

Identifying Construction Defects and Damage through Destructive Testing

Presented to:

Cooper & Scully

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NELSON
FORENSICS

About the Presenter

Licensed Professional Engineer in 4 states

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Publications

The Importance of Destructive Testing for Identifying Concealed Resultant Structural Damage


Flashing of Curtainwall and Storefront Systems in Commercial Applications



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Project Director


Goals



- Increase proficiency in the building envelope
 - Explore common deficiencies in the building envelope that permit water intrusion
 - Evaluate when destructive testing can be beneficial
 - Examine case studies for the investigation of claims related to construction defects
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Building Envelope



- Components of a building that separate outside from inside
 - Roofing
 - Wall Assembly
 - Cladding and Veneer
 - Water-Resistive Barriers (WRB)
 - Waterproofing
 - Flashing
 - Window Wall Systems
 - Prevents air and water flow
 - Interior climate control and energy efficiency
- 

Steep-Slope Roofing



Low-Slope Roofing



Wall Assemblies

Barrier Systems



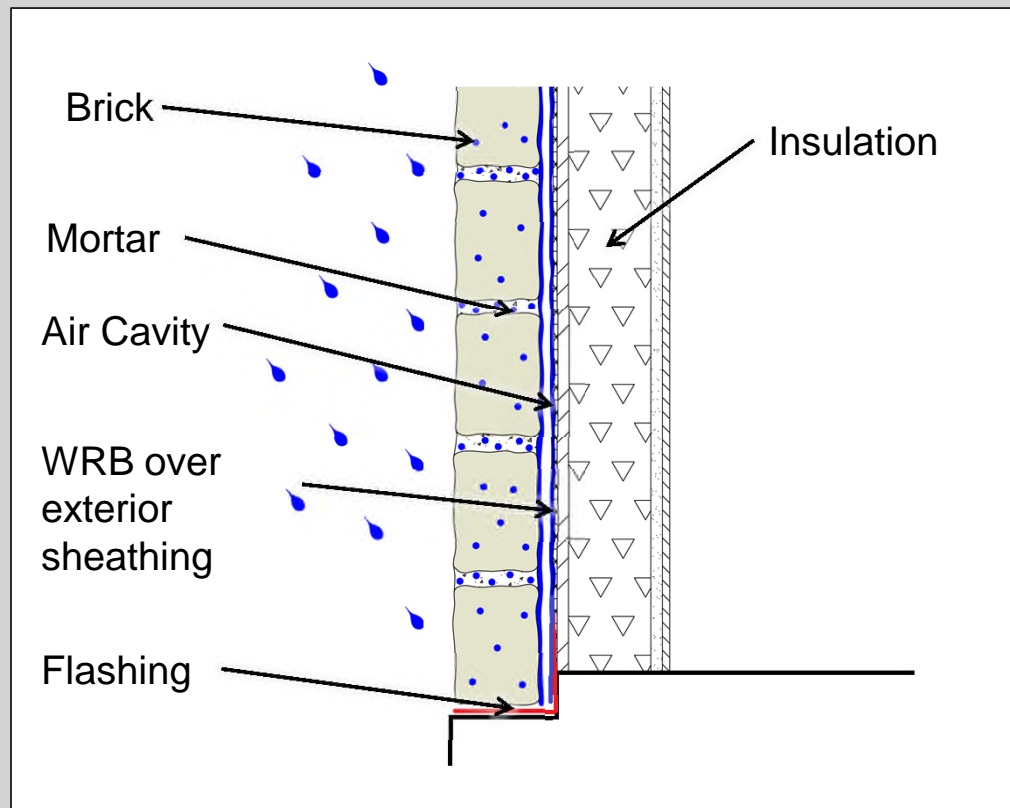
Drainage Plane Systems



Wall Assemblies



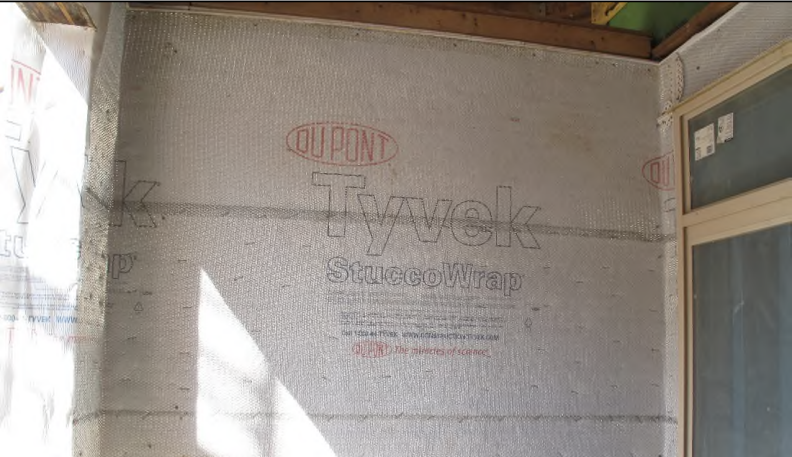
Cavity Wall Drainage Plane Systems



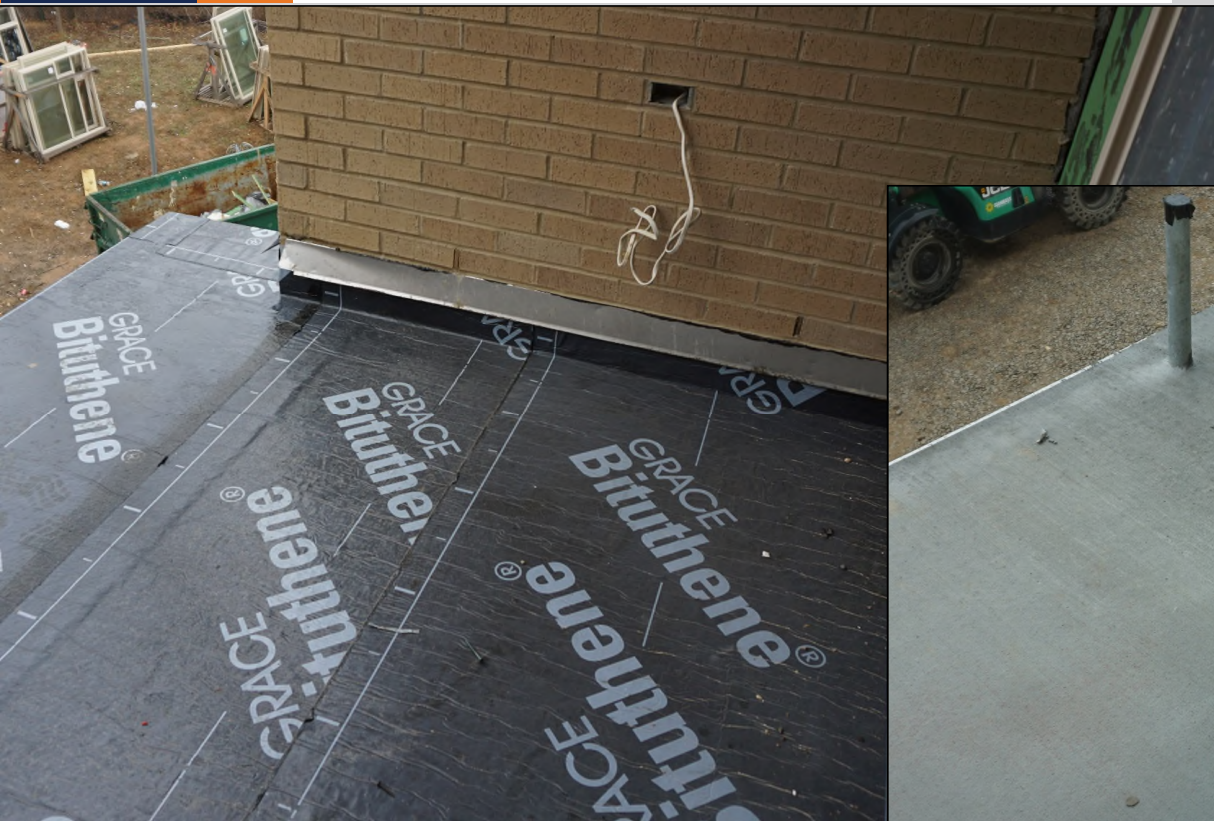
Cladding and Veneer



Water-Resistive Barriers



Waterproofing



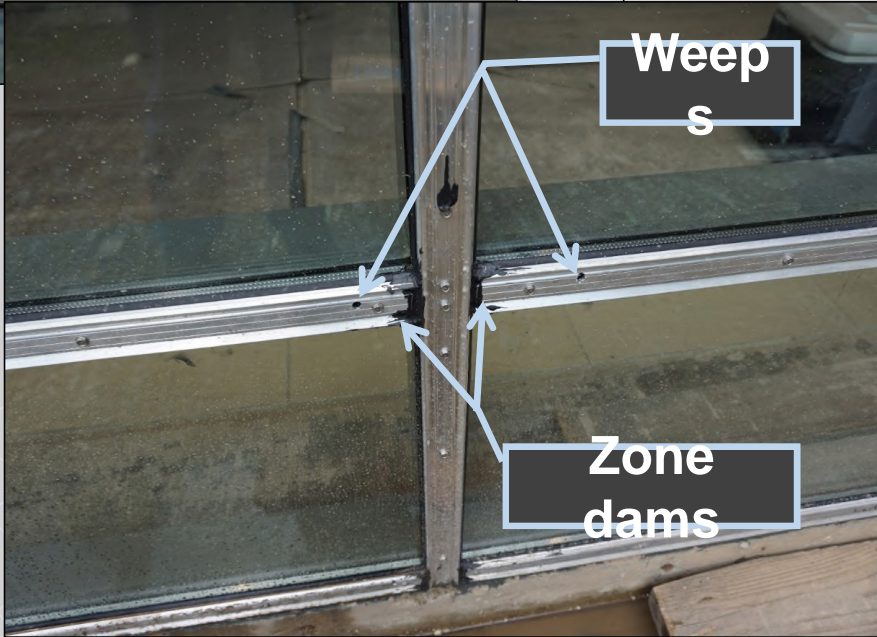
Flashing



Curtainwalls




Photograph by KUT
<https://www.kut.org>



Storefronts



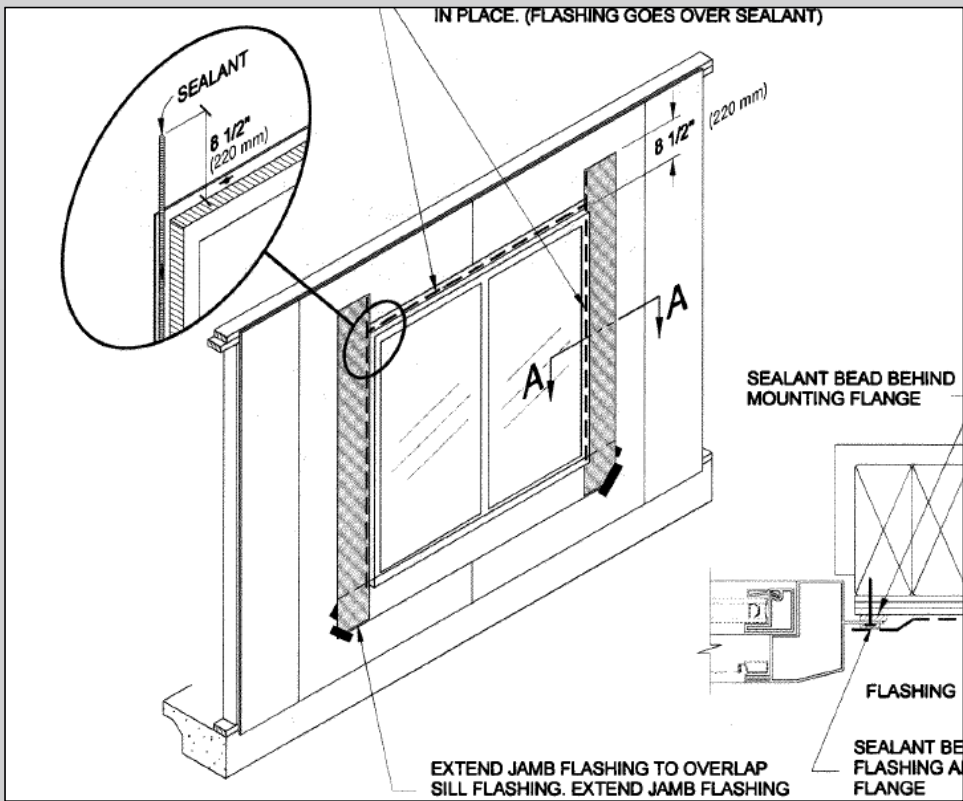
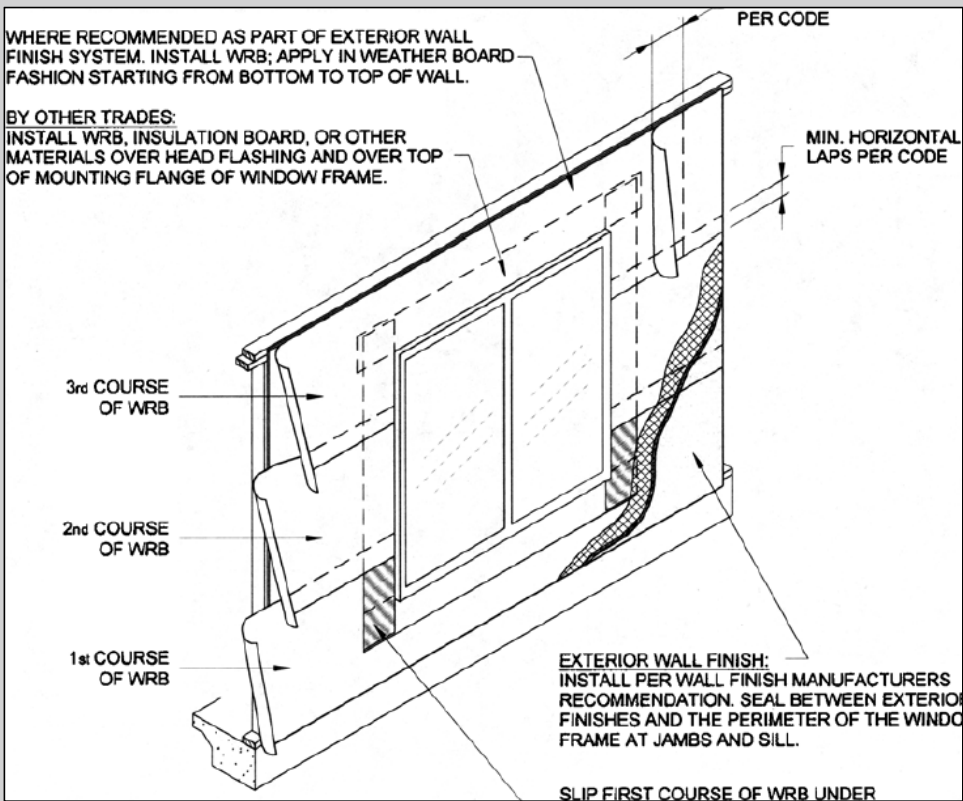
Building Envelope Deficiencies

- Building Code
 - Industry Standards
 - Manufacturer Instructions
 - Common Deficiencies and Examples
- 
- A decorative grid pattern consisting of thin, light gray lines forming a mesh that curves and tapers towards the bottom right corner of the slide.

Building Code

- Minimum requirements to safeguard the public safety, health, and general welfare
- International Residential Code: Wall construction, wall covering, roof assemblies
- International Building Code: Exterior walls, roof assemblies and rooftop structures, gypsum board, gypsum panel products and plaster
- Flashing is required to divert water to the exterior
- References ASTM standards for product requirements and installation

Industry Standards



Steep-Slope Roofing Industry Standards

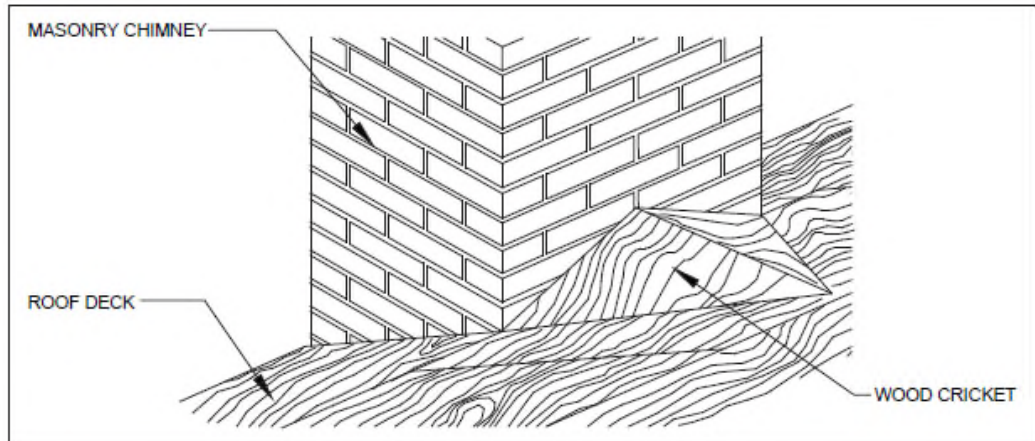


Figure 3-15: Wood cricket built on upslope of a chimney

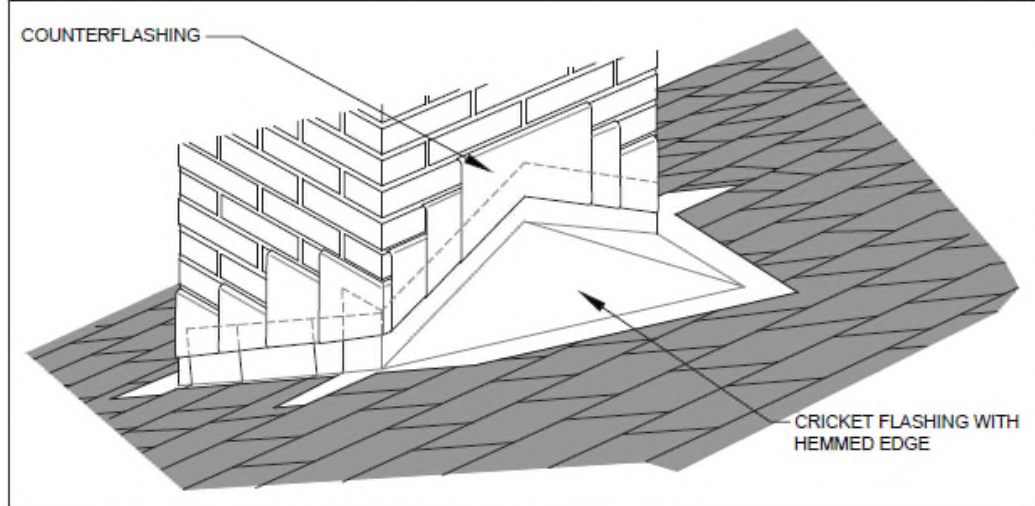


Figure 3-16: Metal cricket flashing for the upslope of a masonry chimney

Low-Slope Roofing Industry Standards

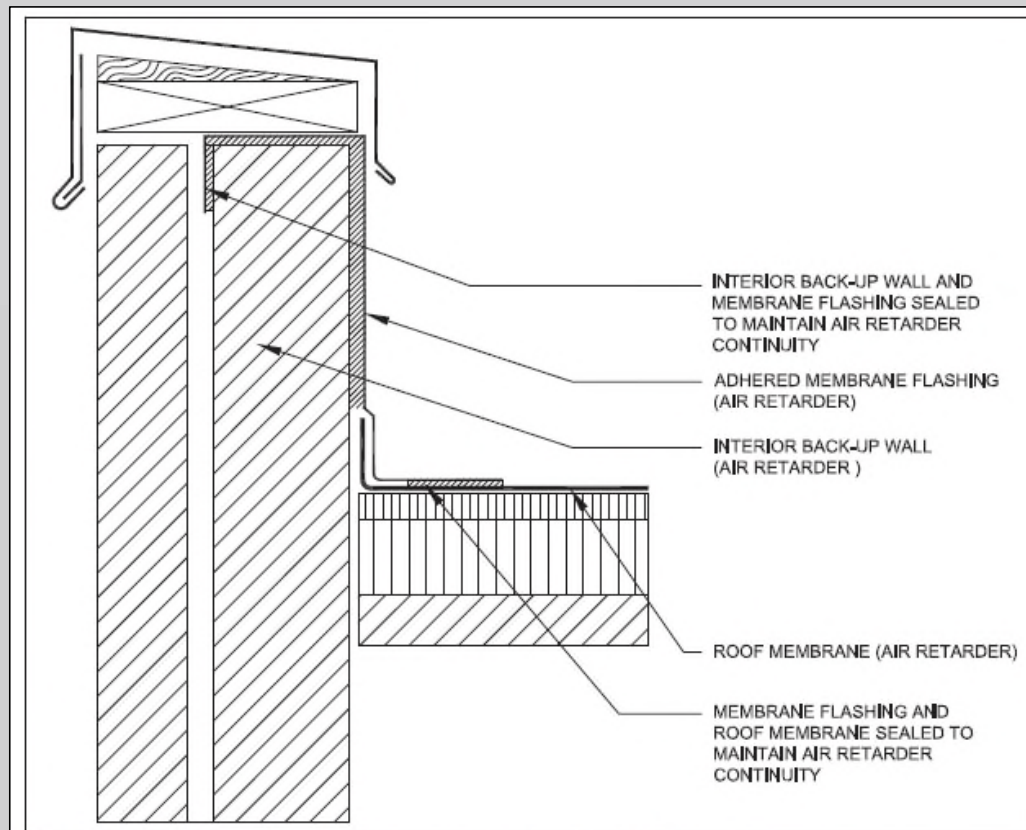
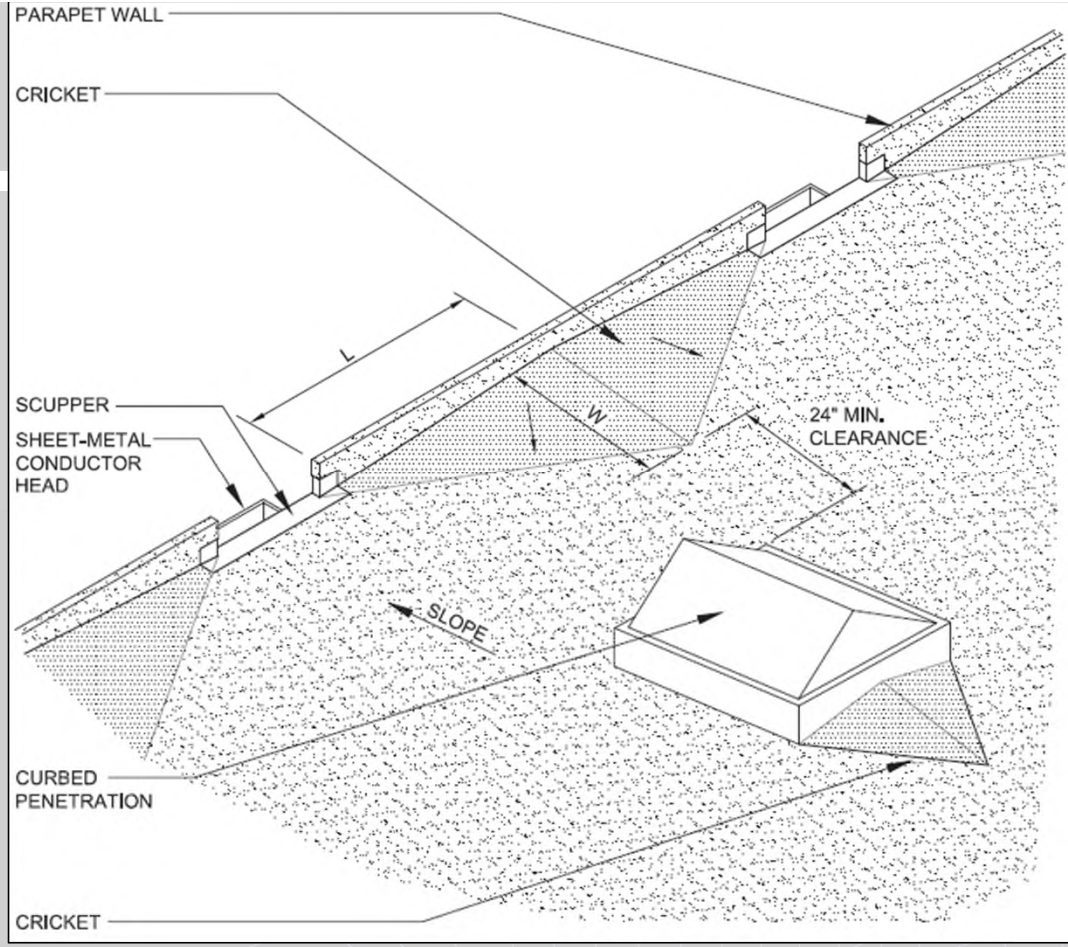
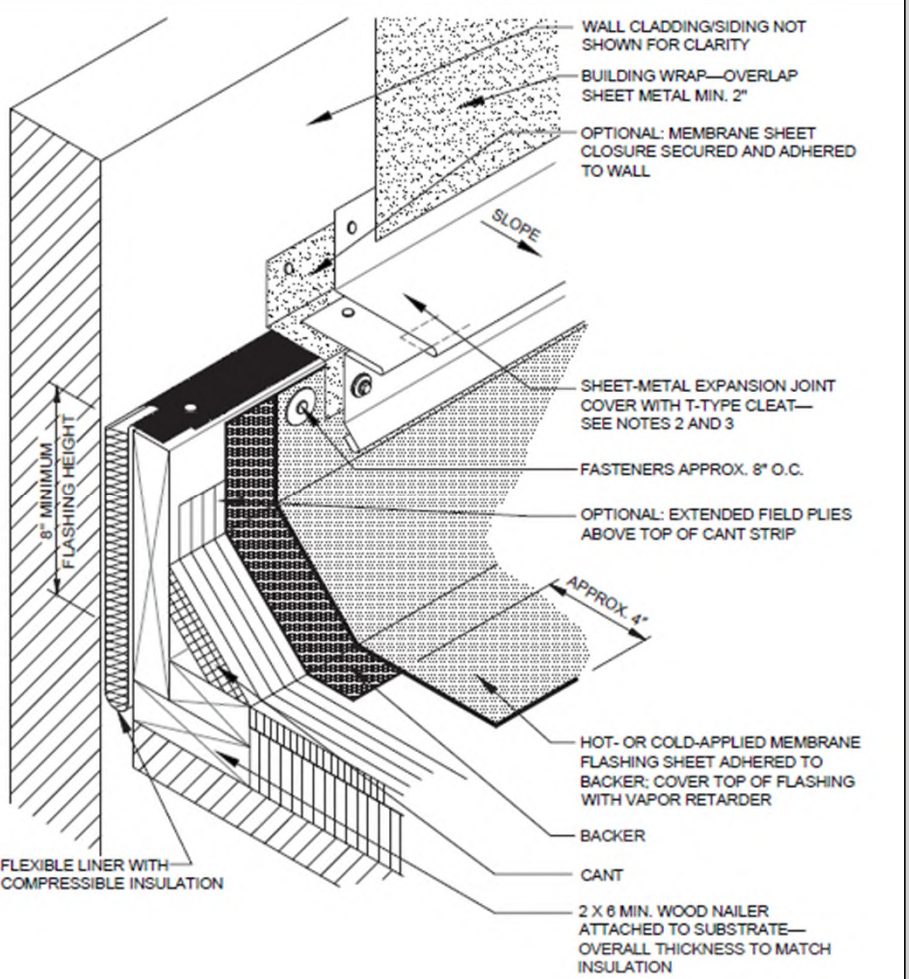


Figure 4-8: Air retarder assembly at roof-to-wall transition: parapet with metal coping (option 3)

Low-Slope Roofing Industry Standards



Indications of Distress

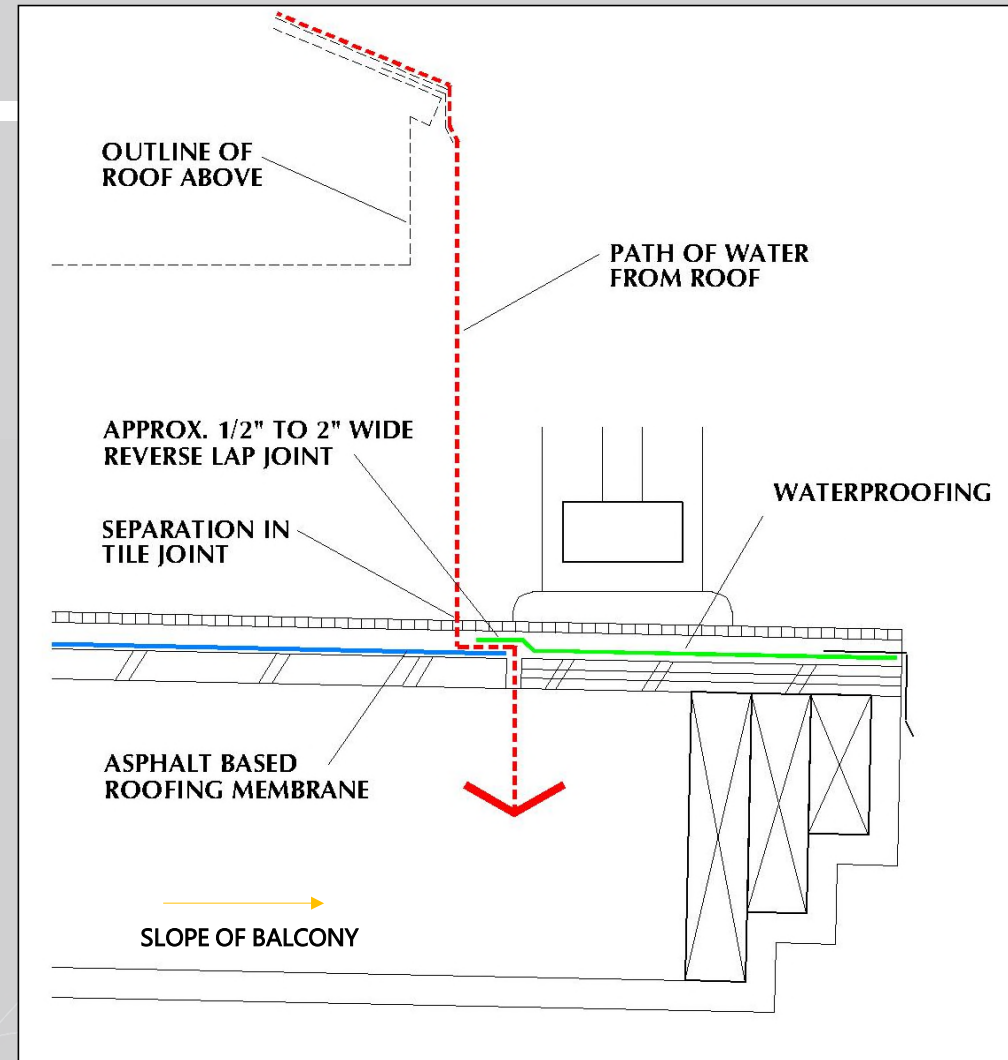


Indications of Distress



Improper Drainage Path

- Flashing and waterproofing concealed by finishes
- Discontinuity of the drainage path
- Water infiltration at the reverse-lapped joint from the roofing membrane to the waterproofing at the edge of the balcony



Lack of Drainage Provisions

- Weepholes
- Weep screeds
- Clearance above impermeable surfaces



Improper Installation of Materials



Improper Installation of Materials



Improper Installation of Materials



Improper Installation of Materials



Degradation of the Building Envelope



Displacement of Building Envelope



Resultant Damage

- 58 mph winds
- Pattern of distress below window



Resultant Damage



Why Perform Destructive Testing

- To pinpoint cause of moisture distress
- Corroborate non-destructive testing results
- Determine the extent of damage
- Evaluate as-constructed conditions

Unknown Specific Location of Water Infiltration



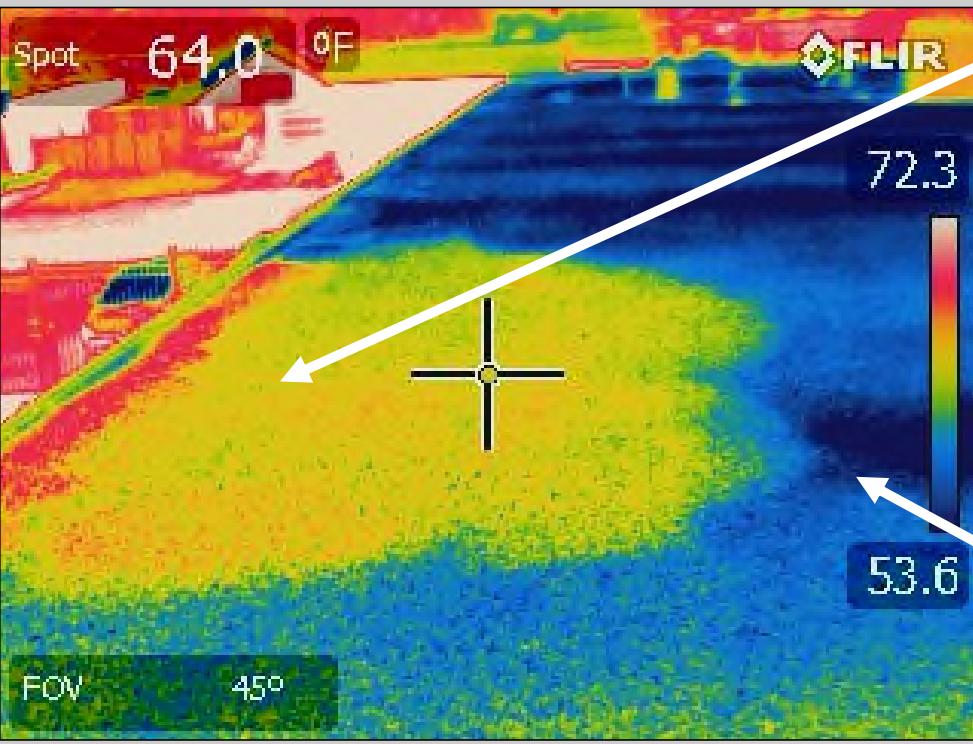
Non-Destructive Testing



Corroborating Non-Destructive Testing



Corroborating Non-Destructive Testing



Why Perform Destructive Testing?



Why Perform Destructive Testing?



Other Issues Identified through Destructive Testing

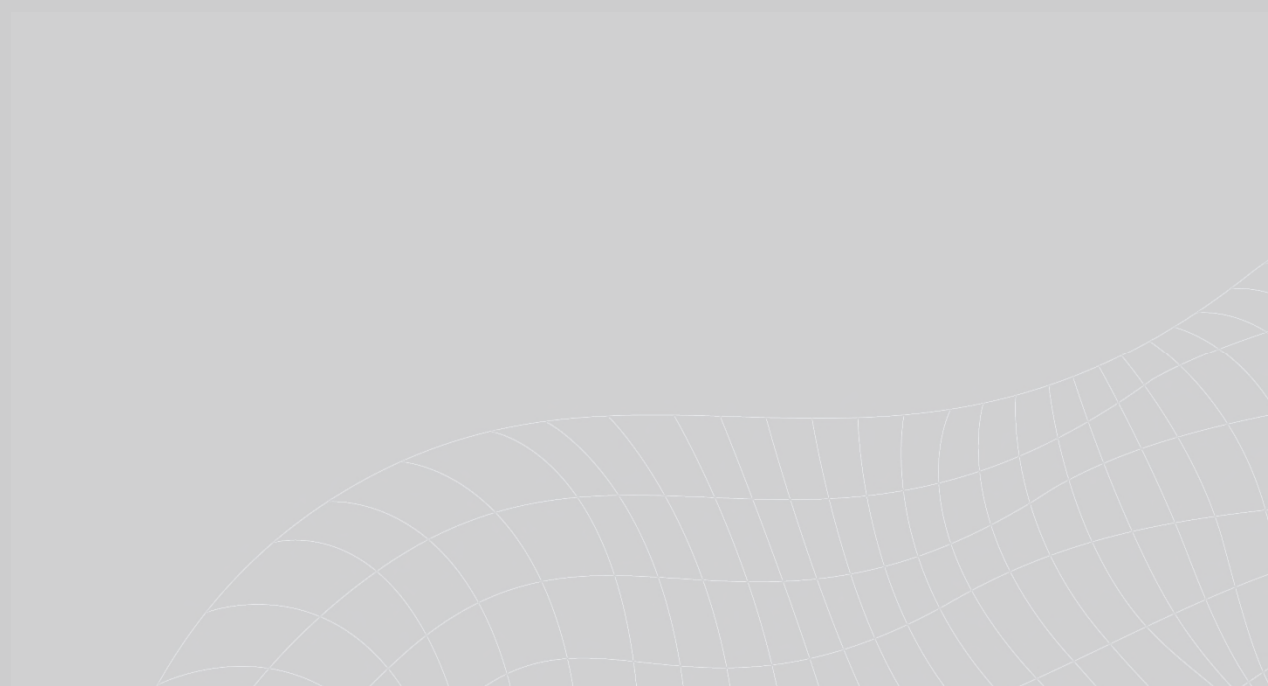


Mandatory Poll Question!!

When is destructive testing beneficial?

- a) Determine the source of water intrusion
- b) Evaluate the WRB and flashing
- c) Corroborate non-destructive testing results
- d) All of the above

Case Studies

- Mid-rise Condominium Building
 - Multi-Building Condominium Development
 - Single-Family Terrace
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- A decorative grid pattern consisting of thin, light gray lines forming a mesh that curves and tapers towards the bottom right corner of the slide.

Mid-Rise Condominium Structure

- Southeast Texas
- Four-story condo building
- Podium construction
- Built 2008
- Stucco and cementitious siding



Interior Moisture Distress



Window Observations

- No deterioration of the stucco
- Some areas of staining and cracking
- Suspected organic growth between the stucco and EIFS banding



Deterioration at the OSB Sheathing



Stucco-Clad Balconies and Columns

- Limited fractures at corners
- No pattern of deterioration visible at the stucco
- No possible resultant interior moisture staining



Limited Separations and Staining at Balcony Perimeters



Destructive Testing Results

- One layer of building paper
- Deteriorated wood sheathing
- Deteriorated wood framing



Deteriorated Sheathing and Framing



Complete Deterioration of Balcony Framing



Life-Safety Concerns at the Balcony Framing



Determining the Extent of Damage



Multi-Building Condominium Complex

- North Texas
- Varying design/layout
- Built in phases
- Adhered stone veneer, stucco, and composite siding



Moisture Intrusion at the Interior



Deterioration at the Windows

- One layer of building paper behind the stucco and adhered stone veneer
- Incomplete flashing around the windows
- Deteriorated sheathing
- Moisture-stained framing
- Isolated areas of deteriorated framing



Crushed Stucco at the Balcony Columns



Building Envelope Deficiencies

- One layer of building wrap
- Discontinuous weather barrier
- Incomplete flashing
- Reverse-lapped flashing



Destructive Testing at Multiple Conditions



Additional Testing and Temporary Shoring



Varying Degrees of Damage



Central Texas Terrace

- Built in 1929 with multiple renovations since
- Reported moisture distress around the terrace



Moisture Distress and Replaced Framing Below



Removed Slate Pavers to View Wall and Terrace Interface



Openings Above Replaced Framing

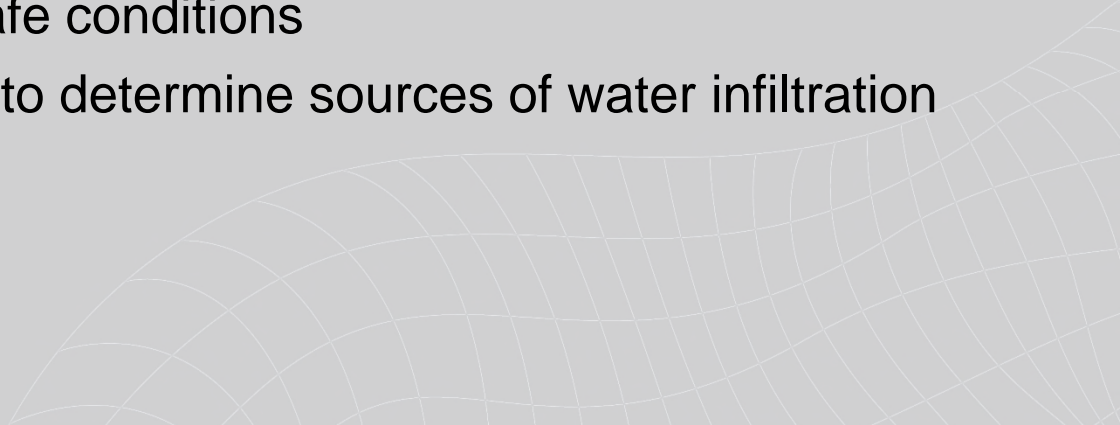


Discontinuous Flashing and Negative Drainage



Closing



- Construction defects may not correlate with visible distress at the interior or exterior
 - Distress to the sheathing or framing may occur before distress manifests at the finishes or cladding
 - Water intrusion can be related to multiple factors
 - Some conditions conducive to interior or framing distress are visible without removing any finishes
 - Construction defects can lead to unsafe conditions
 - Destructive testing can be necessary to determine sources of water infiltration
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Thank you!

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