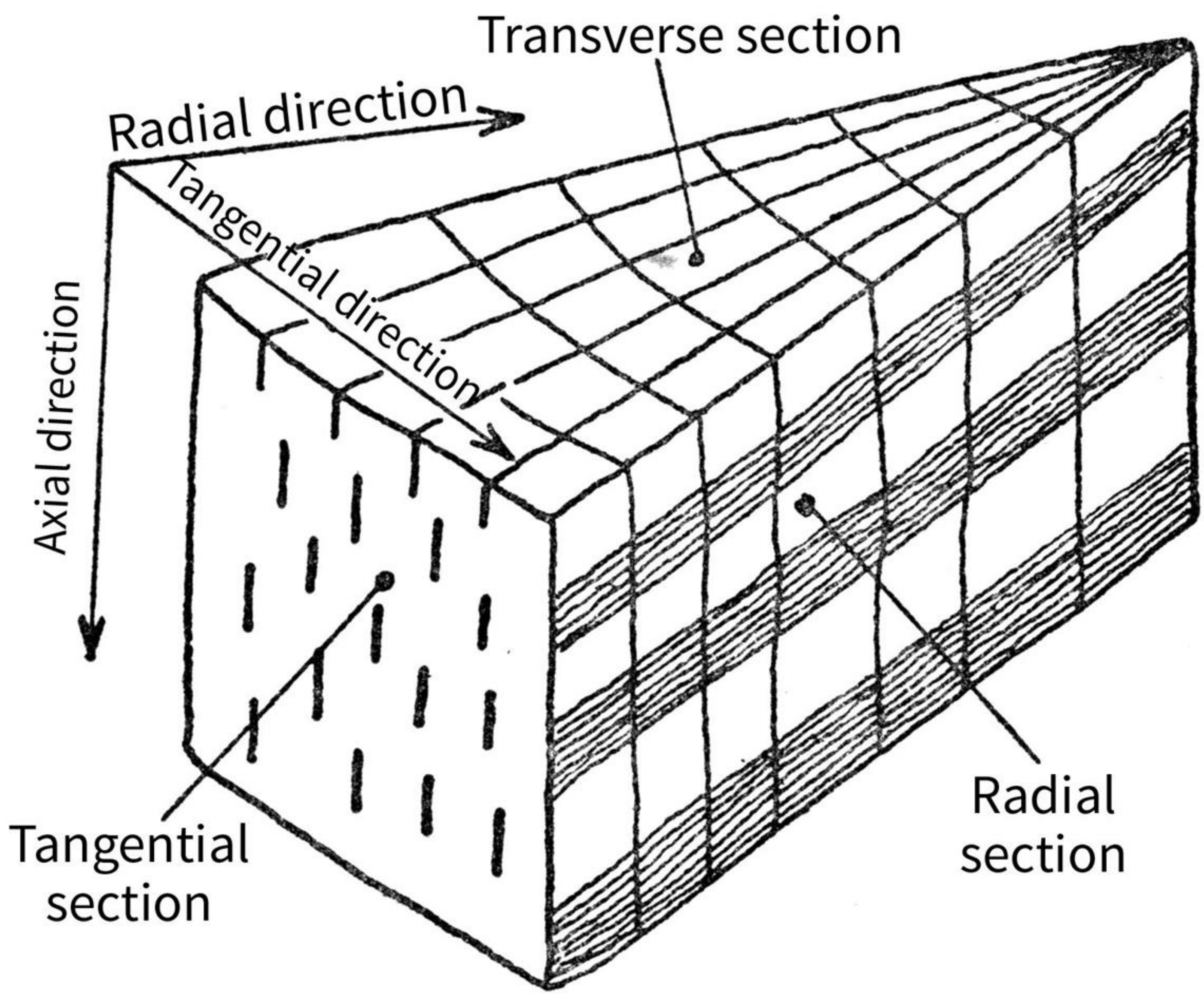
3.) Stop moisture laden air on the warm side of the assembly.

4.) Do not stop liquid water from exiting the cold side of the assembly.

Funny Shapes



3-Dimensional



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?

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

ΔD = Dimension Change
D_i = Initial Dimension
MC_f = Final MC
MC_i = Initial MC
S_T = Tangential Shrinkage Value

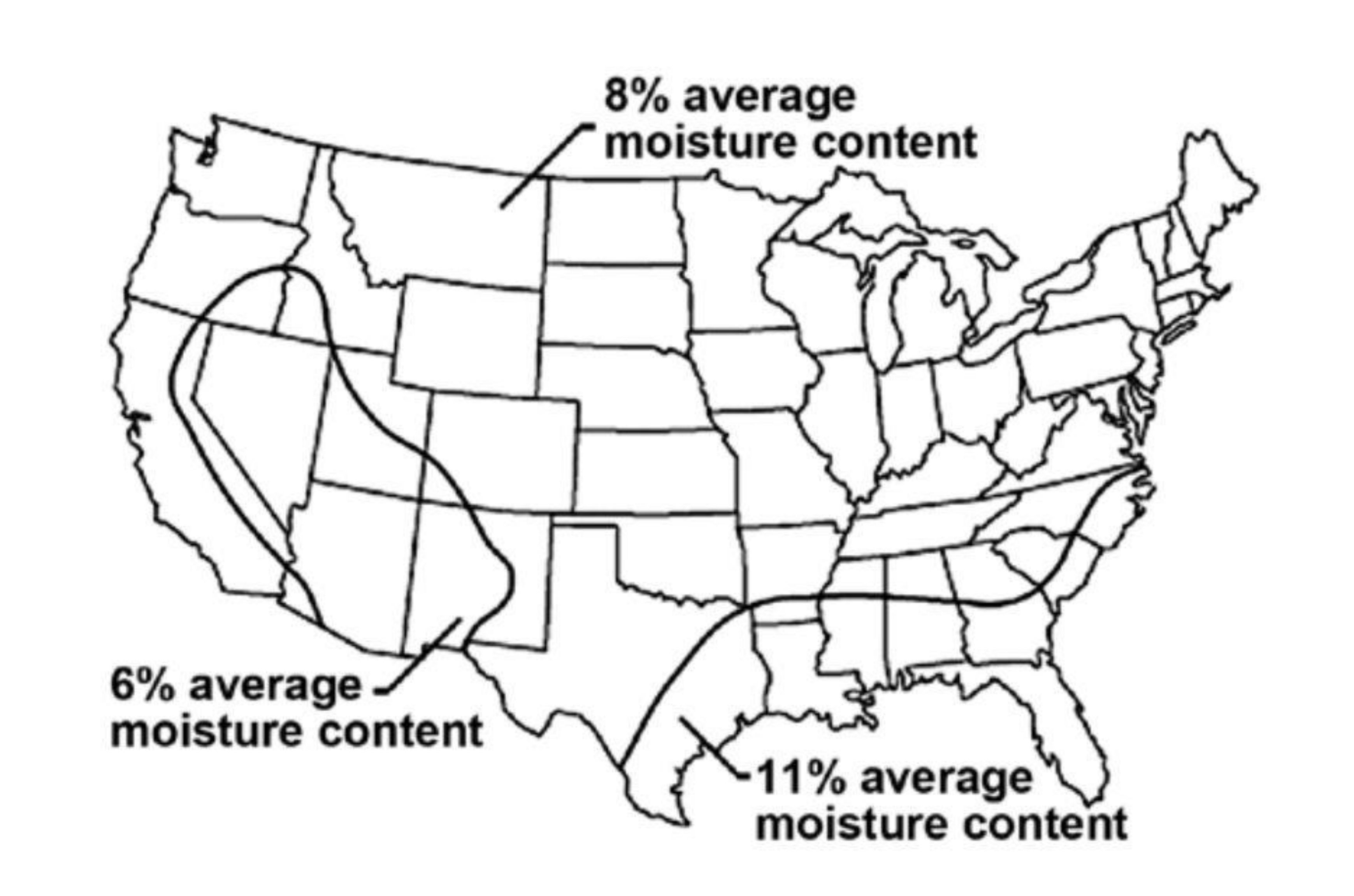
FPL “Wood Handbook”, Eq. 13-3

Green/Inital MC

Species	Green Sapwood MC
White Pine	148%
Doug. Fir	115%
White Oak	78%

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?

MC_i = Initial MC = 30%
MC_f = Final MC = 8%
S_T = Tangential Shrinkage
(Wood Handbook, Table 4-3)

Species	S_T	% Shrinkage
White Pine	7.4	-5.4%
Doug. Fir	7.5	-5.5%
White Oak	10.5	-7.7%

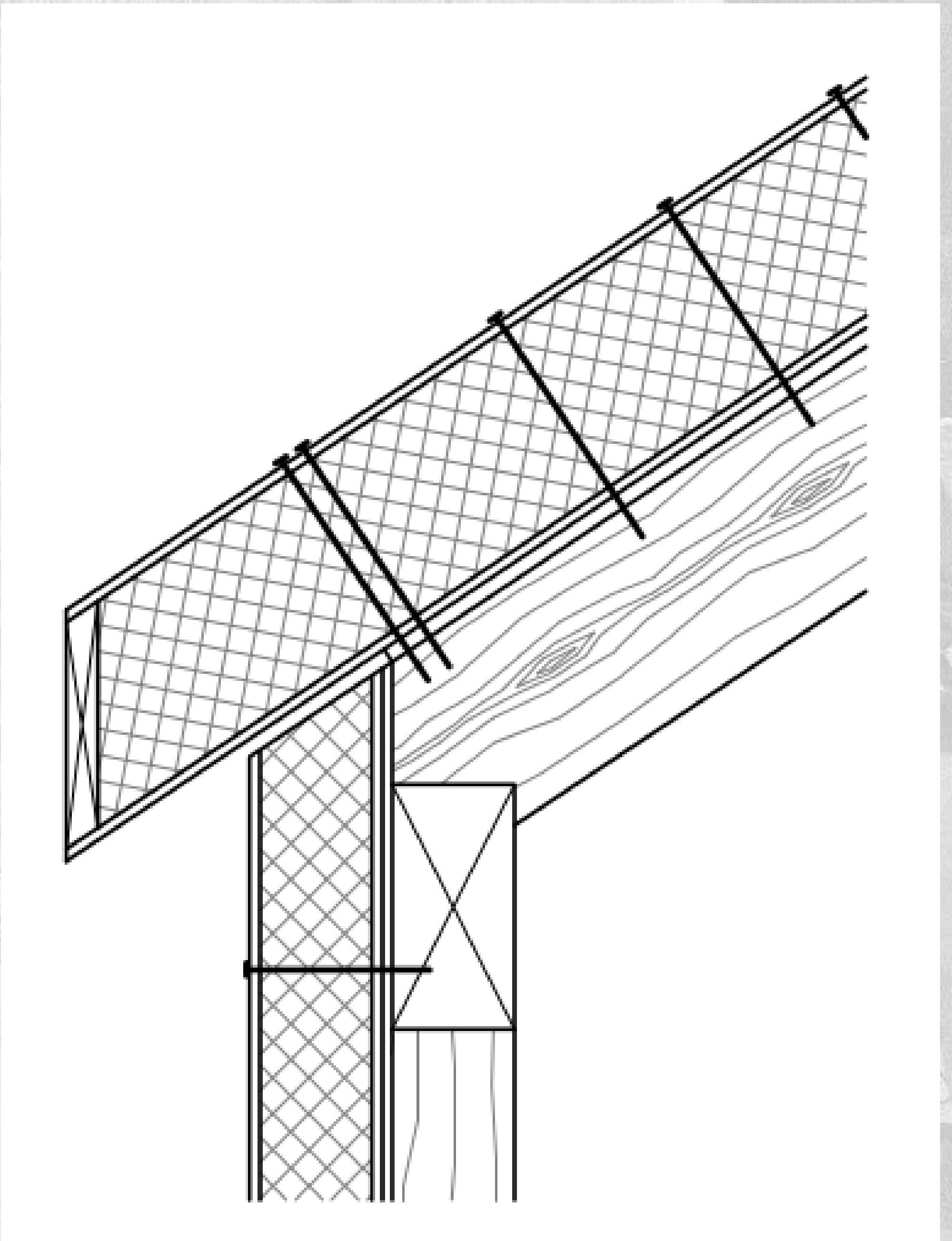
KD Lumber?

MC_i = Initial MC = 19%
MC_f = Final MC = 8%
S_T = Tangential Shrinkage
(Wood Handbook, Table 4-3)

Species	S_T	% Shrinkage
Spruce	7.3	-2.8%
Doug. Fir	7.5	-2.8%
Yellow Pine	7.5	-2.8%

Stacked Timber

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

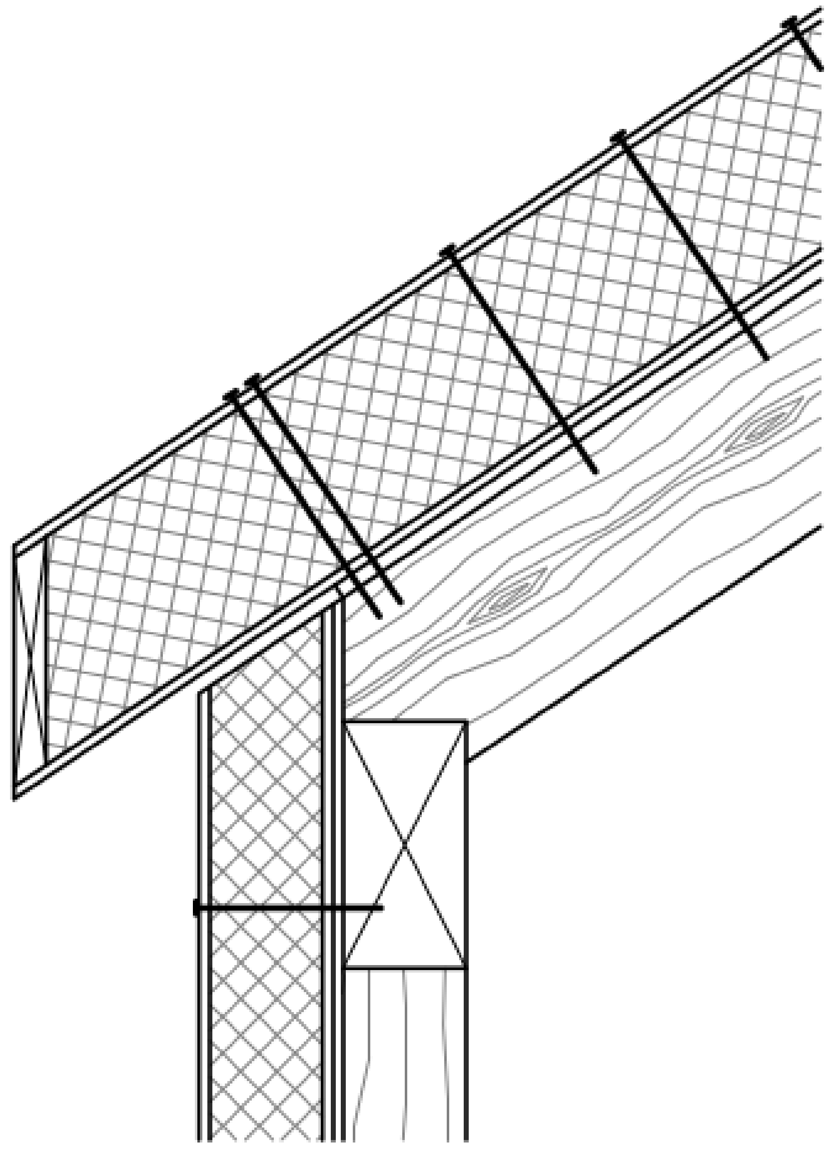


Stacked Timber

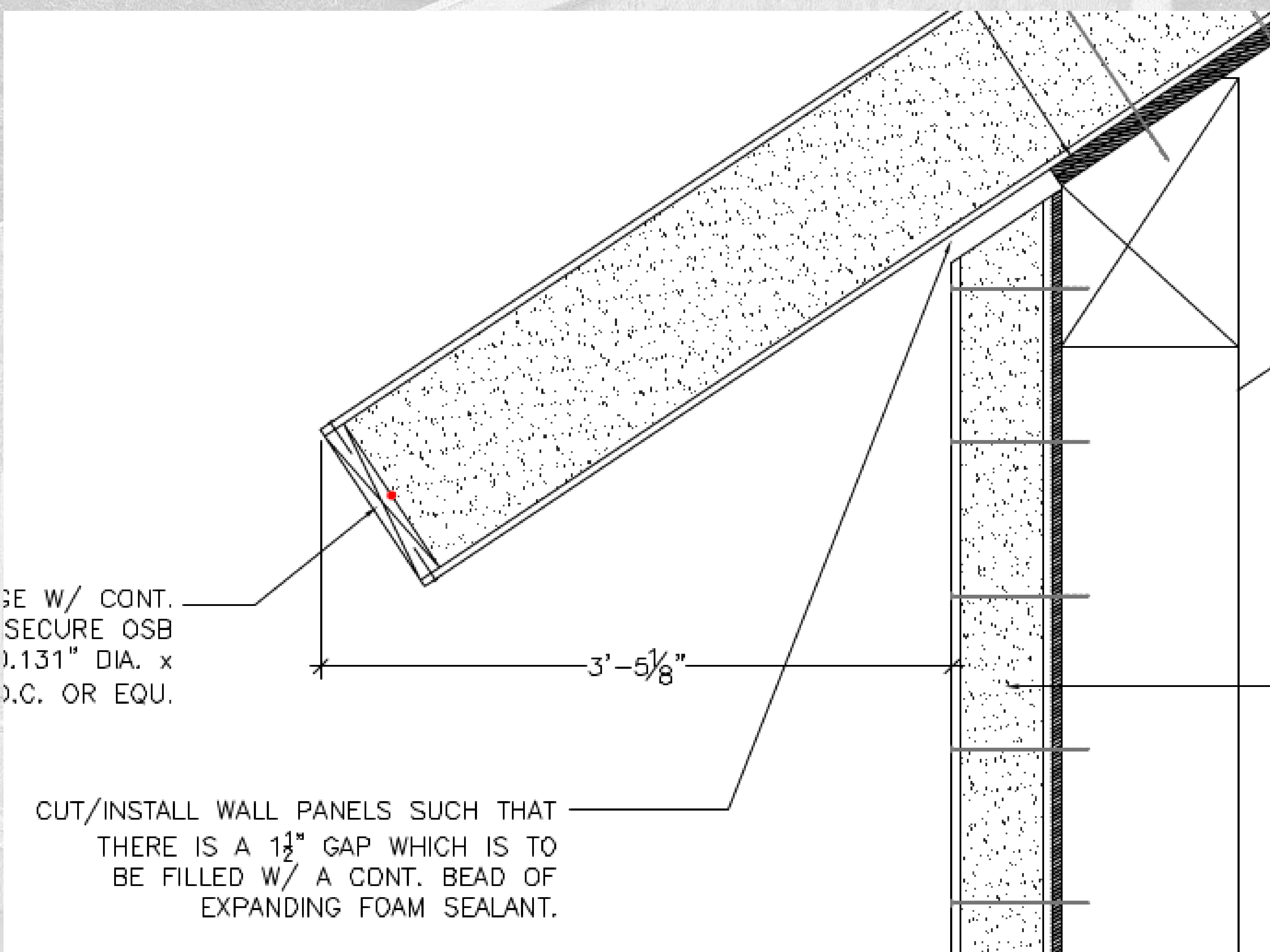
- Rafter
  (5”)cos(34 deg)(5.5%)
  = 0.23”

- Plate
  (12”)(5.5%) = 0.66”

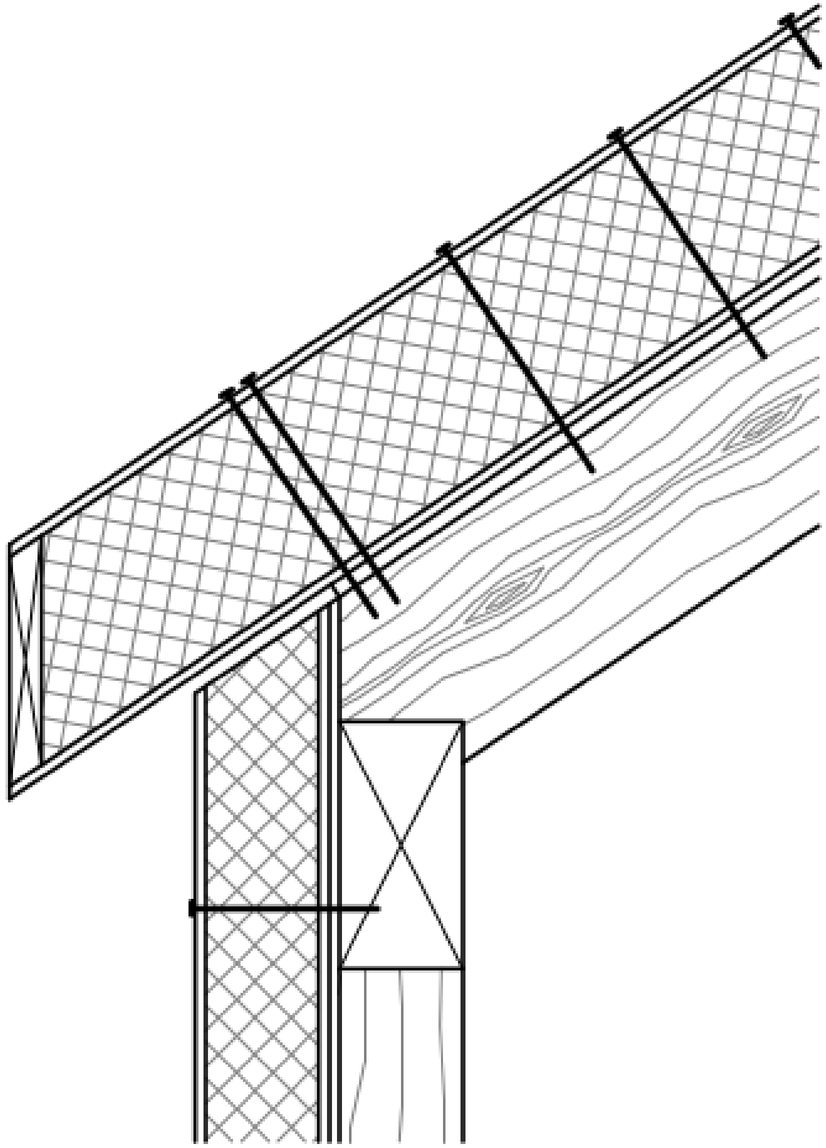
- Total: 0.89” = 7/8”



What To Do...

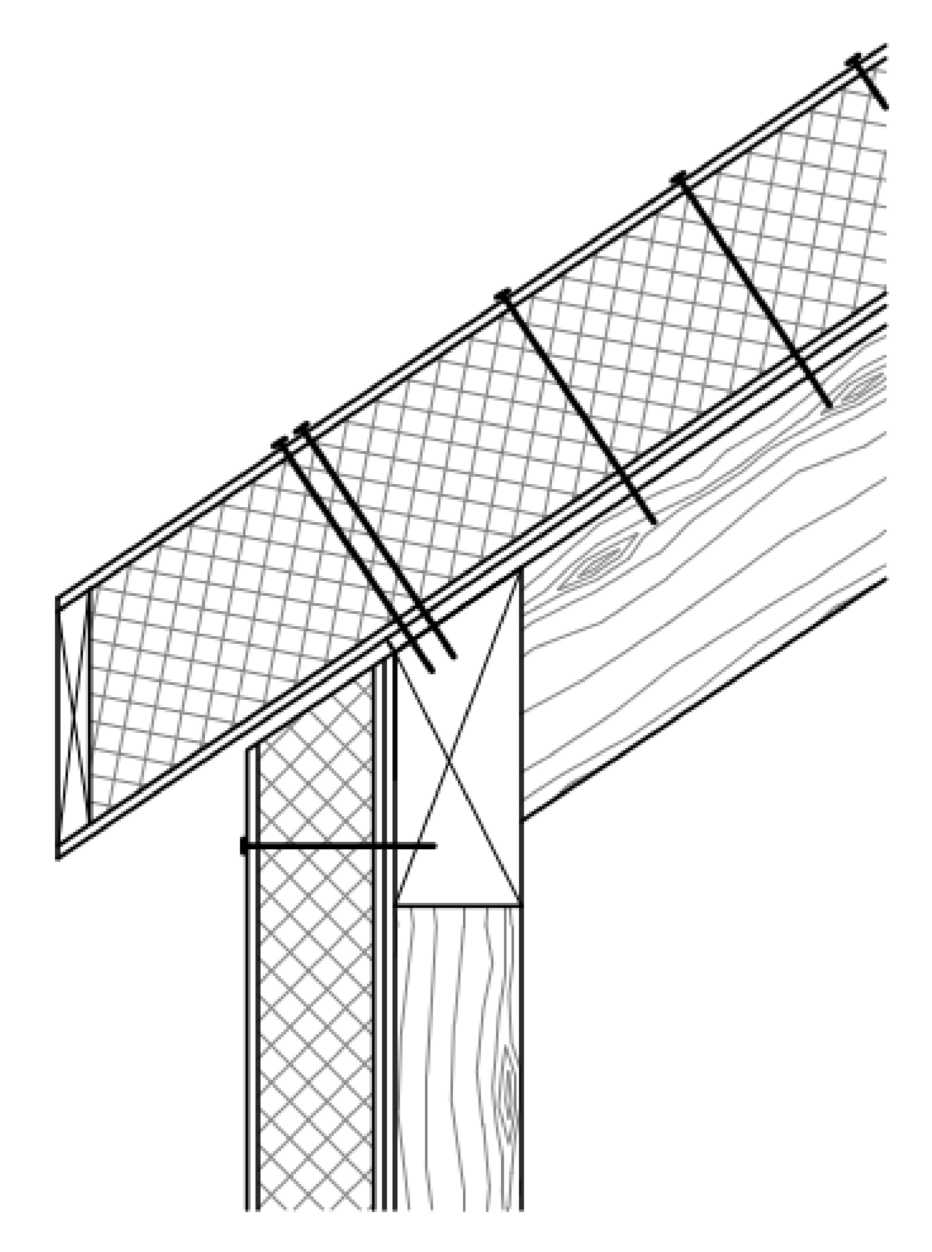

GE W/ CONT.
SECURE OSB
0.131" DIA. x
O.C. OR EQU.
3'–5⅛"
CUT/INSTALL WALL PANELS SUCH THAT
THERE IS A 1½" GAP WHICH IS TO
BE FILLED W/ A CONT. BEAD OF
EXPANDING FOAM SEALANT.

Wait, what about the diaphragm connections?



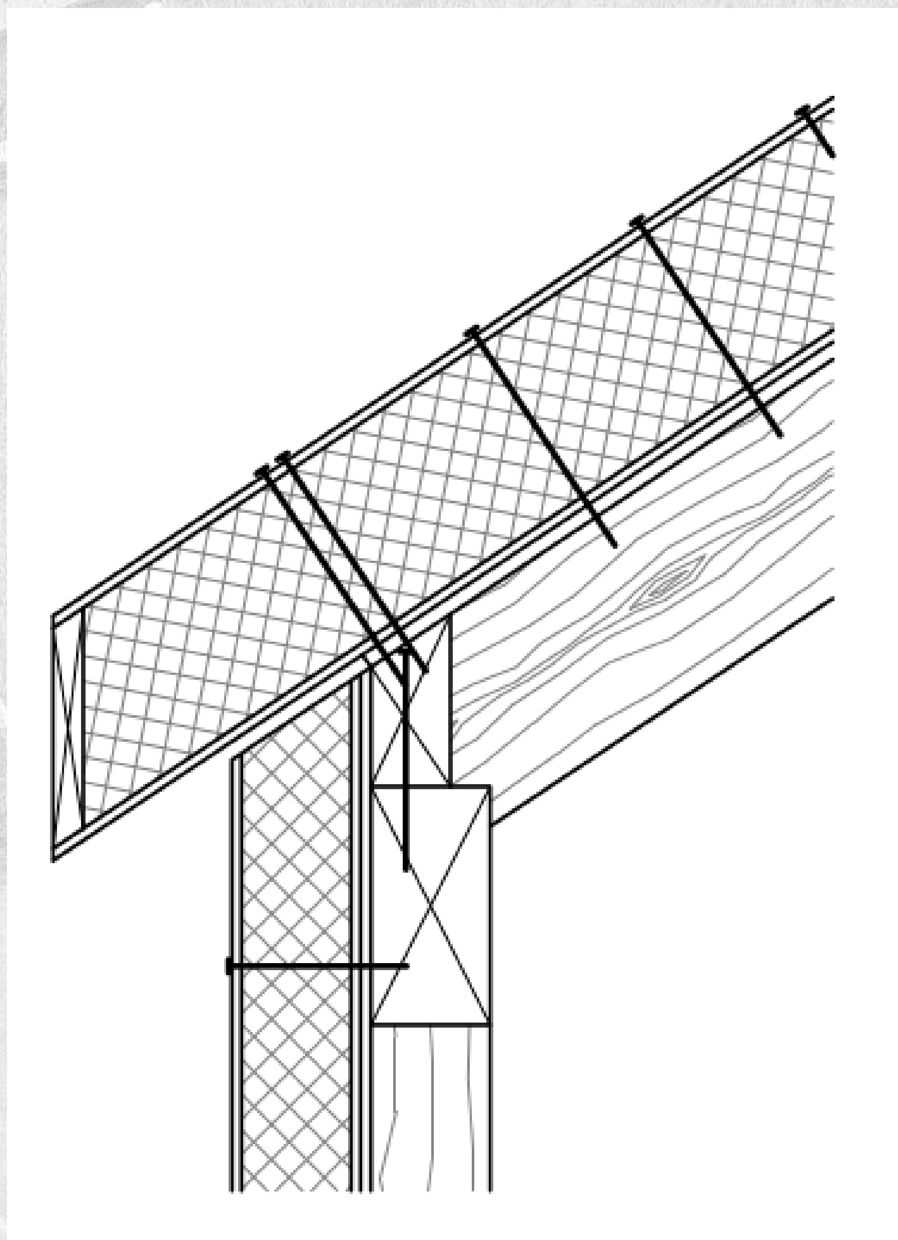
- Uplift at rafters?
- Rolling load on rafter?
- Out of plane shear load on rafter?

Wait, what about the diaphragm connections?



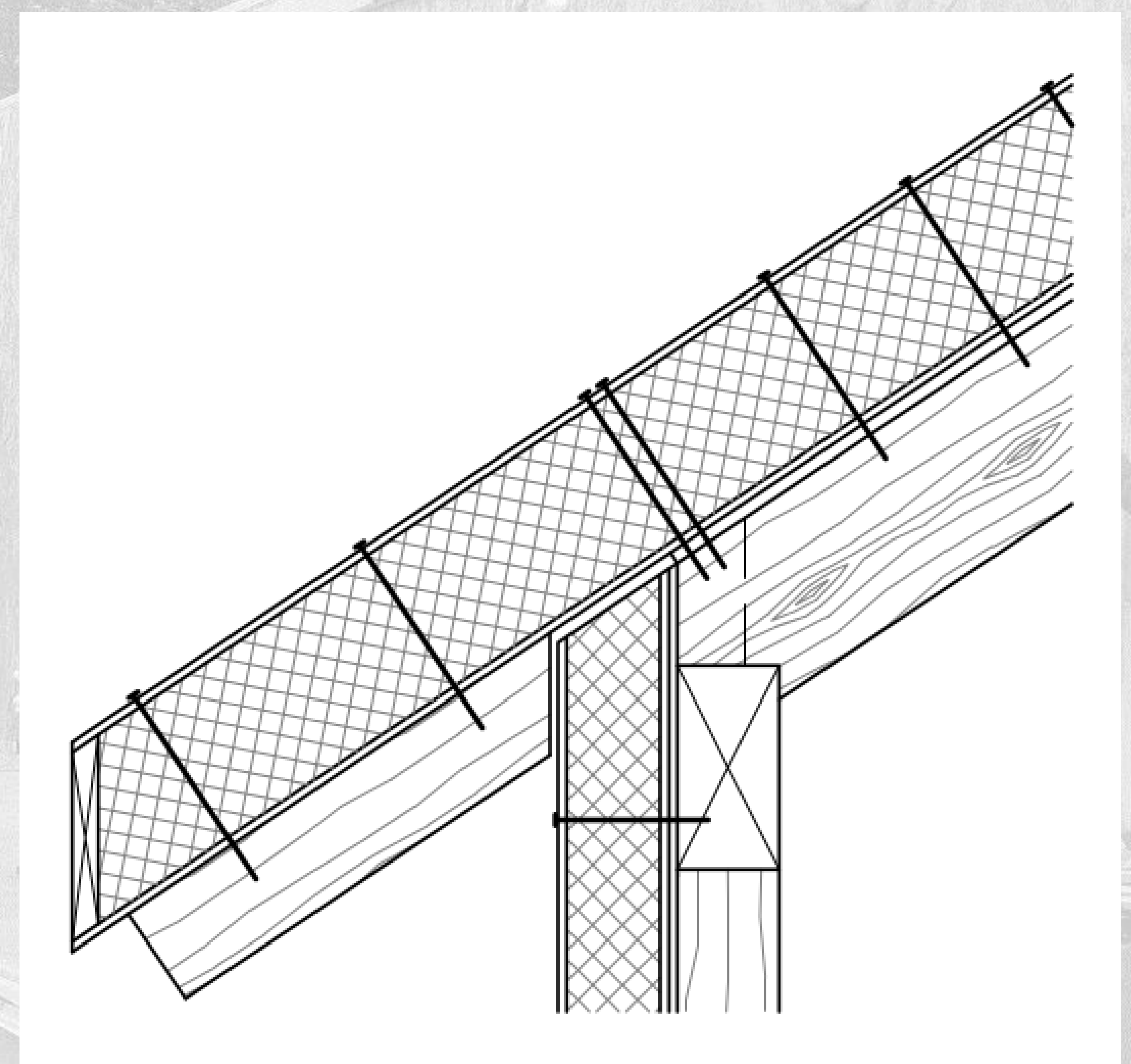
Beveled Pla

Wait, what about the diaphragm connections?

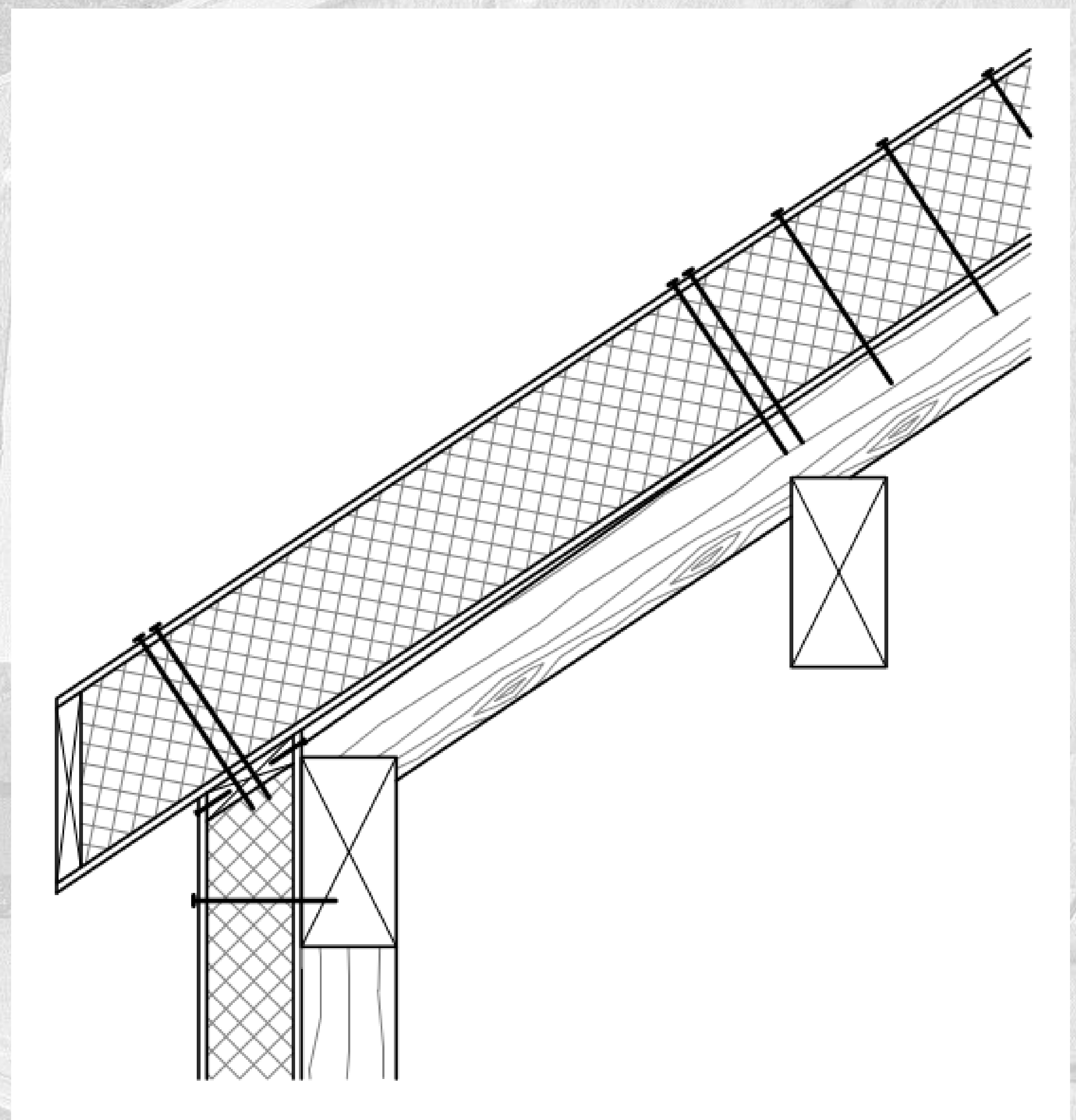


Bevel Blocking on Plate

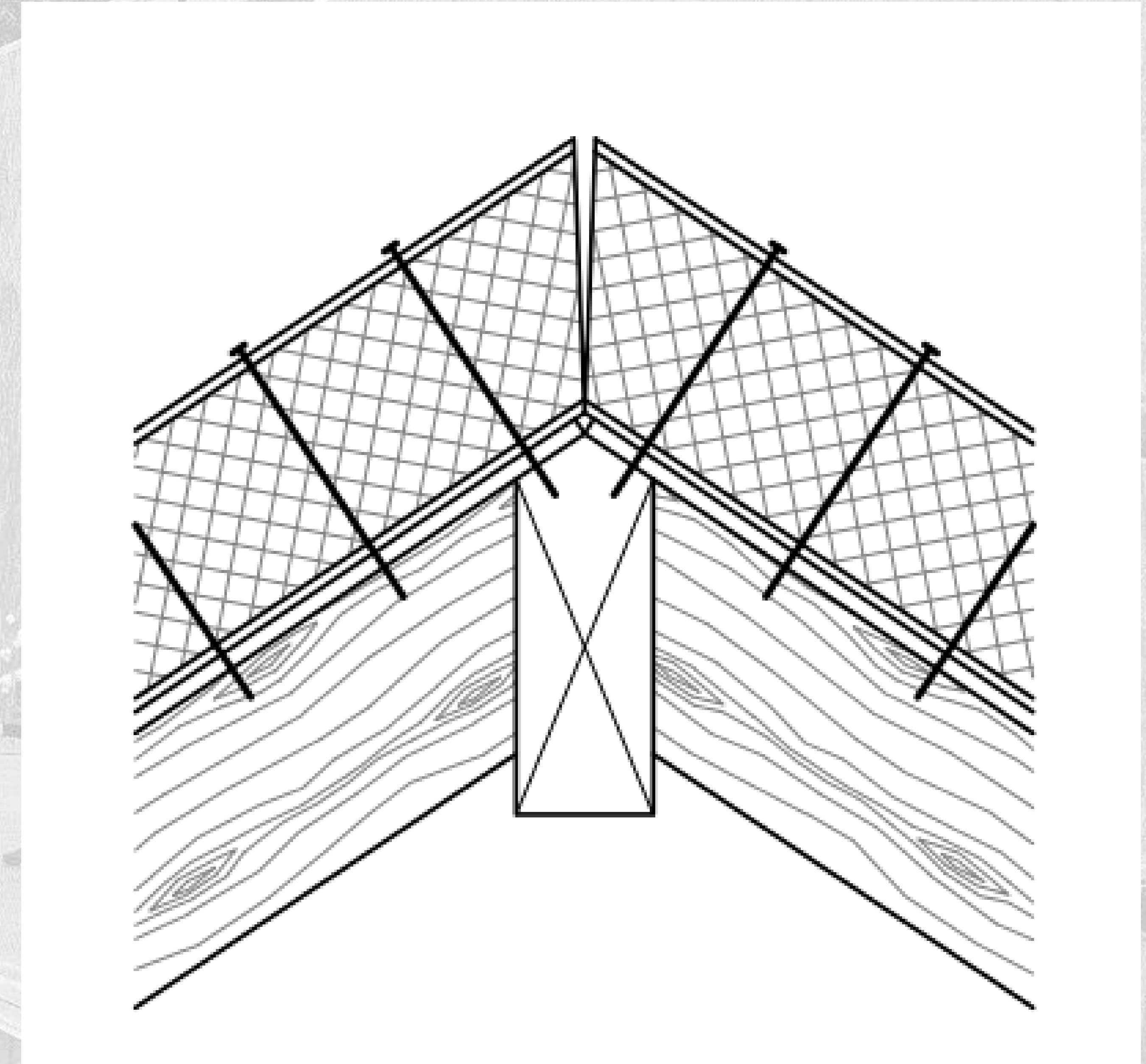
Rafter / Purlin Tails



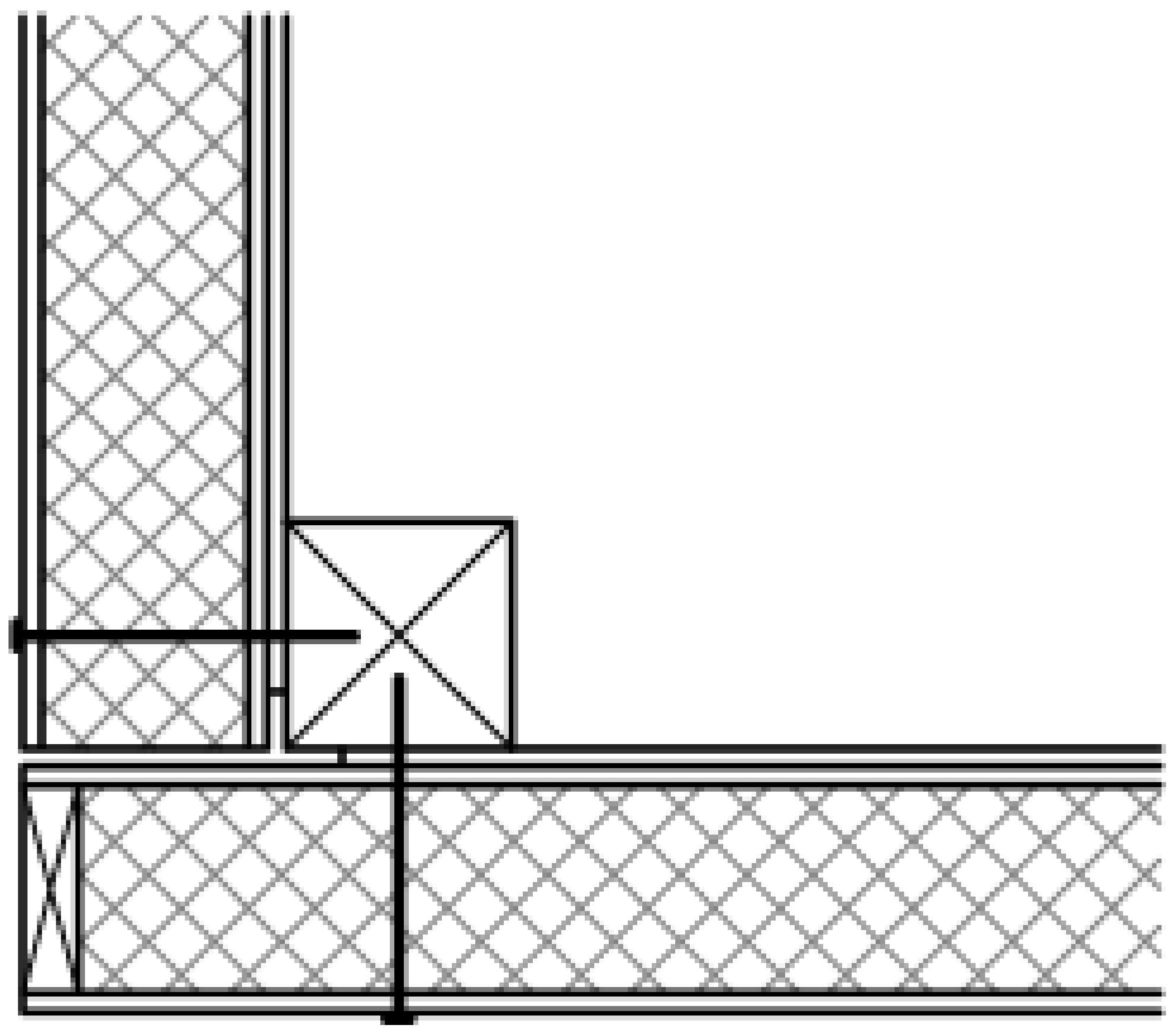
Bridging the Transition



What About Roof Diaphragm Edges?



Outside Corners



KD 2x Shrinkage Matters

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

Cyclic (high deflection or temperature based)

1) Tape (on inside)
2) Gaskets for larger gaps
3) Spray foam for thermal control only it will not maintain an air seal.

One time or little movement joints (timber shrinkage)

1) Spray foam gaps
2) Spray foam for foam to foam joints.
3) Mastic for foam to wood or wood to wood
4) Tape inside for all joints with wood in them.

Construction:
Everyone has to give a damn.