



# Avoiding Moisture-Related Issues in Modern Low-Slope Roofs

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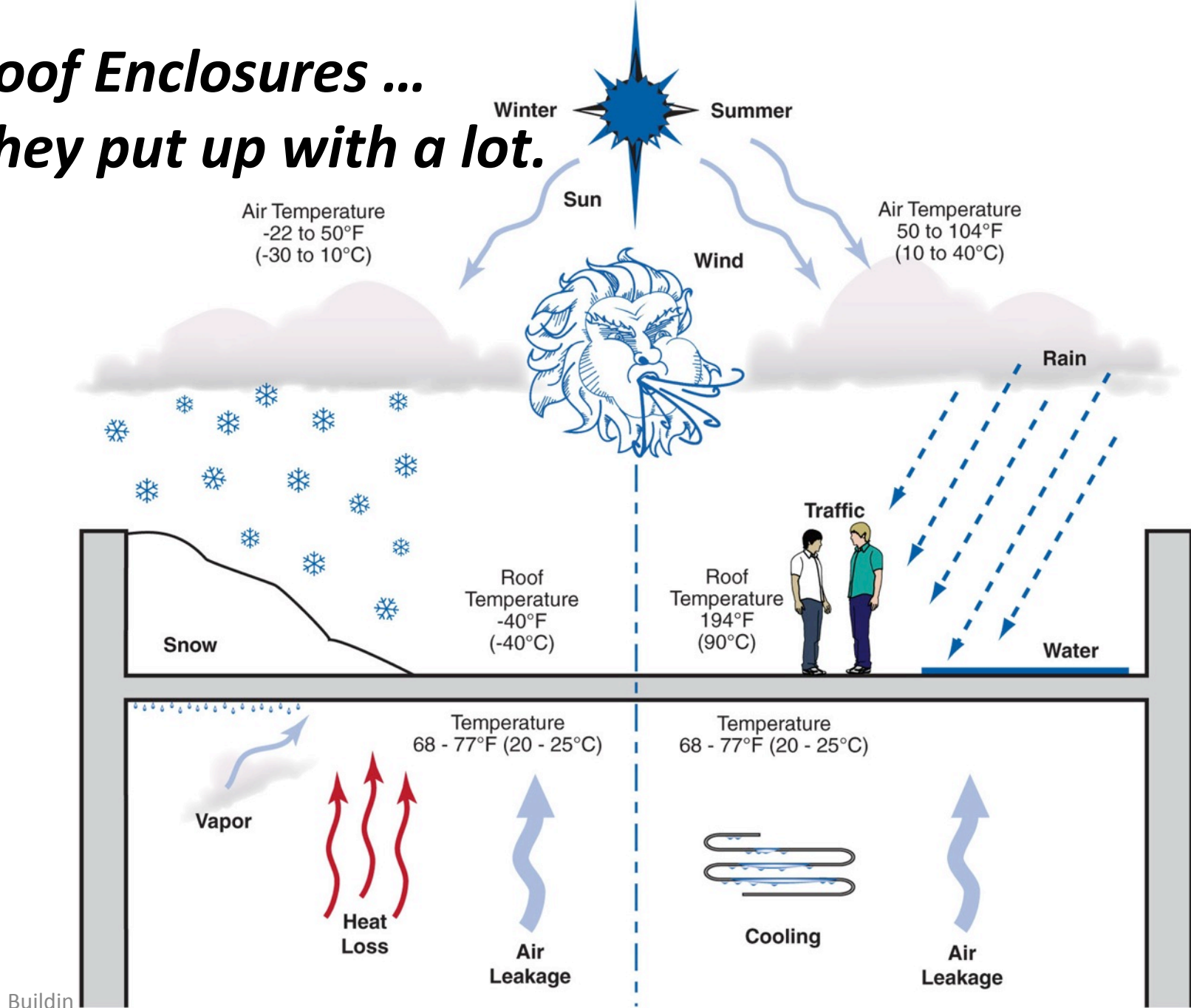
# Modern “High Performance” Roofs

- What are high performance roofs?
  - They don’t leak
  - Enable buildings with low operational energy
  - Provide comfort & safety
  - Ensure good Indoor Air Quality
  - Last a long time (economy, sustainability)

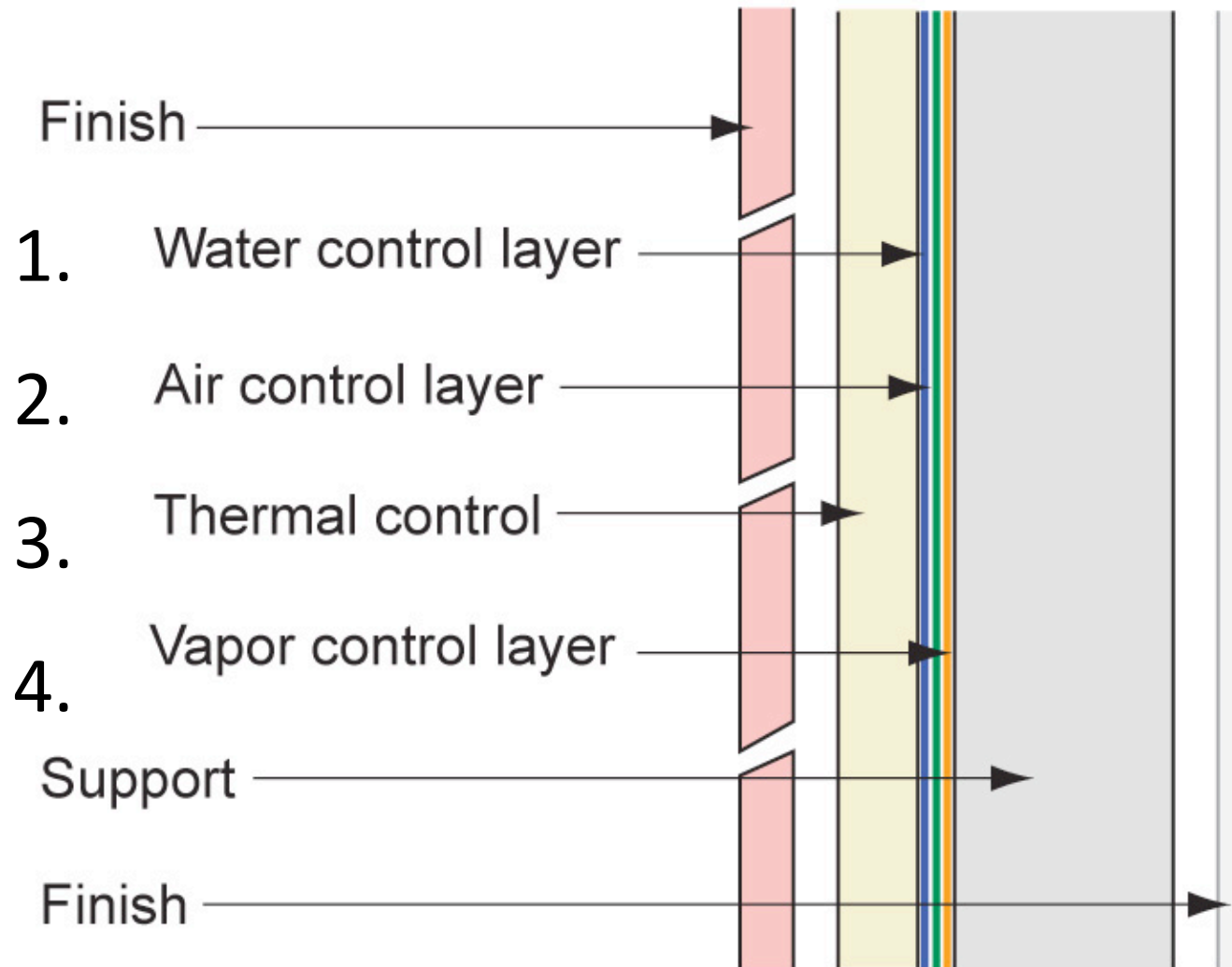
# How to achieve

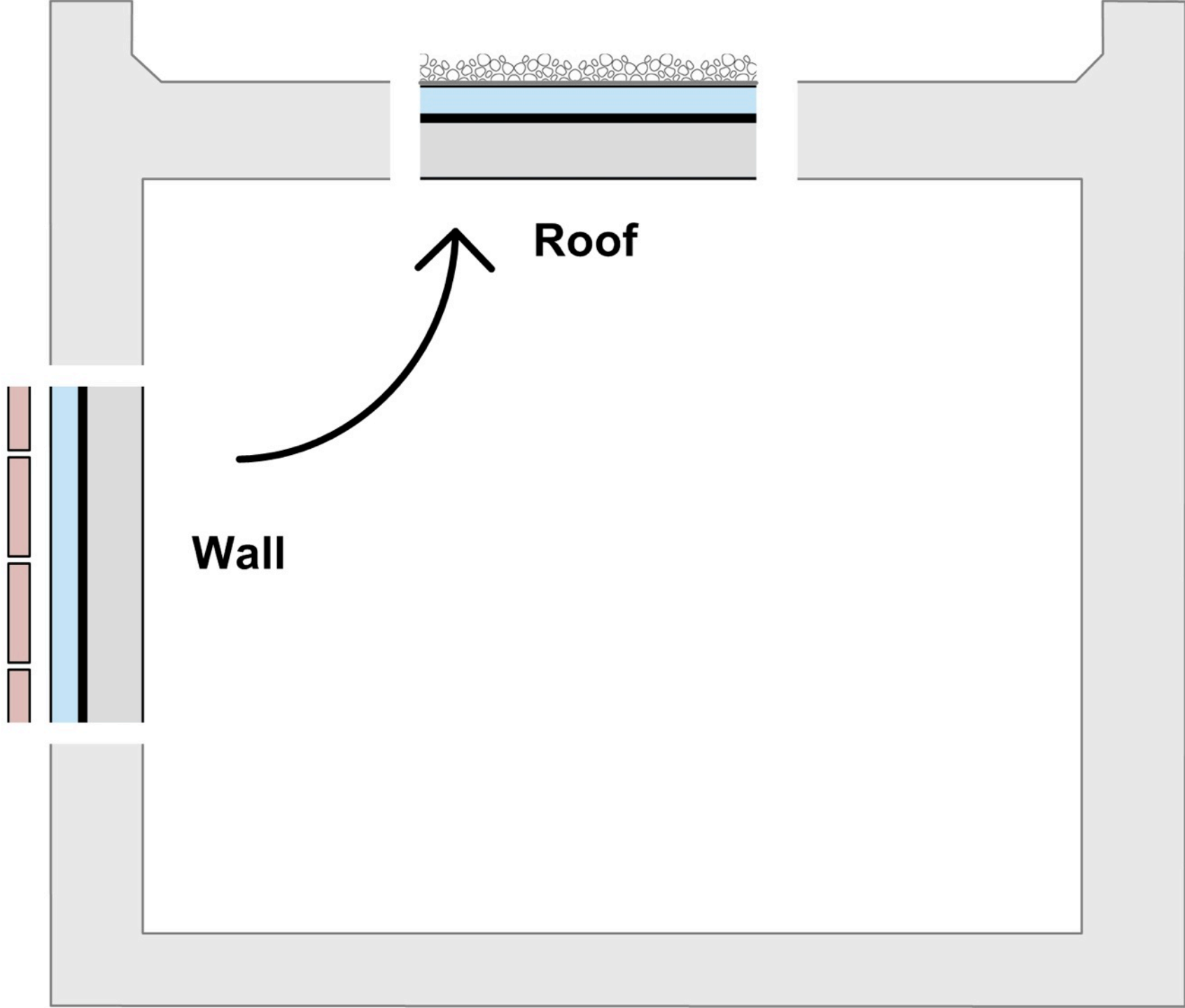
- Don't leak
  - No holes
- Insulation
  - Easy. Continuous ASHRAE 90.1, says R30 plus
- Airtightness
  - Provide an air barrier! A focus of this seminar.
- Durability
  - Material selection *and* system design

# Roof Enclosures ... They put up with a lot.

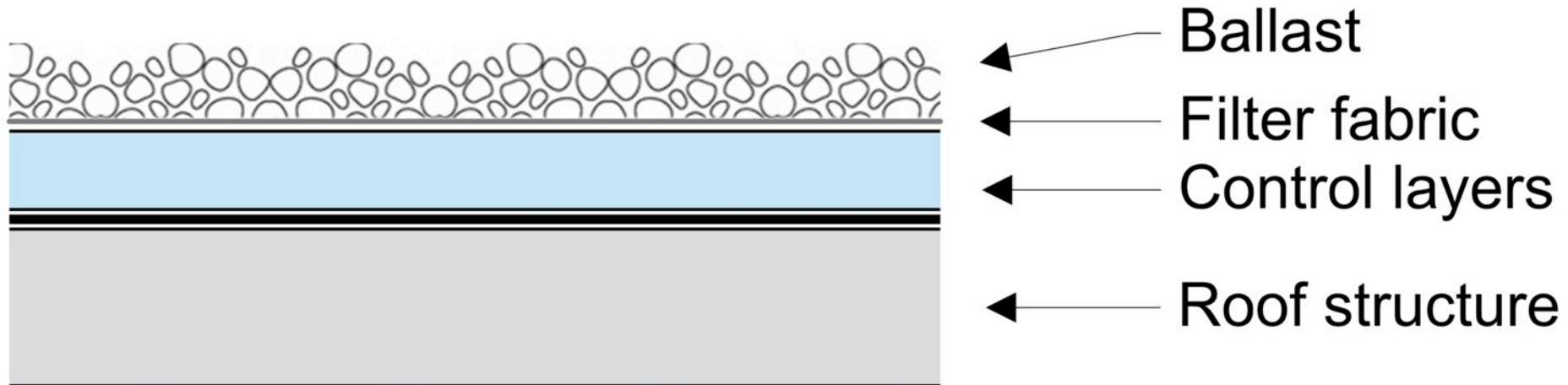


# The classic “Perfect” Enclosure





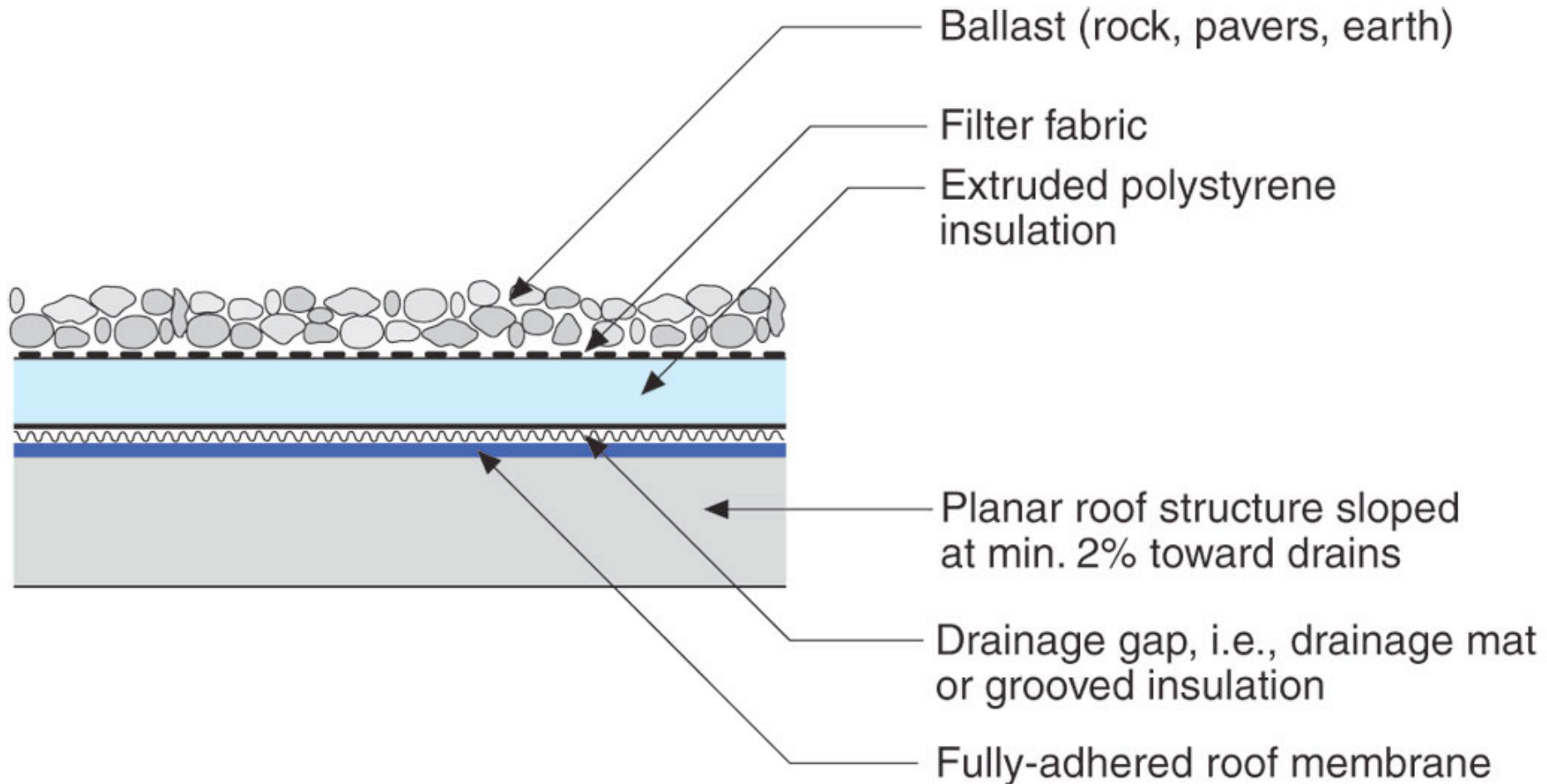
# The “Perfect” Roof?: Protected Membrane Roof



**Some owners insist on it. Eg. US Federal Government (GSA)**

# Details matter to get full durability

## Experience has taught us....



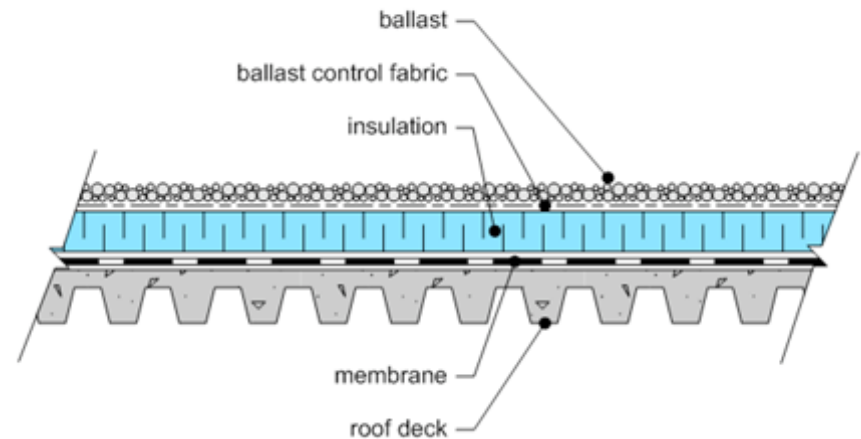


# PMR “Inverted” Roof

- Pros:
  - Preferred approach
  - Exterior insulation eliminates thermal bridges
  - Protects membrane
- Cons:
  - Added weight of ballast is major limitation
  - Can only use XPS



Typical Inverted Roof System

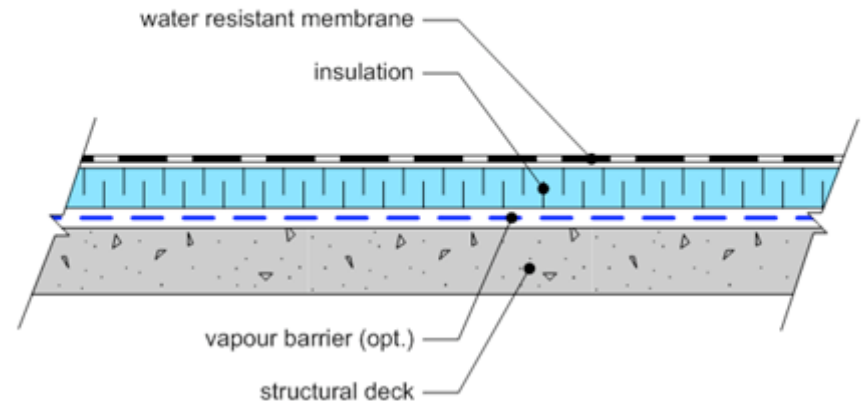


# Exposed membranes

- Most common solution
- Pros:
  - Lightest weight
  - Wide variety of insulation and membranes
- Cons:
  - Exposed membrane!
  - Need separate air and vapor barrier membranes



Exposed Membrane Roof





It's a roof, not a pool





**It's a roof, not a ice rink**



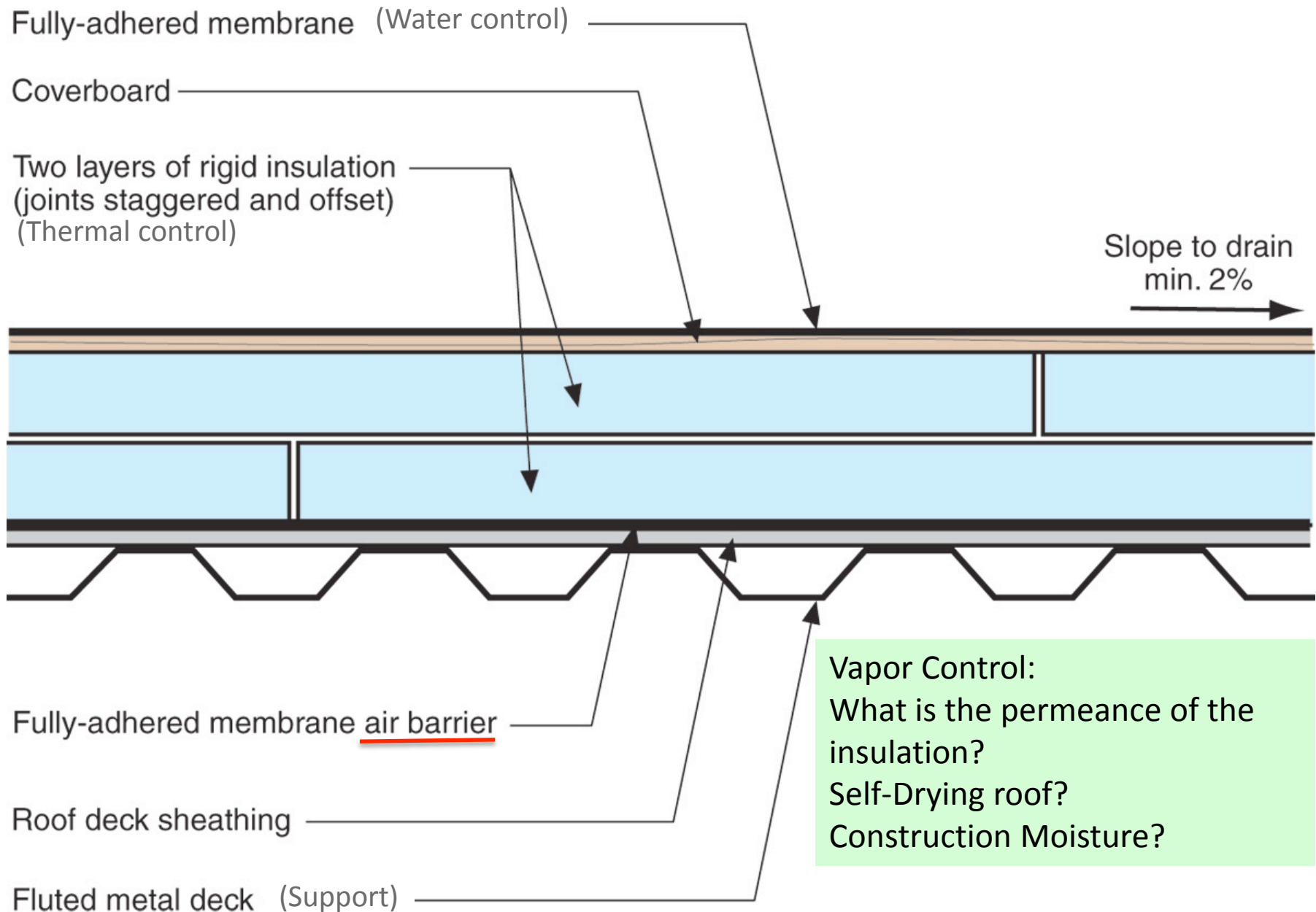


**“Money spent on roof slope is one of the best bargains in the construction business”**  
**Wayne Tobiasson, US Army CRRL**



# Slope

- 2% is a good design value for slope
- Laps still resist drainage a bit
- Account for roof sags: long span steel often sags more than slope
- Be careful of roof drains at columns



# Vapor Control

- Vapor barriers do not need to be supported against wind or be perfectly continuous
- Polyiso insulation usually has low enough permeance to manage vapor diffusion
- Stonewool insulation usually needs additional vapor control
- Very low permeance vapor barrier at deck will often trap water in roof assembly



# Durability & Membranes

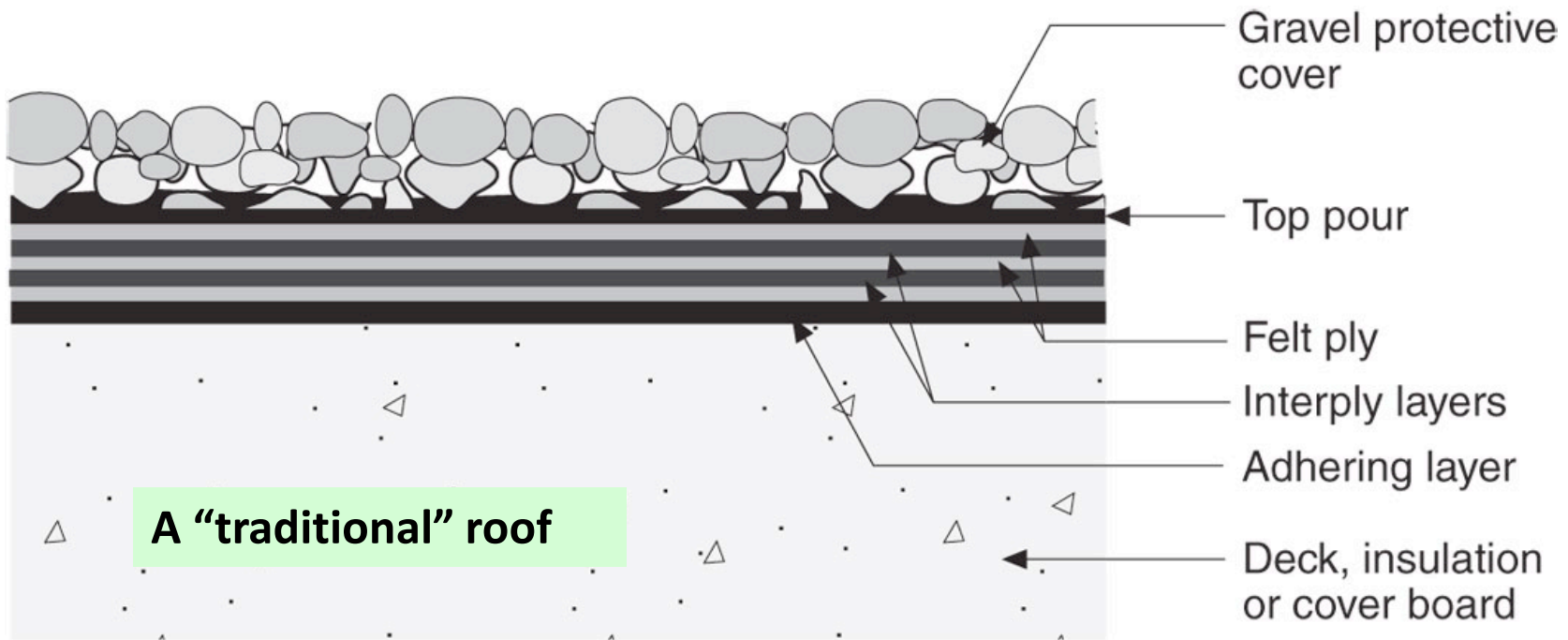
- What causes most materials to fail?
  - **Heat**
  - **Moisture** (corrosion, biological, etc.)
  - **Ultra-violet radiation**
  - Others, oxygen, ozone, specialty chemicals, etc.
- Classification of materials
  - Polymer
  - Mineral
  - Metals

# Exposed Membrane Selection

- Material? Asphalt, TPO, EPDM, PVC, etc.
- Single-ply vs Multi-ply?
- Factory made or site made?
- Polymer durability limited by high temperature and UV exposure

# Best UV Protection: rocks

- But, you need to hold down to resist wind



*From Baker, M.; Roofs, 1980*

## ***Roof membrane***

- ***UV protected by rocks and***
- ***kept cool by white ....***





## *New and retrofit solution*











# White roofs

- Lower heat gain: great!
- Reduce stress on exposed roof membranes
- **But:** Reduces drying out of roof
- **Thus:** Require better moisture control!
  - Air barrier
  - Construction moisture



## White roofs: the coming storm



*Where is the air barrier?*

**WESTERN STATES ROOFING CONTRACTORS ASSOCIATION  
(WSRCA)  
TECHNICAL BULLETIN No. 2014-L  
Winter, 2014**

**To: Roofing Contractor Members, Design Professionals, and  
Roofing Industry Members**

**From: WSRCA's Low-Slope Roofing Committee**

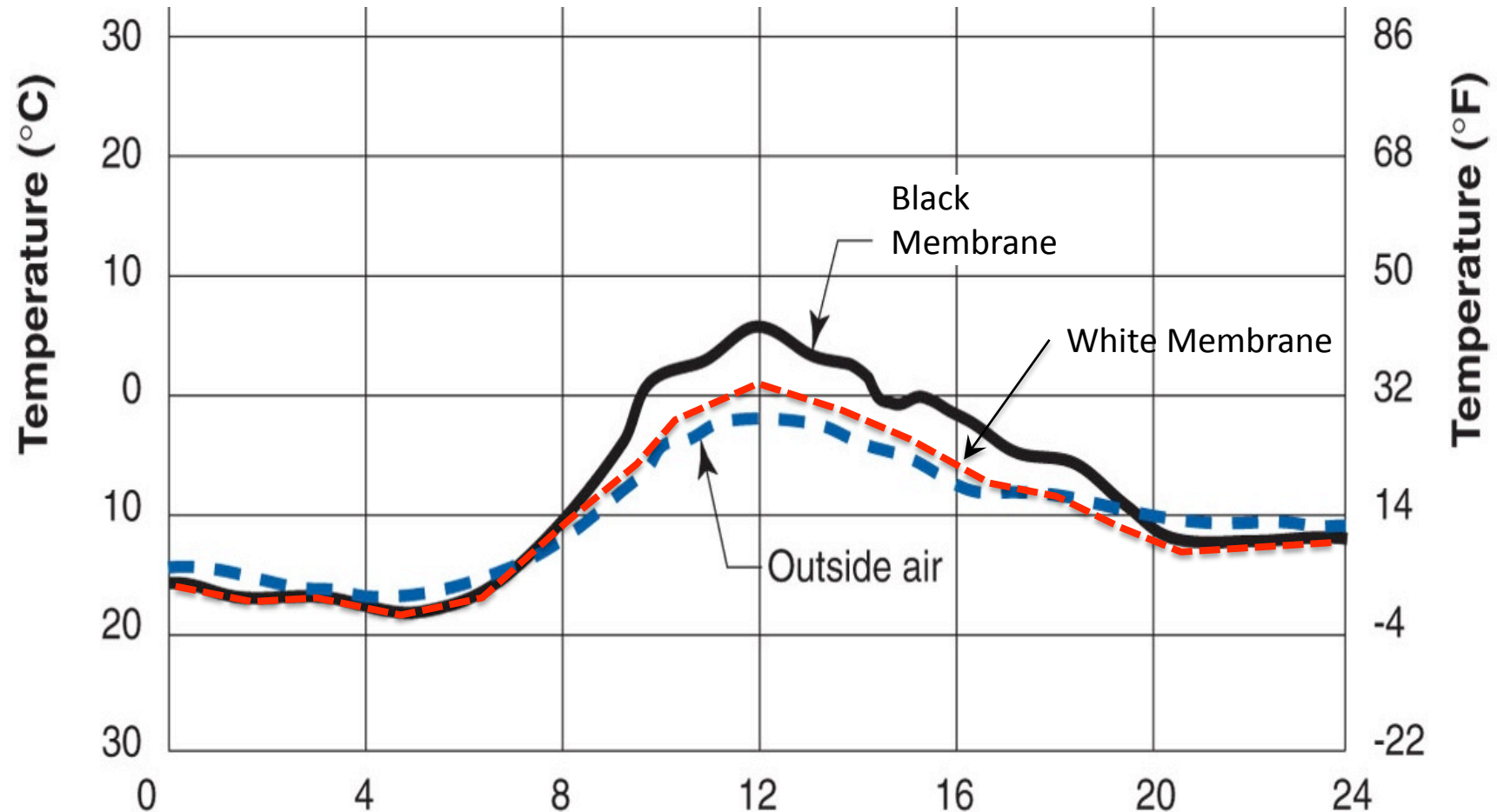
**Subject: Vapor Retarder Technical Information – “Vapor Retarders 201”**

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**More Reports of Condensation and Moisture Accumulation with Loose-laid and Mechanically-attached, Light-colored Single-ply:**

With the recent mass trend toward “cool roofs” and white- or light-colored single plies, even being specified in predominately heating-climates<sup>1</sup>, there are relatively new roof condensation problems being reported. Wind-flutter and the pumping of internal building generated and/or occupancy generated moisture, combined with night-time radiative cooling of the roof's surface, are reported as causing frost formation-related condensation and melting drip-back moisture problems, which are reportedly contributing to moisture problems within some building types that lack roof vapor retarders, and/or proper exterior wall vapor retarders. This relatively new issue or phenomenon is reportedly being discovered more often with mechanically attached single plies, located on buildings that lack vapor retarders and are situated in predominately winter-time heating climates.

# White Membranes stay cold



**Hours of a winter day**

*From Baker, M.; Roofs, 1980*

# ORNL: Rocks+White save Energy!

— Bare Black EPDM    — Under 10 lb/ft<sup>2</sup> Stone    — Under 24 lb/ft<sup>2</sup> Stone  
— Bare White TPO    — Under 17 lb/ft<sup>2</sup> Stone    — Under Uncoated Paver  
— Under 21 lb/ft<sup>2</sup> Coated Paver    — Under 16 lb/ft<sup>2</sup> Coated Paver

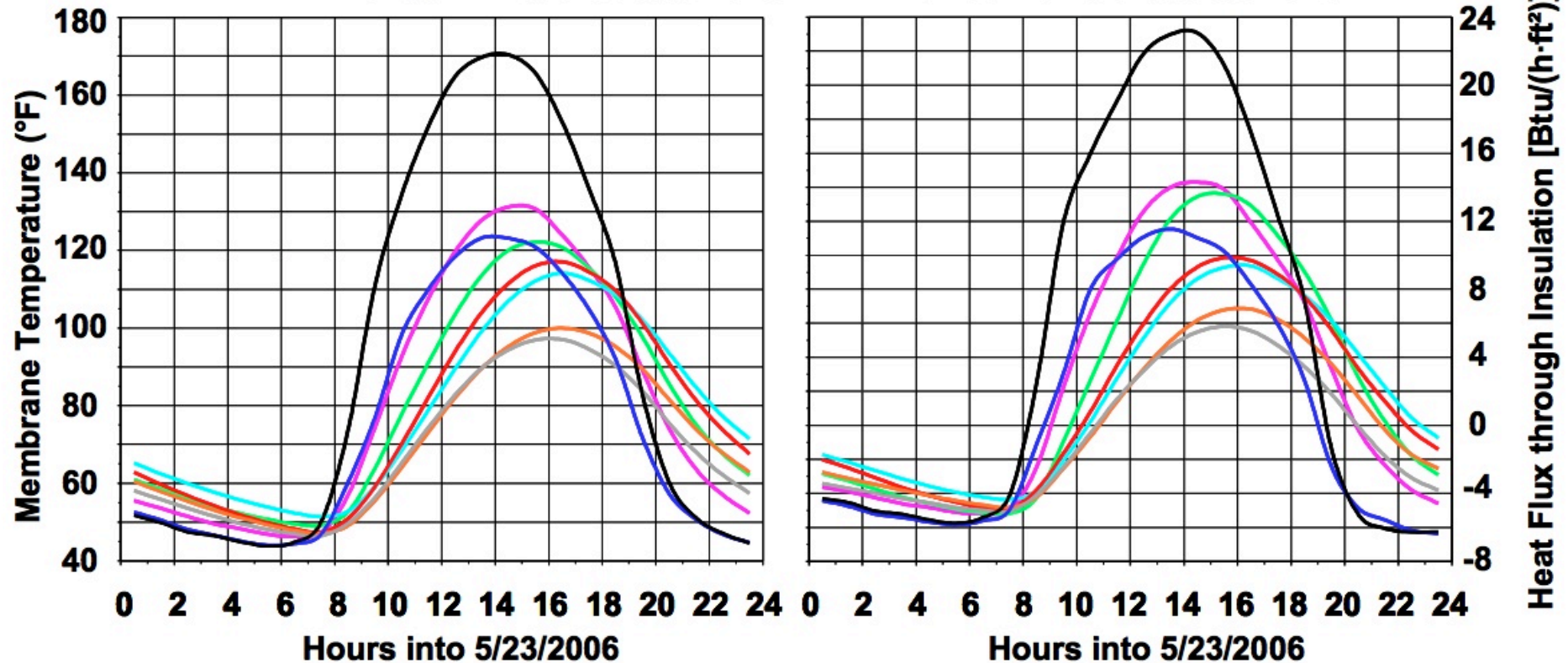


Figure 10. Membrane temperatures and roof heat fluxes twenty-six months into experimental program.

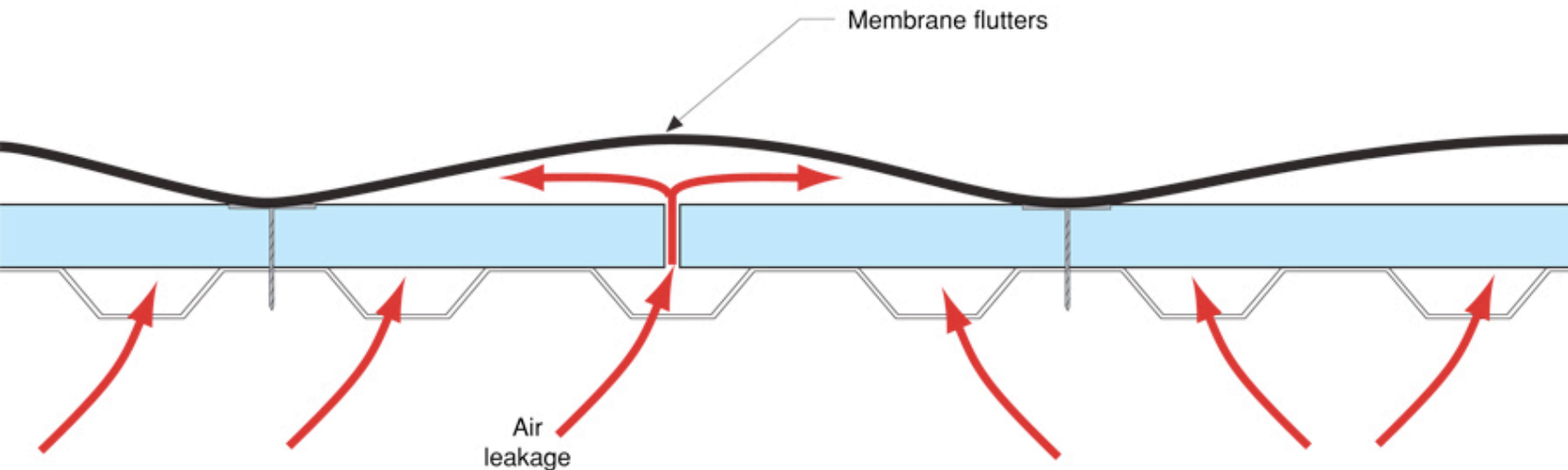
# Problems

No deck Air Barrier

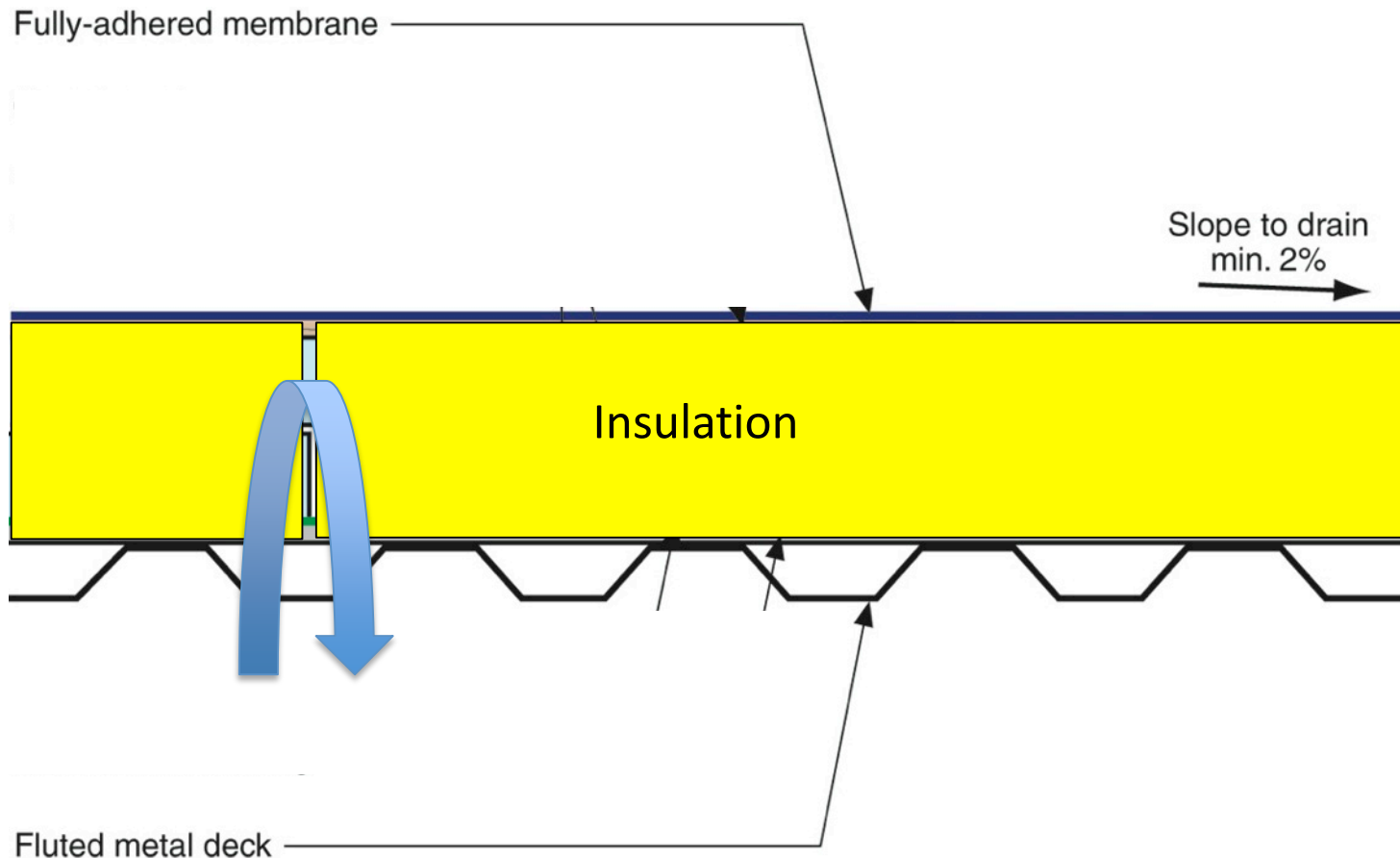
+ No fully-adhered membrane

+ White Roof

= accumulation of moisture & failure



# Even fully-adhered can fail

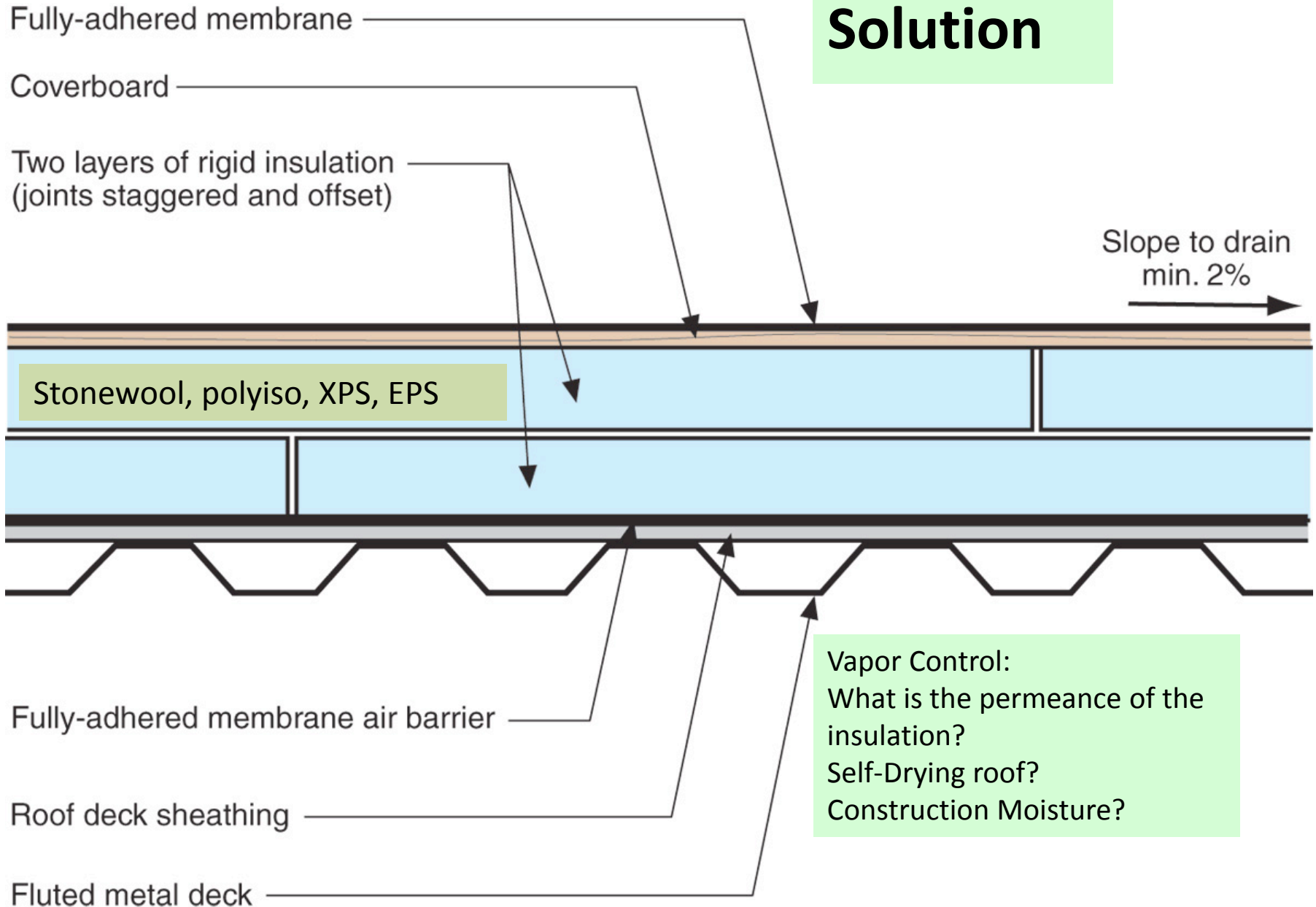


# Low-level air barriers

- Roof membranes can be air barriers
- In practise, a deck level air barrier is more reliable, easier to control
  - Other benefits include secondary roof during construction and re-roofing



# Solution





# High-performance, air *and* vapor barrier



Photo courtesy of Garland Industries





# Deck Cover Board

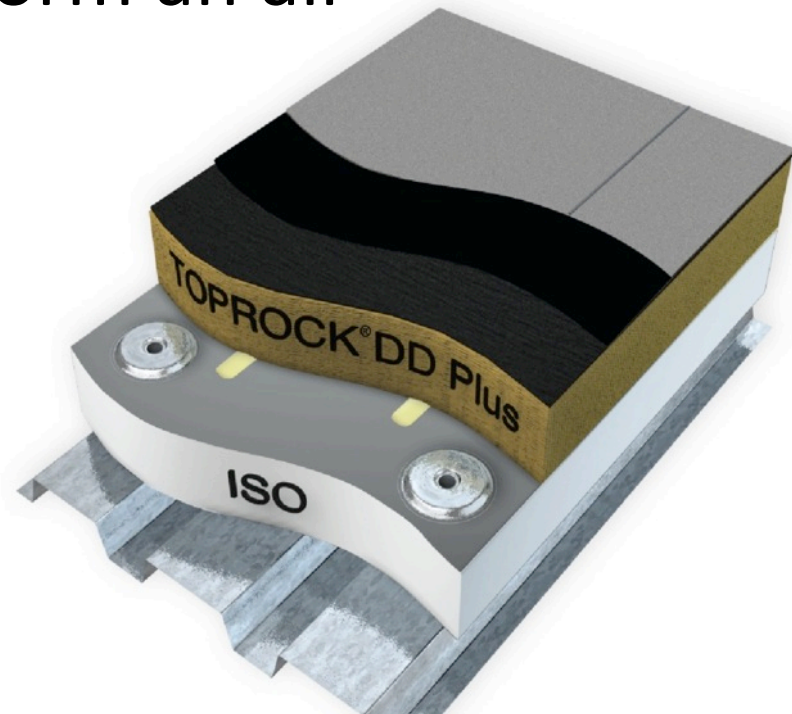
- Seal the joints, or cover the whole surface to form an air barrier
- Note: Gypsum board is vapor permeable





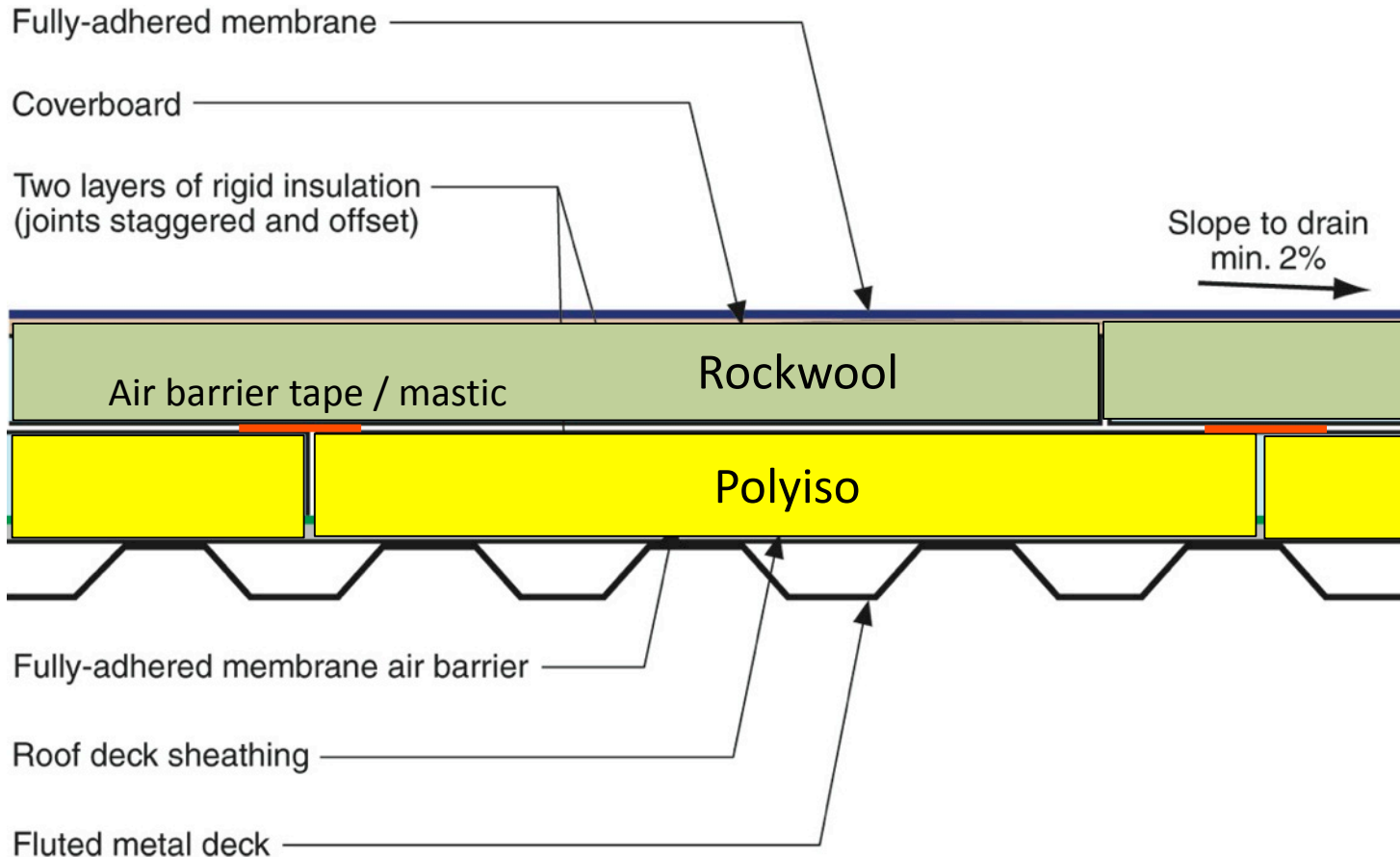
# Deck-level Air Barriers

- Stonewool hybrid roofs
- Low-cost: *Seal joints* of rigid polyiso, mechanically attached, to form an air barrier
- Use the deck-level polyiso as vapor control



Drawing courtesy Roxul Inc.

# Hybrid Roof



**Cheap Air Barrier: Sandwich taped/sealed membrane between two polyiso layers**



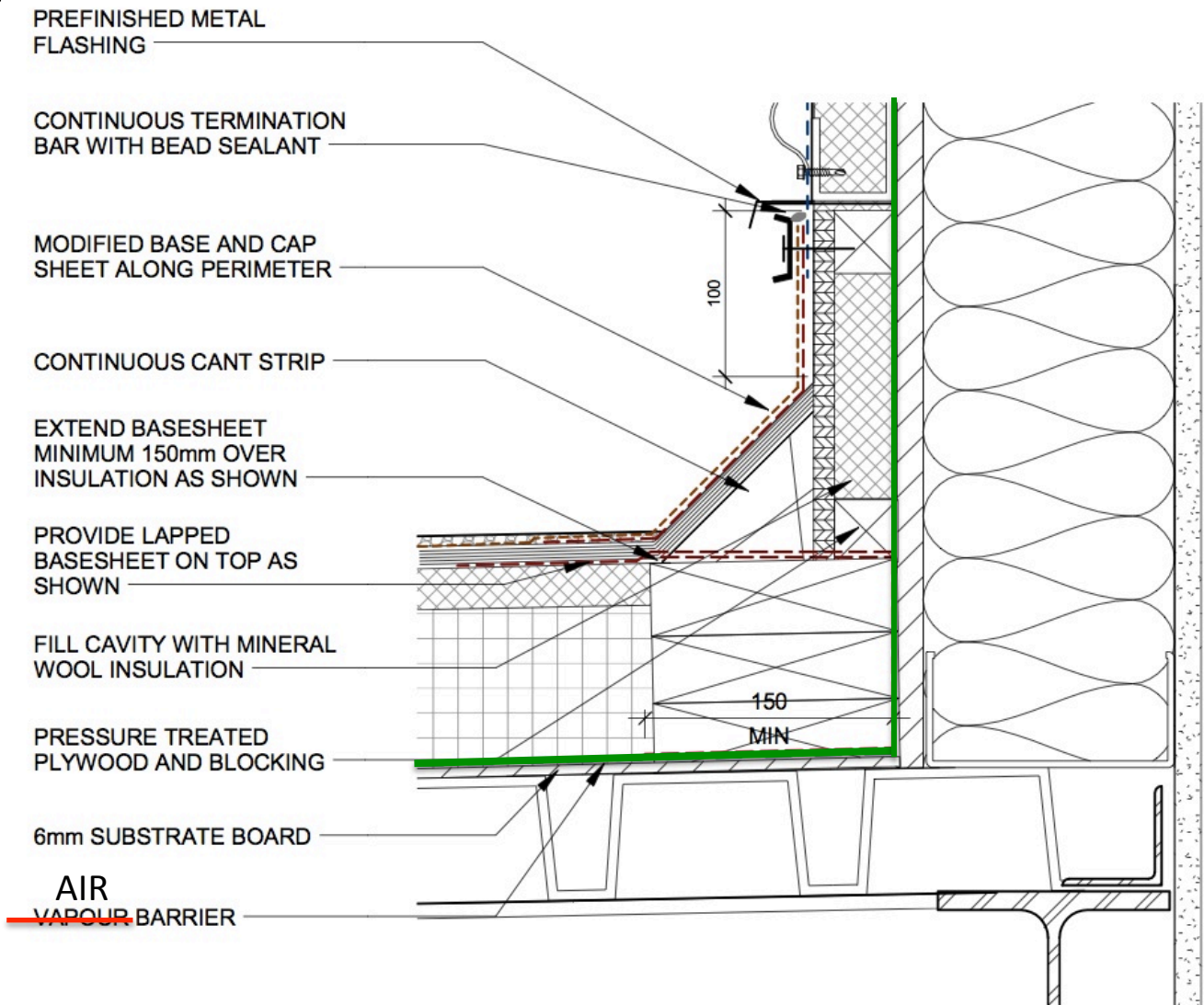
Photo courtesy: Andy Shapiro

# Special Applications

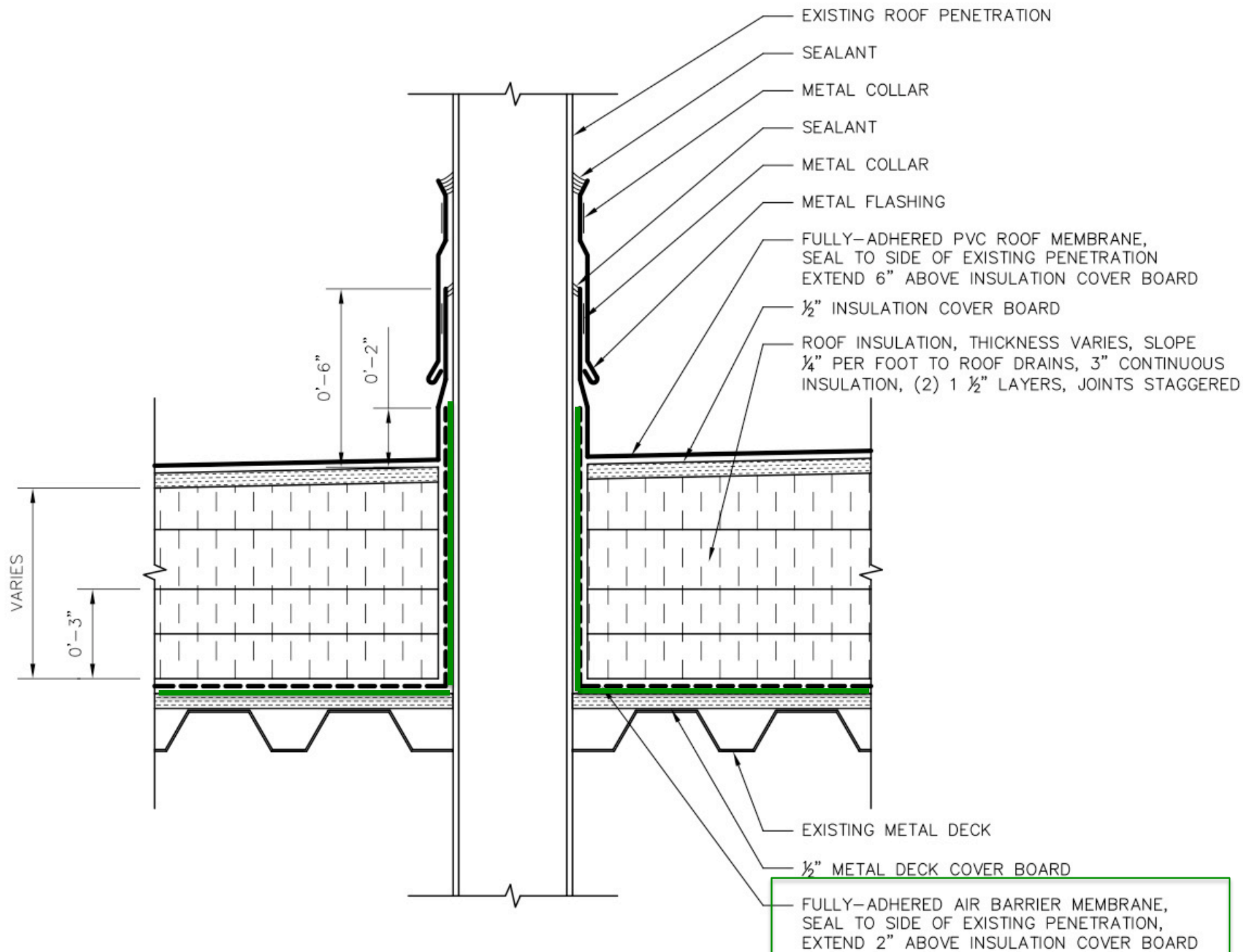
- Swimming pools
  - Esp in cold climates
- Freezer buildings
  - Esp. in hot humid climates
- Badly (normally) operated hospitals
- MUST have a deck level air barrier
  - Sealed at all edges, penetrations!

# Details

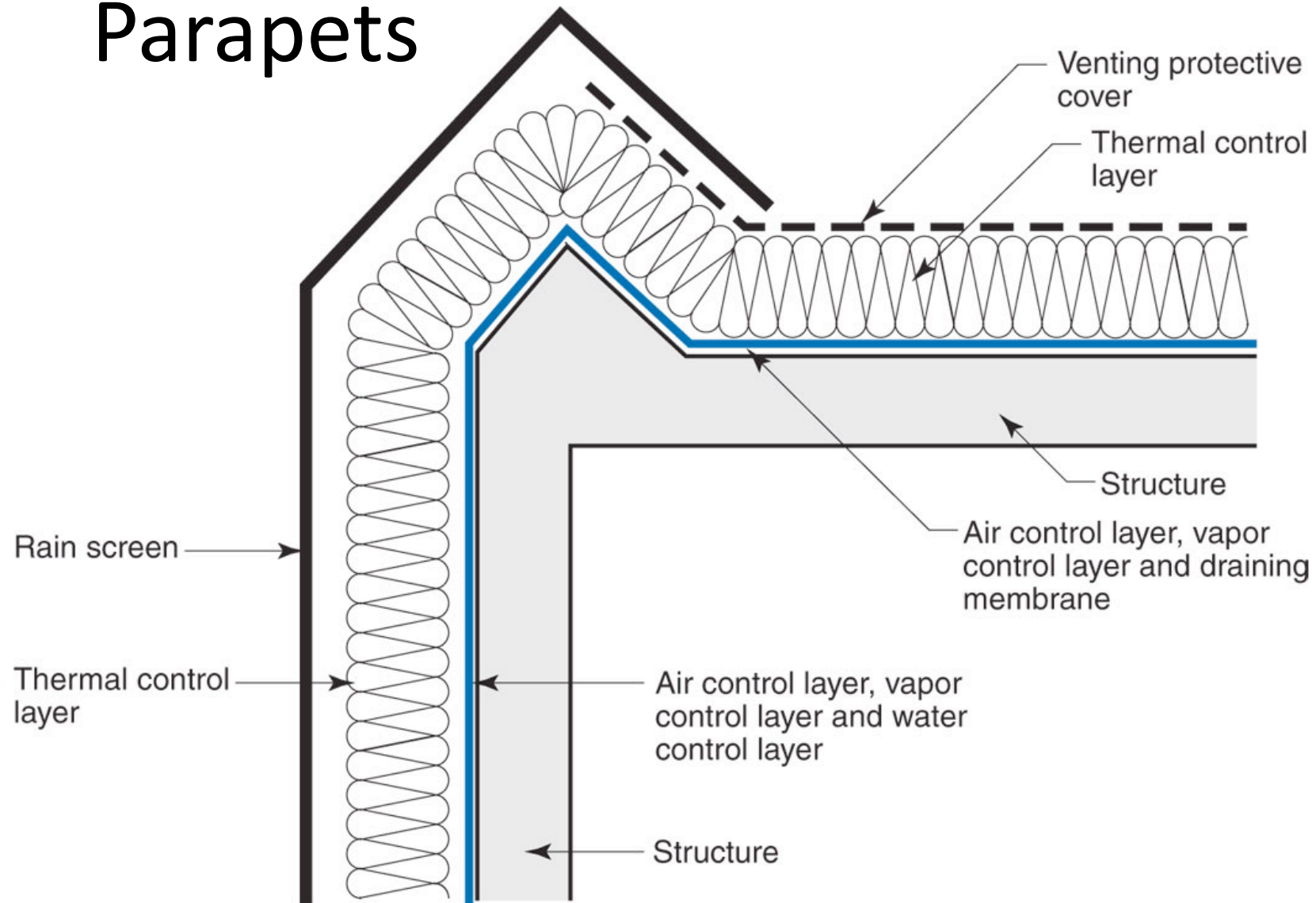
- Penetrations and edge of roof
- *Continuous* air barrier







# Parapets



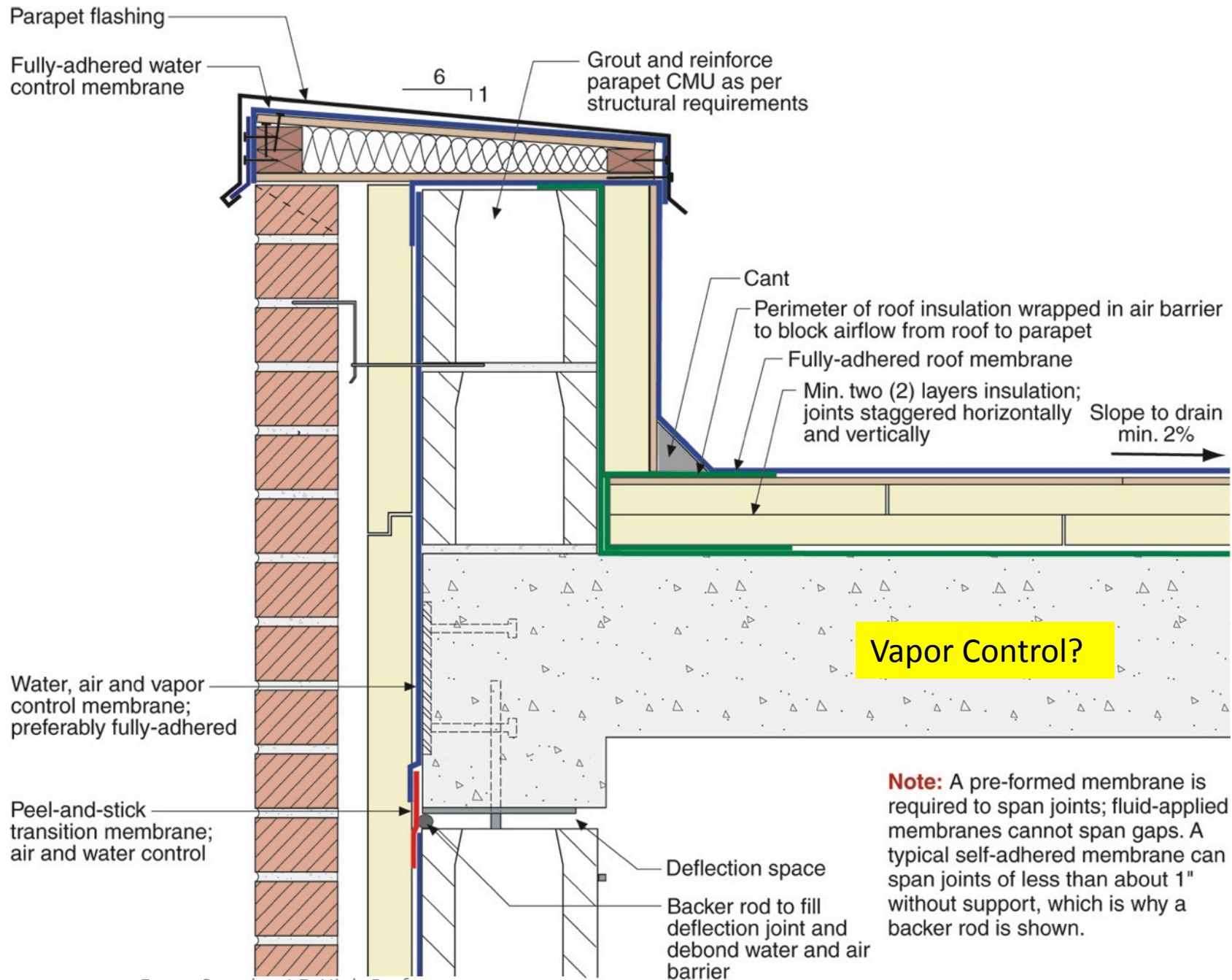
From: Straube, J.F. *High-Performance Enclosures*,  
Building Science Press. 2012.

# Parapets

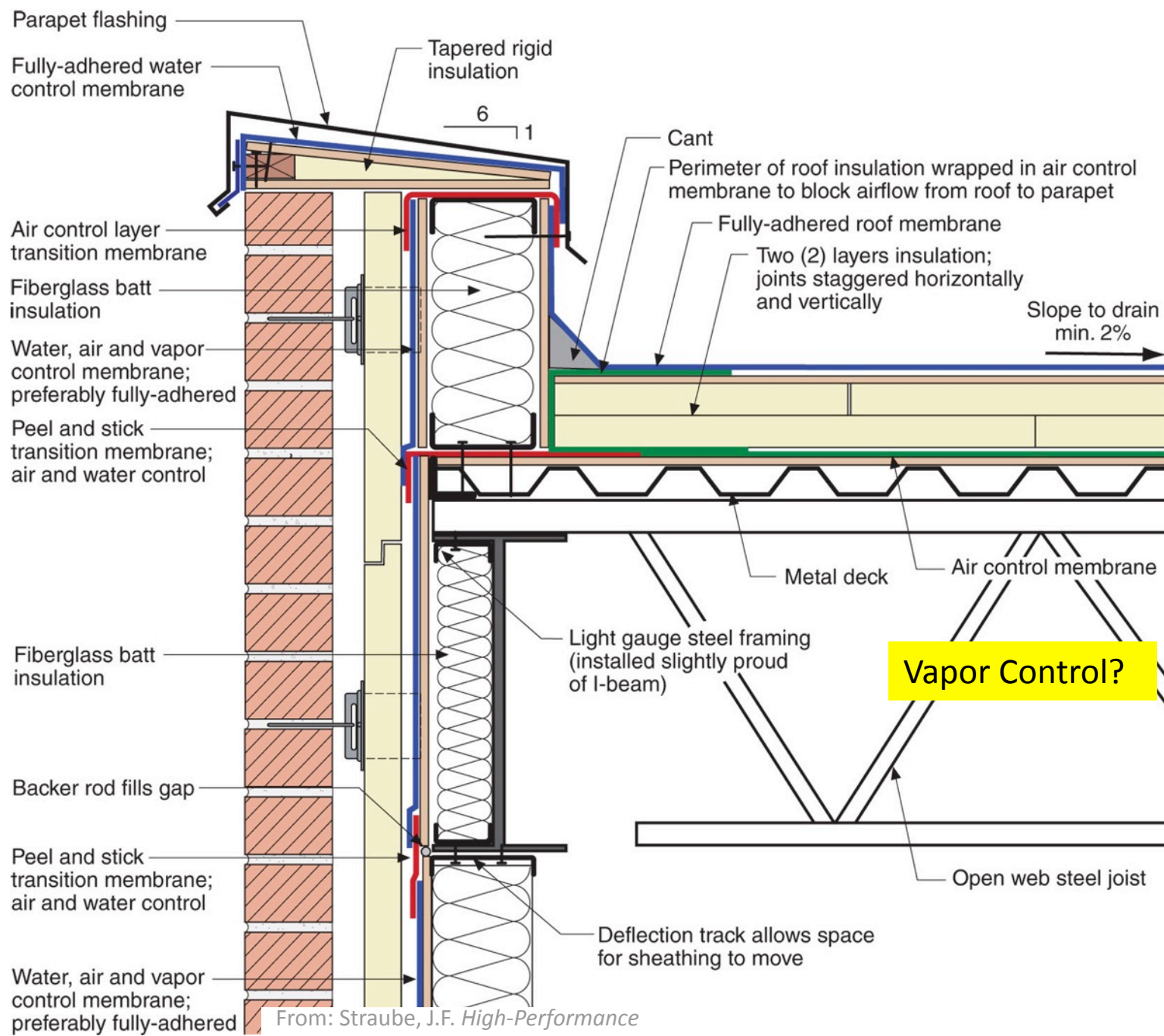
- Common failure location
- Usually wrap roof membrane over





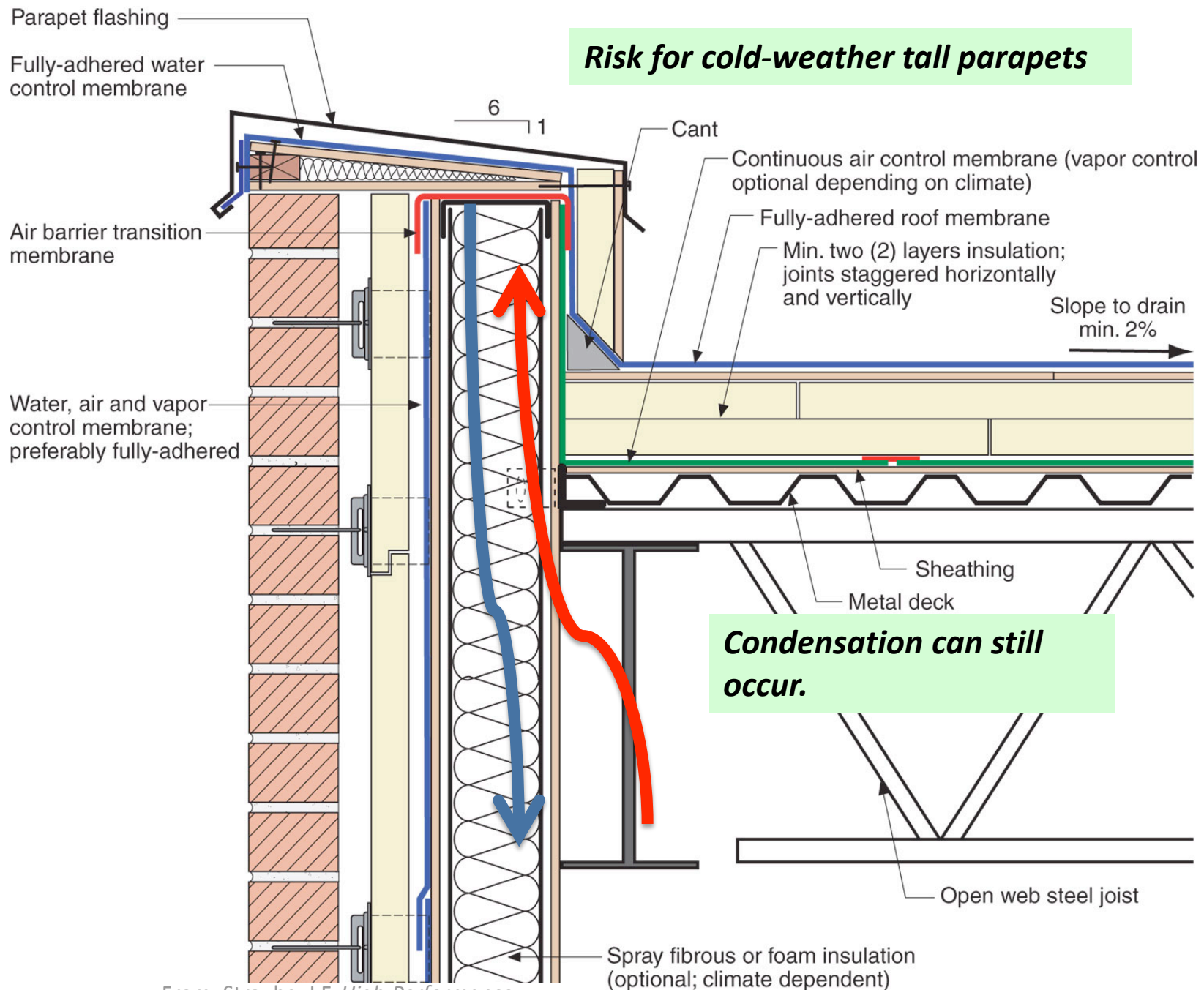


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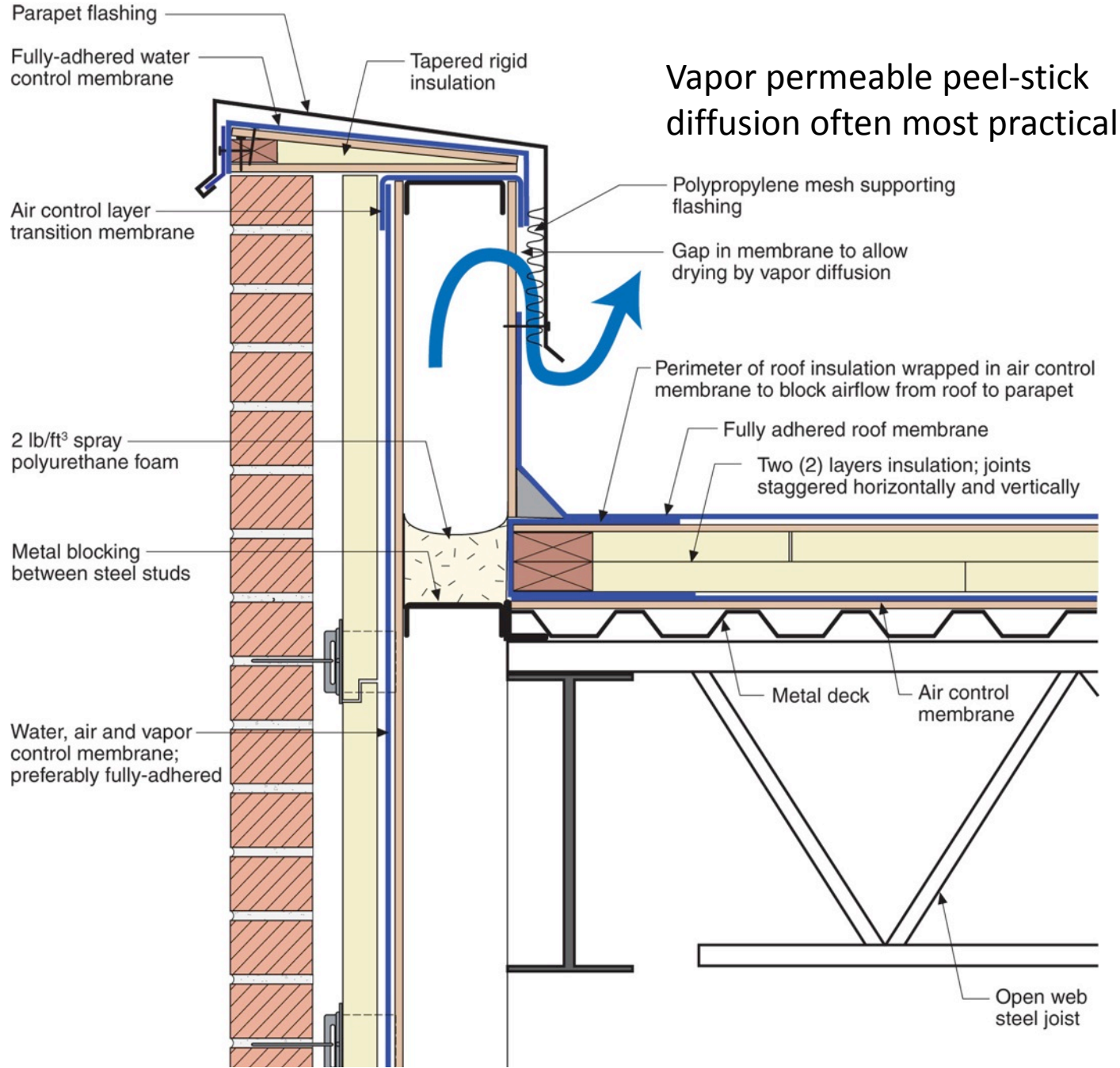


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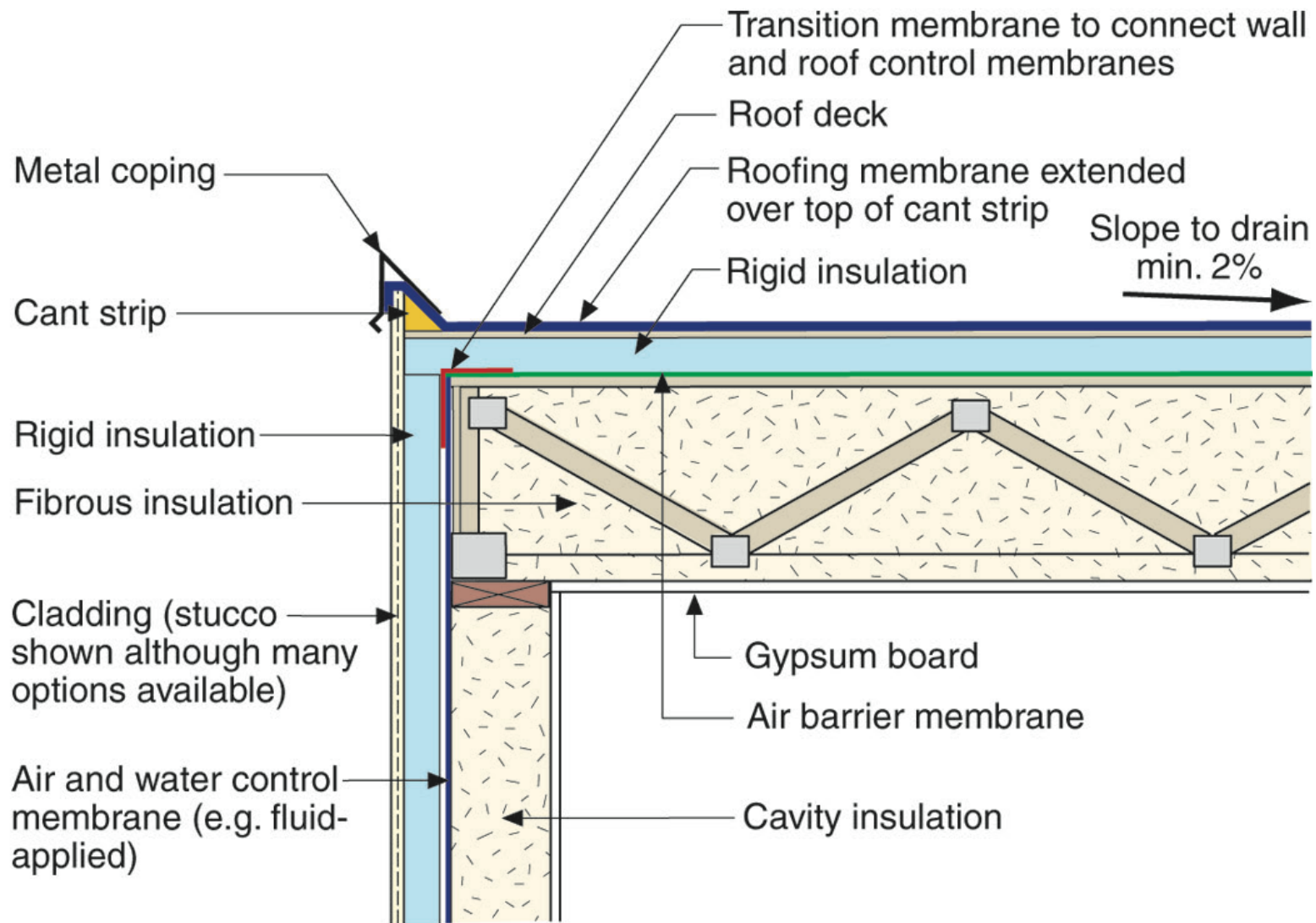




**Condensation can still occur.**



From: Straube, J.F. *High-Performance Enclosures*, Building Science Press 2012.



From: Straube, J.F. *High-Performance Enclosures*, Building Science Press 2012.

# Conclusions / Summary

- Good slope is critical
- *All* low-slope roof membranes benefit from lower temperatures and UV protection
- Cool roofs are cooler... so condensation risks increase
- Now need a deck-level air barriers
- Fully-adhered membranes are best
- Vapor Control, *not* Vapor Barriers



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