



Building Envelope Inspection

**Georgia Institute of Technology
Facilities Design & Construction
Friday July 2, 2021**

Learning Objectives

- **Building Envelope Inspection**
 - Why
 - Inspection Protocol
 - Roofing/Façade/Below Grade Construction
 - Reporting

AIA
Continuing
Education
Provider

Innovative Engineering, Inc.



- **Scott L. Weiland PE SE**
 - **BSCE University of Michigan**
 - **Graduate Studies:**
 - San Jose State University
 - Georgia Institute of Technology
 - **Level I sUAS Thermographer**
 - **BESI Building Envelope Certified Level 2**
 - **Haag Certified Inspector – Commercial Roofs**
 - **Articles:**
 - **IFMA FMJ Magazine** – Legionnaires' Disease: COVID-19 for Buildings?
 - **Structure Magazine** – Building Façade Inspection Part I & II
 - **Georgia Engineer** – Building Façade Inspection Part I & II
 - **AIA Design Equilibrium** – Building Façade Inspection
 - **BOMA Georgia Insight Magazine** - Falling Building Façade Closes Atlanta Streets



Innovative Engineering, Inc.



- **Trey Thomas PE**
 - **BSCET, Southern Polytechnic State University**
 - **15 Years in Design and Restoration Engineering**
 - Co-author of Forensic articles
 - **OSHA Qualified Fall Protection Engineer**
 - **OSHA Competent Person for Boom & Scissor Lifts**
 - **SPRAT Level 2 Rope Access Technician**
 - **FAA Part 107 Remote Pilot Certificate**
 - **FAA Part 107 Daylight Waiver**
 - **Level I Thermographer**
 - **Expert estimator (within 5% of actual)**

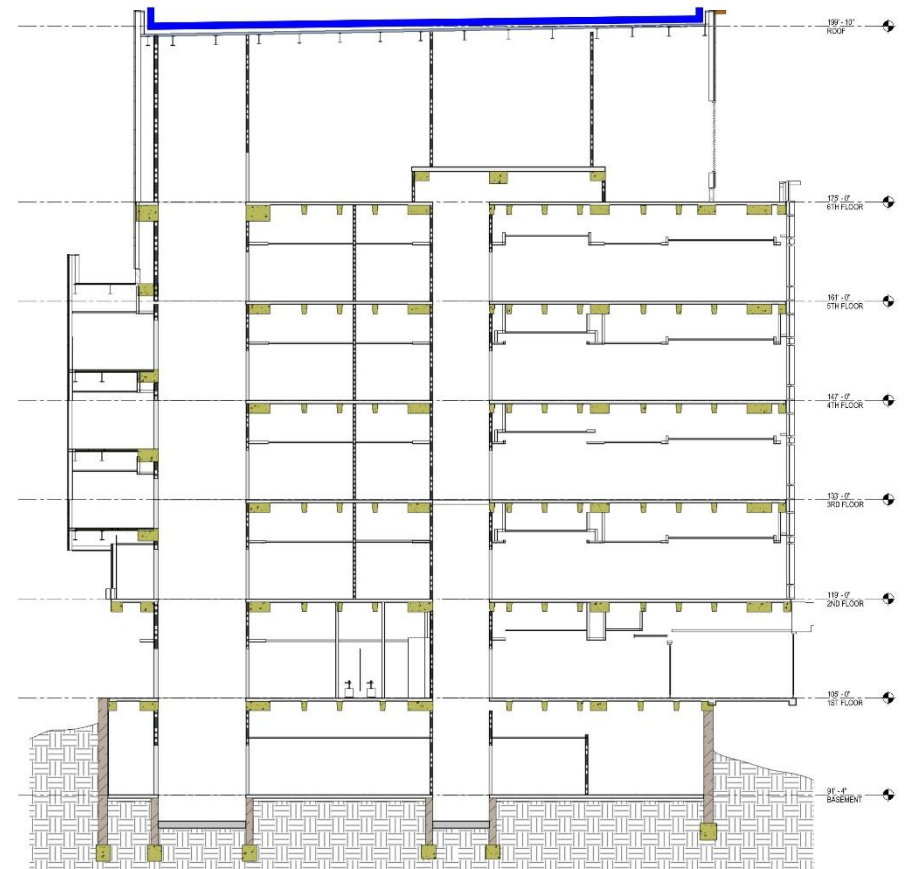


Building Envelope - Definitions

Envelope



Roof

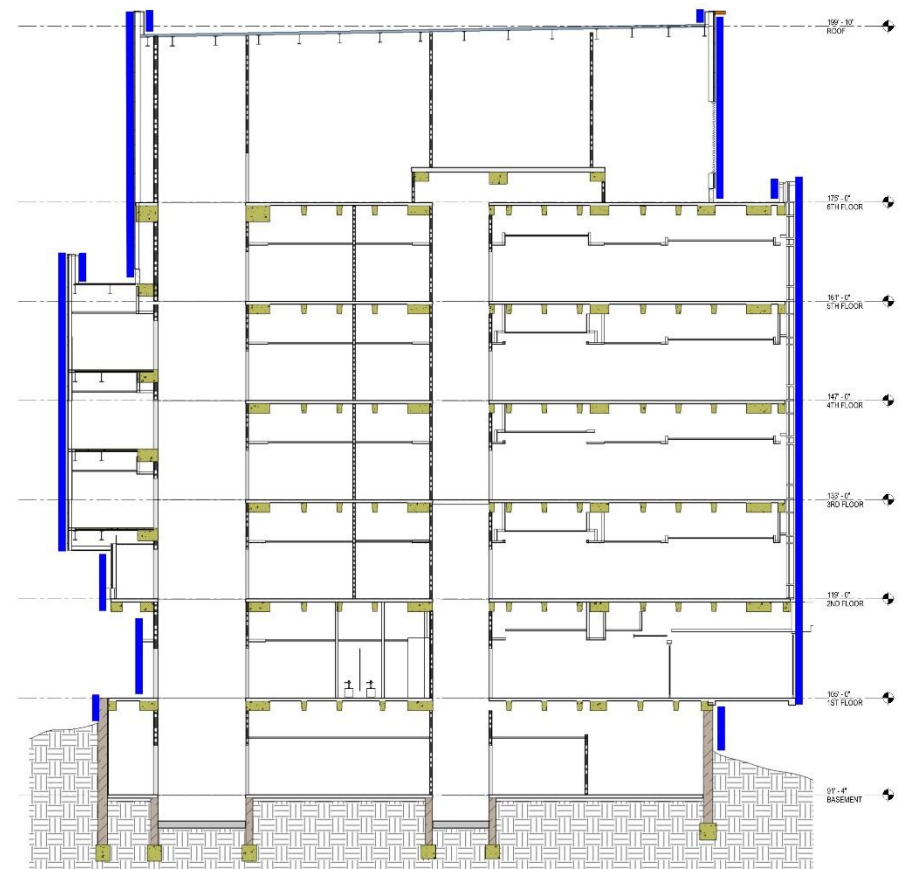


Building Envelope - Definitions

Envelope



Facade

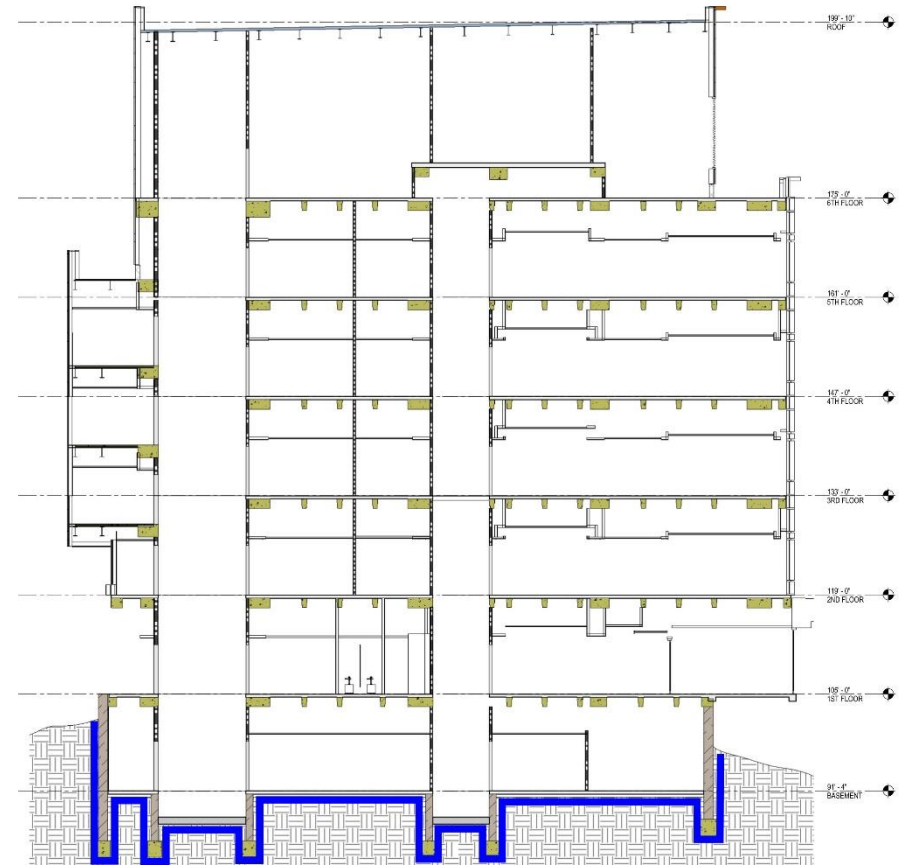


Building Envelope - Definitions

Envelope



Below Grade



Façade Cornice Collapse – 2017 Atlanta Sidewalk



Champlain Towers Collapse

- Built 1981
- 12 Story, 136 Units
- Appears to be Cast-In-Place Concrete
- Grade Level Parking Garage
- 2018 Report
- 40 Year Recertification Underway



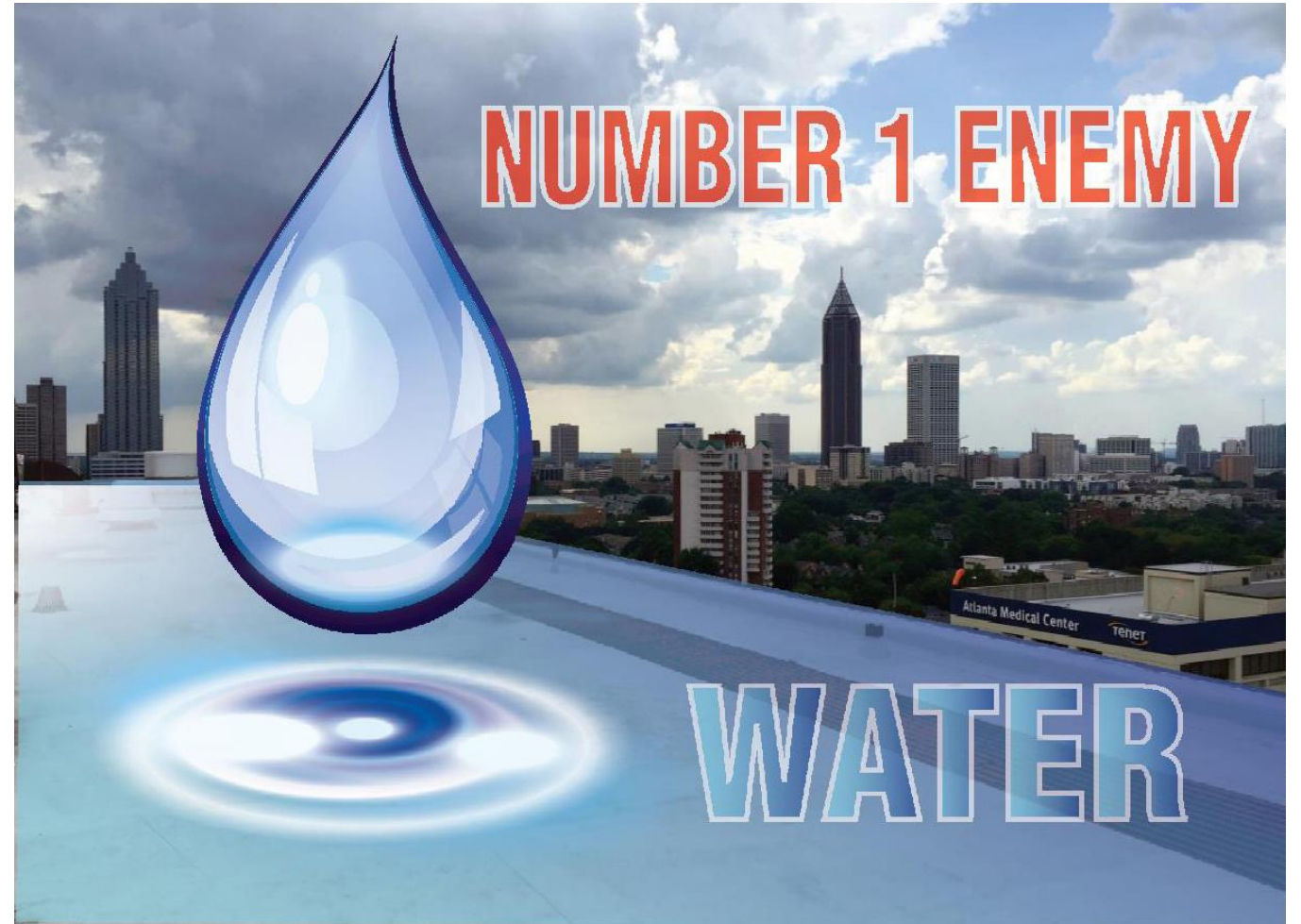
Building Science – Environmental Separator



- **Structural resistance to wind.**
- **Environmental protection from the elements, including moisture & temperature.**
- **Architectural appearance and aesthetics.**

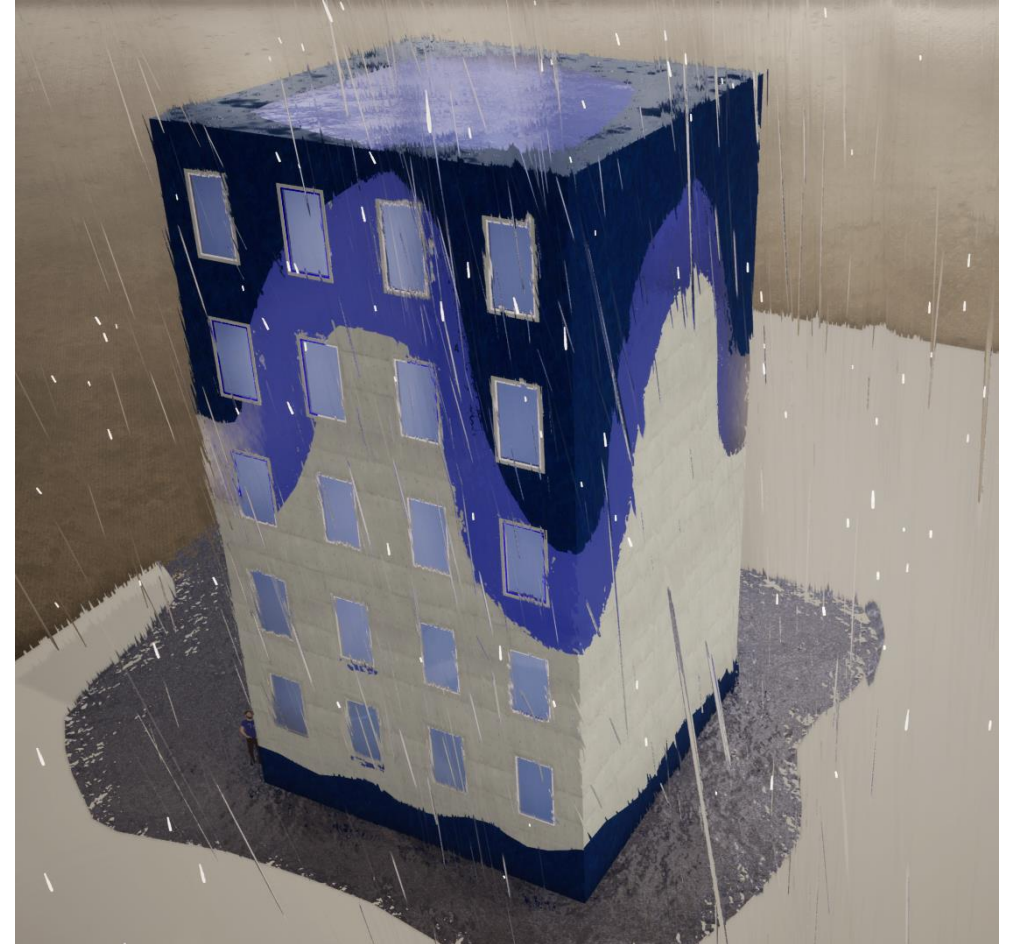
Building Science – Sources of Deficiencies

- **Natural Aging**
- **Leakage**
 - Roofing
 - Walls
 - Windows
 - Joints
- **Movement of Materials**
 - Thermal
 - Moisture
 - Elastic Deformation
 - Creep
- **Other (Short Term Exposure)**
 - Impact Damage
 - Lightning Strike



Building Science – Moisture Exposure

- **Water Intrusion: 70% of construction litigation**
- **Damage Functions**
 - Water
 - Heat
 - Ultra-Violet Radiation



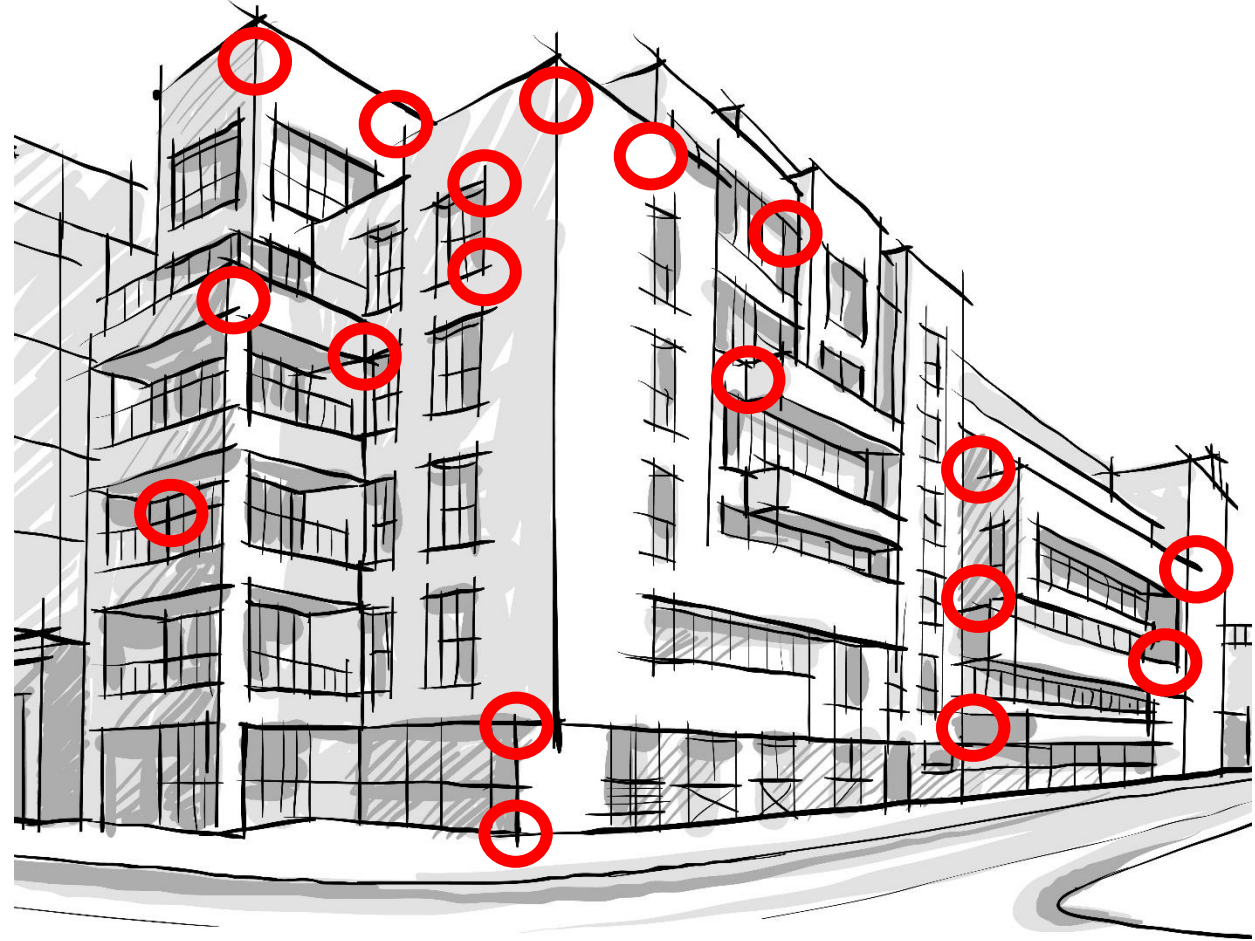
Building Science – Water Shedding



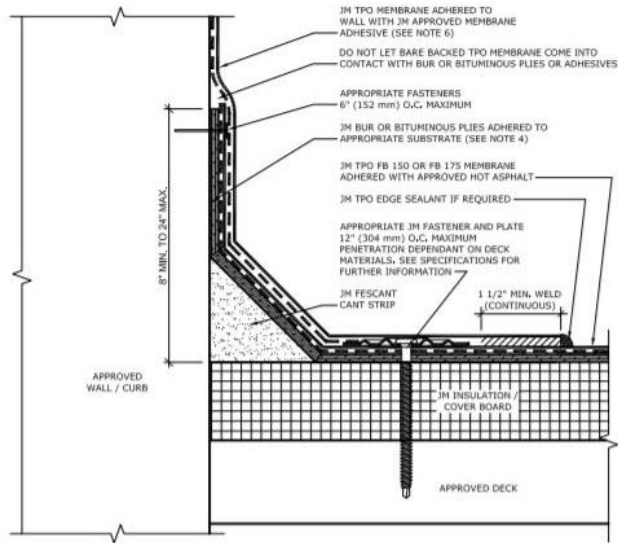
Building Envelope Inspection

Building Science - Principles

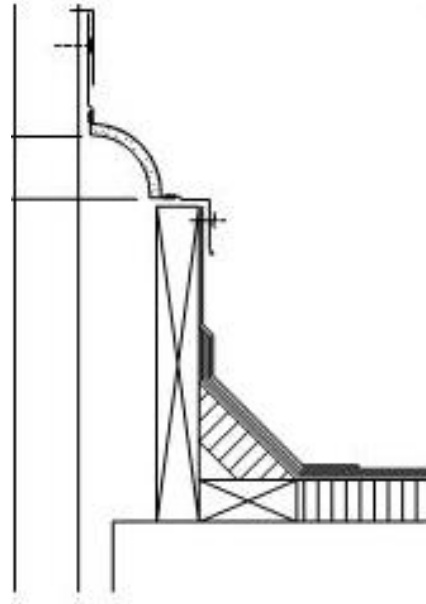
- **90%/1%**
 - 90% of the water intrusion problems occur within 1% of the total building exterior. Usually at terminations and transitions
- **99%**
 - 99% of water intrusion problems are attributable to human error including detailing, specifications, or installation. Not material or system failures.



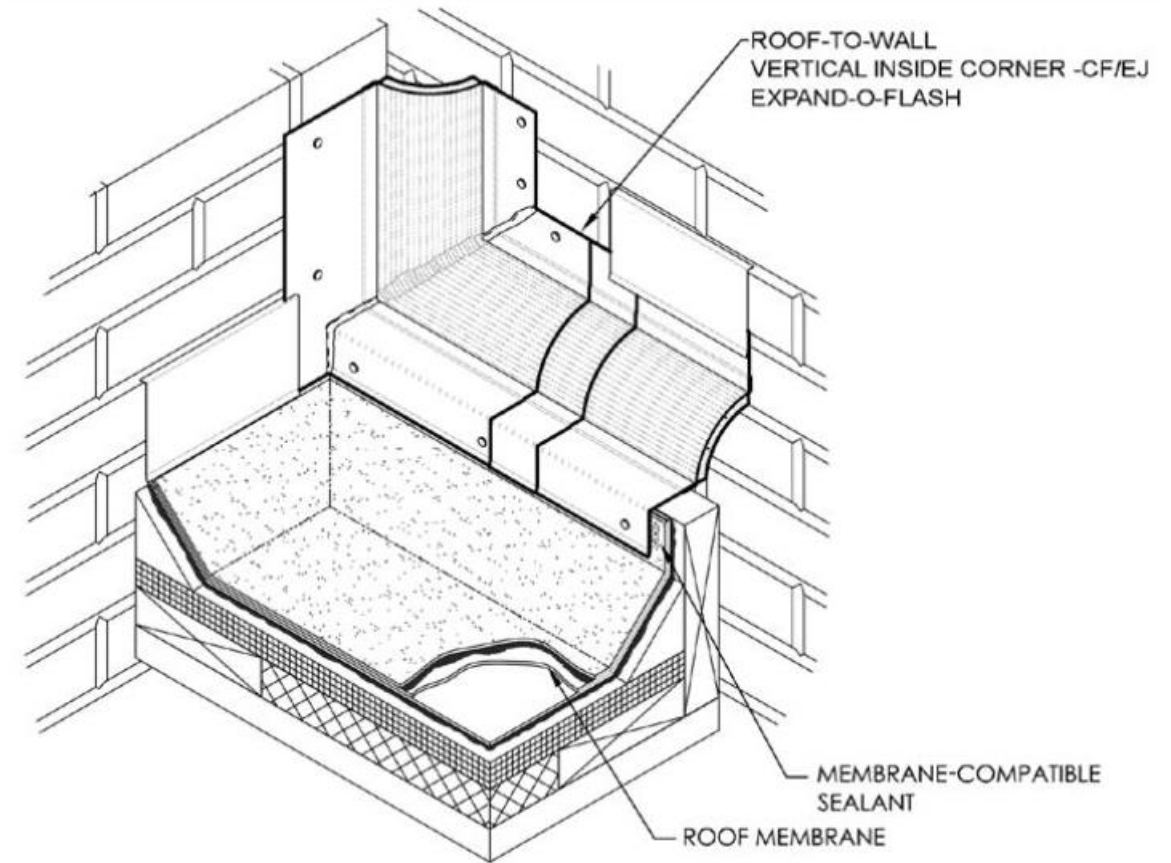
Building Science - Transition Details



2 D



3 D

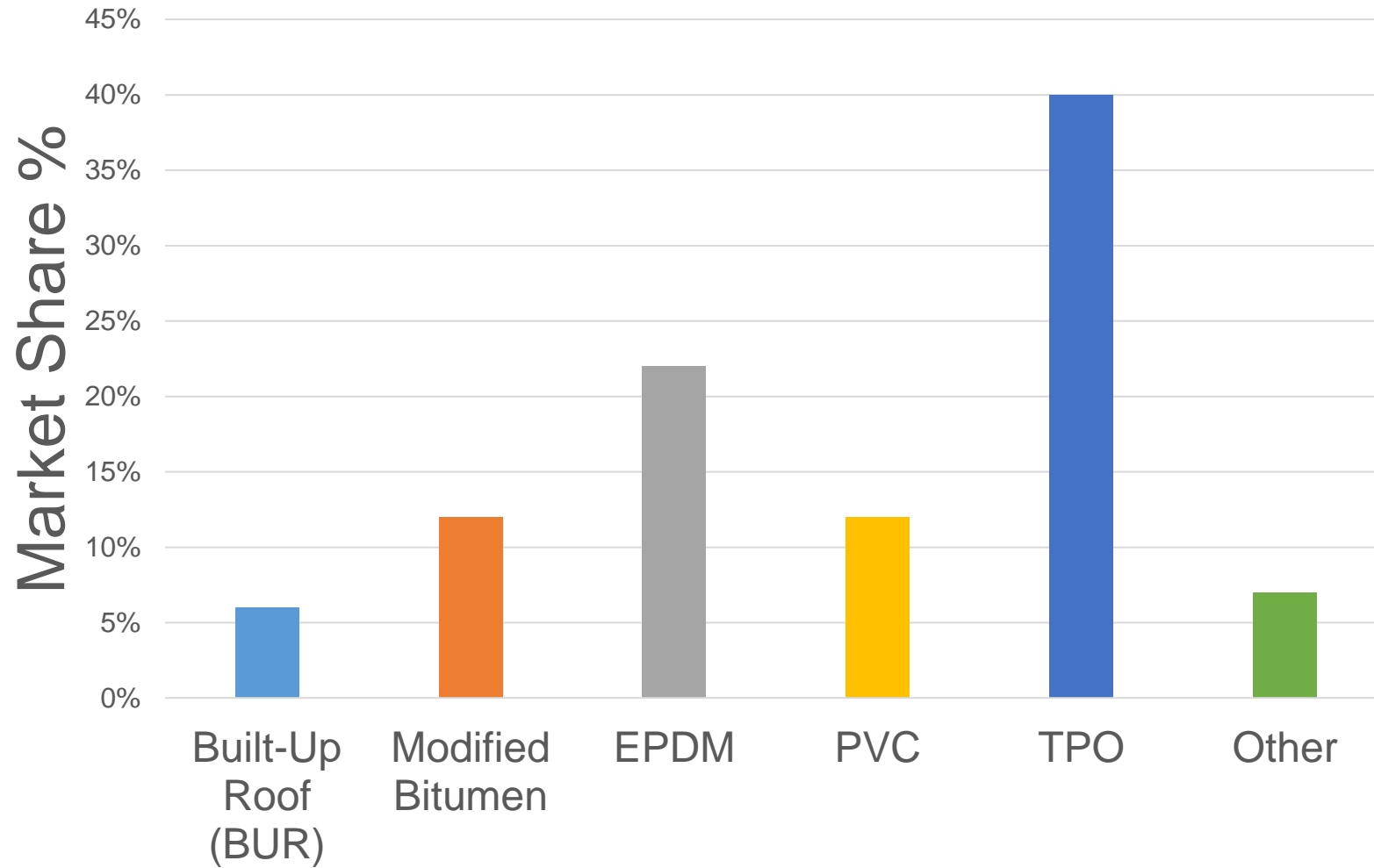


Inspection Protocol

- **Diagnose**
- **Prescribe**
- **Treat**

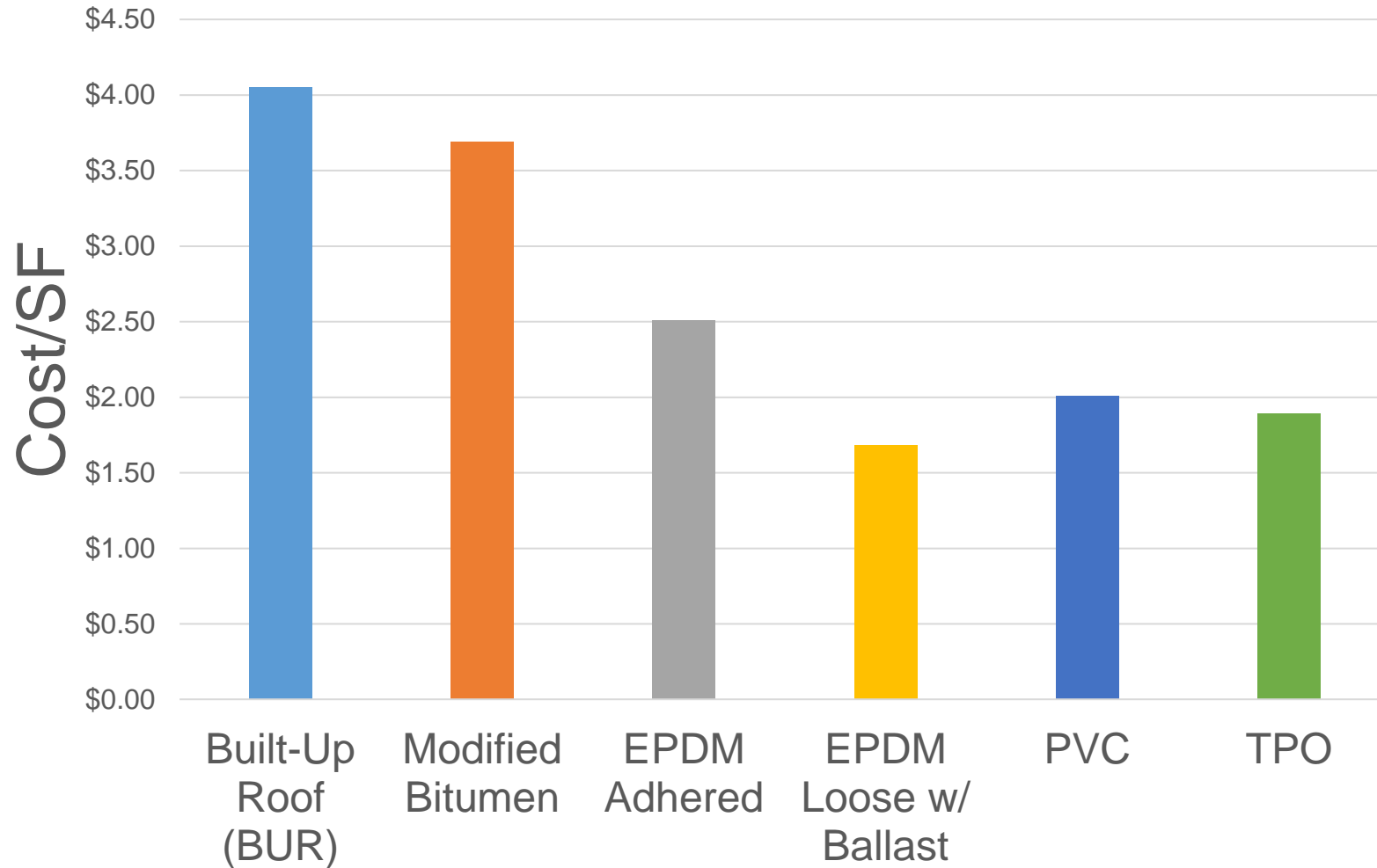


Roofing - Common Material Market Share



- Built-Up Roof (BUR)
- Modified Bitumen
- EPDM
- PVC
- TPO
- Other

Roofing - Common Material Cost Data



- Built-Up Roof (BUR)
- Modified Bitumen
- EPDM
- PVC
- TPO
- Other

Roofing - Natural Aging



Sealants



Roofing/Flashing

Roofing - Ponding



Ponding > 48 Hours

- **Ponding:** Most common factor in roofing failure
- **Water Shedding:** Can make up for shortcomings in design, construction, durability, & maintenance.
- **Degradation:** Asphalt & Polymeric materials
- **Freezing:** Erodes surface aggregate
- **Voids:** Manufacturers warranty

Roofing – Organic Growth

- Improper roof slope
- Improper drains, overflow drains, & overflow scuppers
- Clogged drains & scuppers
- Poor Housekeeping
- Roof collapse
- Promotes organic growth



Organic Growth

Roofing - Built-Up Roofing (BUR)



Blistering



Slippage

- **Blistering**
- **Splits**
- **Ridging/
Wrinkling**
- **Slippage**

Roofing - Modified Bitumen



- **Defective Lap Seams**
- Shrinkage
- Checking
- Blistering
- Delamination
- Slippage
- Splitting

Roofing - EPDM



- **Lap-Seam Failure**
- Flashing
- Other Common Problems – 8%
 - Puncture
 - Shrinkage
 - Wind Uplift
- Minor Problems @<3%
 - Fastening
 - Blistering
 - Embrittlement

Roofing - PVC



- **Embrittlement**
- **Puncture**

Photo by RCI

Roofing - TPO



Image by RCI

- **Premature Aging**
 - Erosion of Top Surface
 - Small Holes/Slits
 - Cracking
 - Separation
- **Seam Failures**
- **Newest Roofing Material**

Roof Inspection Protocol



- User interviews
- Document Research
- Attic/Plenum Survey
- IR Moisture Survey (Dusk)
- Confirmation Testing
- Visual Moisture Survey (Dawn)
- Reporting
- Estimating

Roof Inspection

- **Attic/Plenum Space**
 - Water Stains
 - Rust
 - Pipe leaks
 - Condensation



Roof Inspection - Drone Infrared

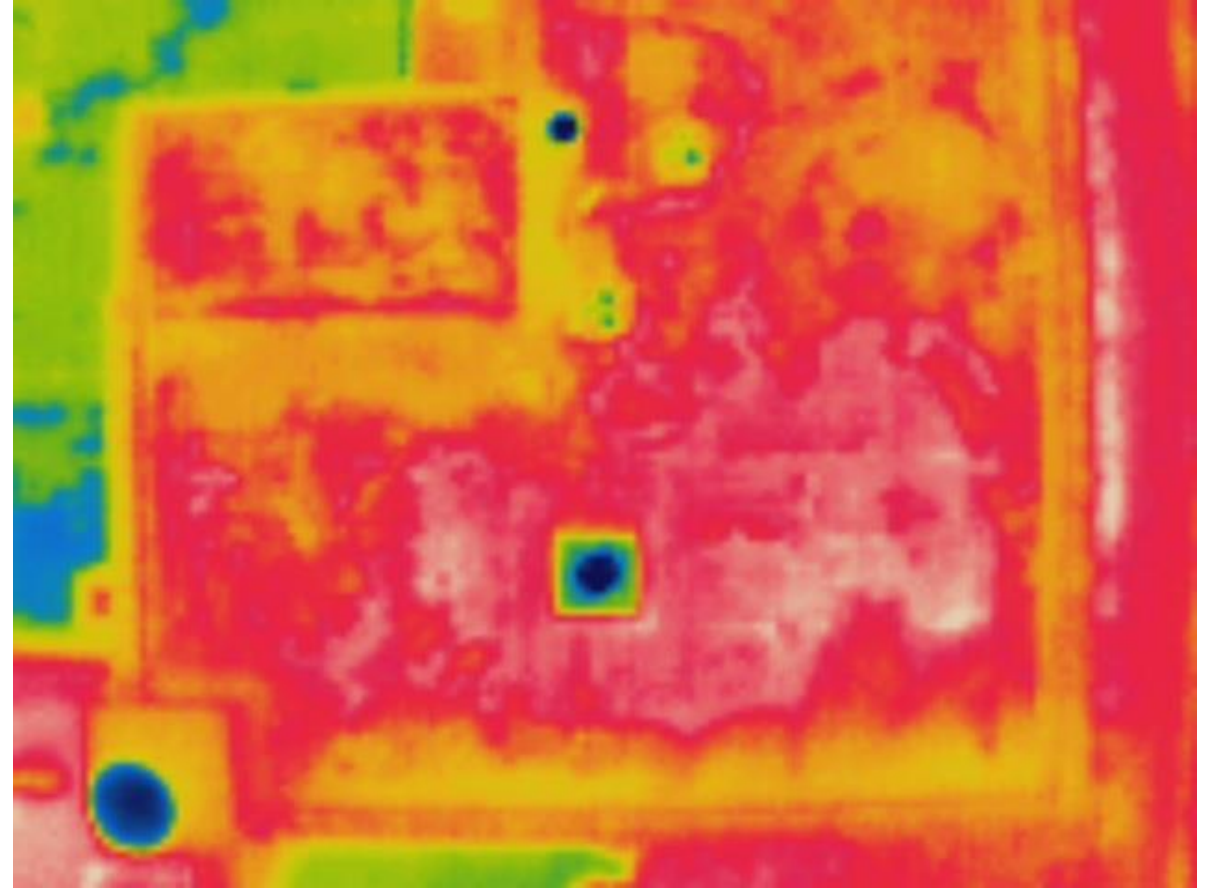
- Infrared Camera (IR)
- Best After Dusk
 - Insulation and Moisture Heats Up During the Day
 - Dry Insulation cools off faster than Wet Insulation
- Daylight Waiver Required
- Height to See Major Portions of Roof
- Safer and More Accurate than Handheld



Roofing Inspection – Thermal Imaging

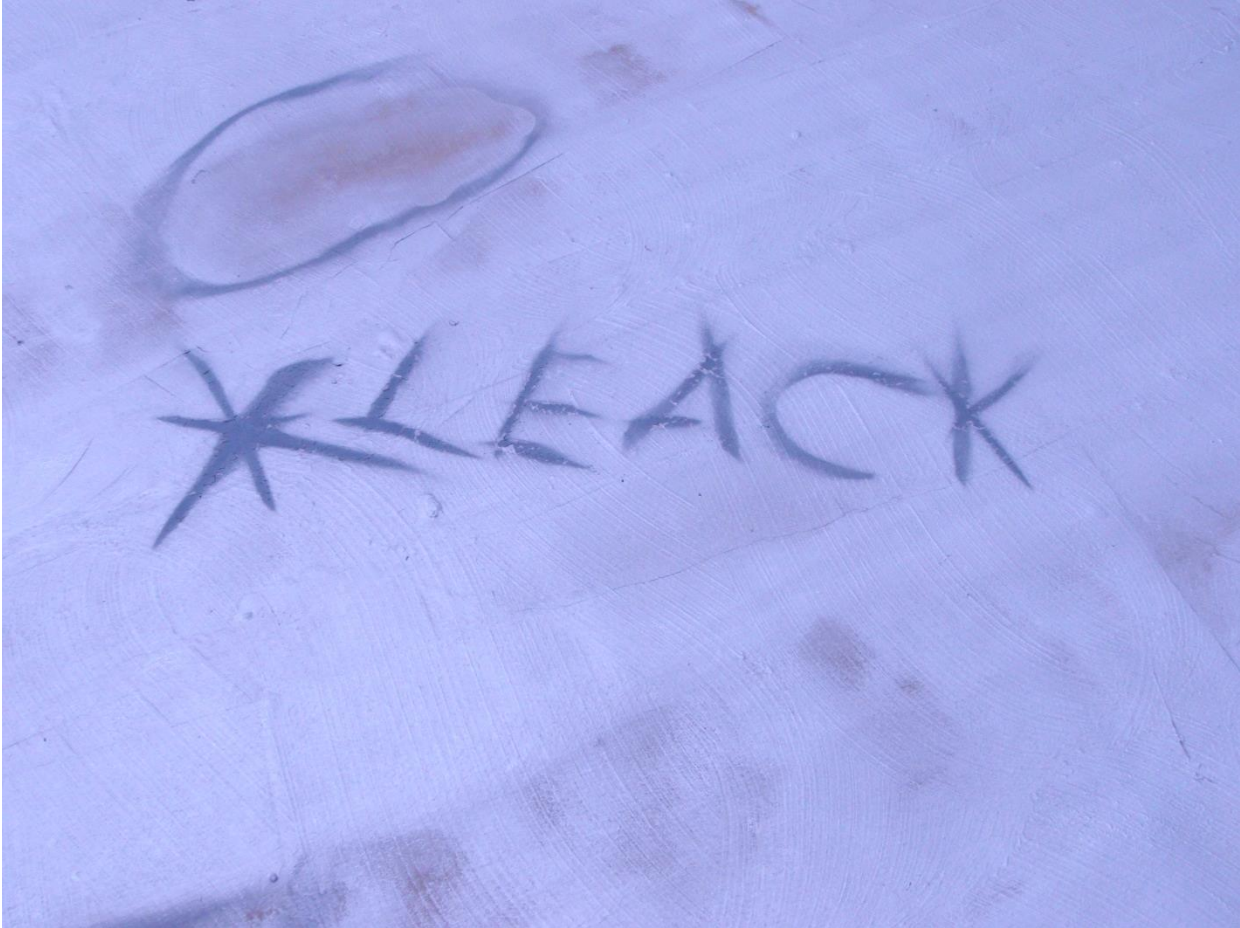


Visual Red-Green-Blue (RGB)



Infrared (IR)

Roofing Inspection – Visual at Dawn

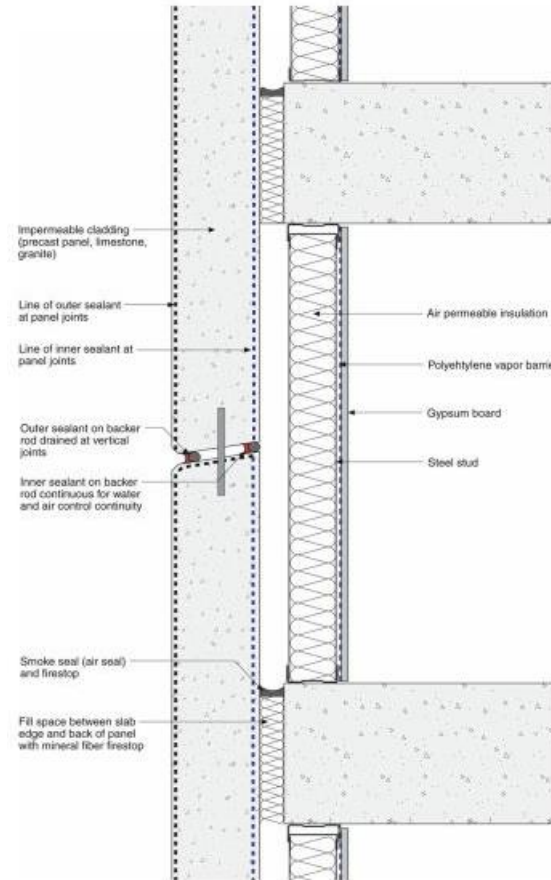


- Easiest when someone finds the leak for you.
- Membrane Deterioration
- Debris
- Ponding
- Wet spots
- Seams
 - Separation
 - Oozing Water
 - Oozing Bubbles
- Flashing
- Holes, Punctures, Other Damage

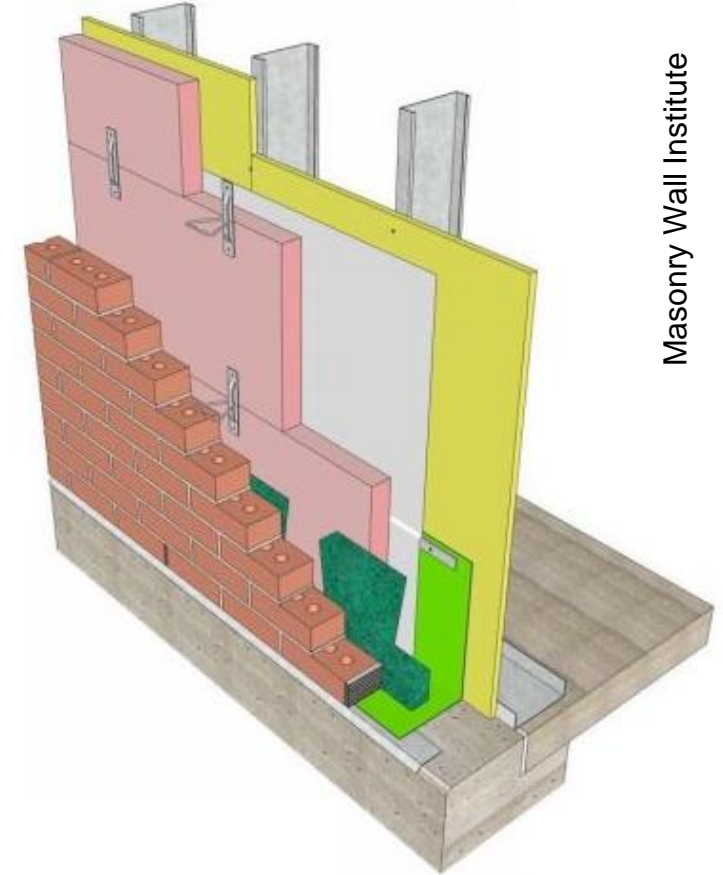
Façade – 3 Wall Types



Mass Wall

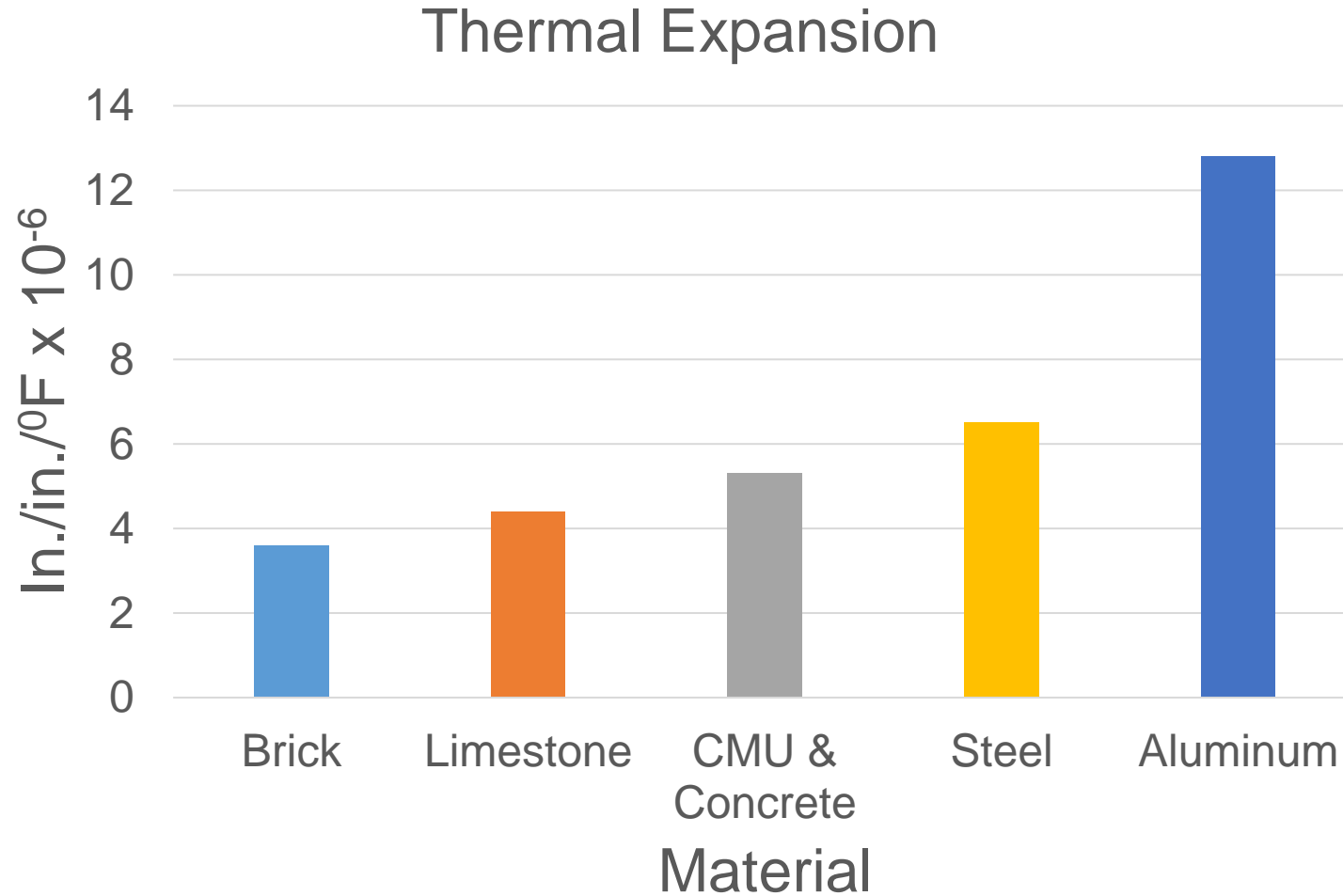


Barrier Wall



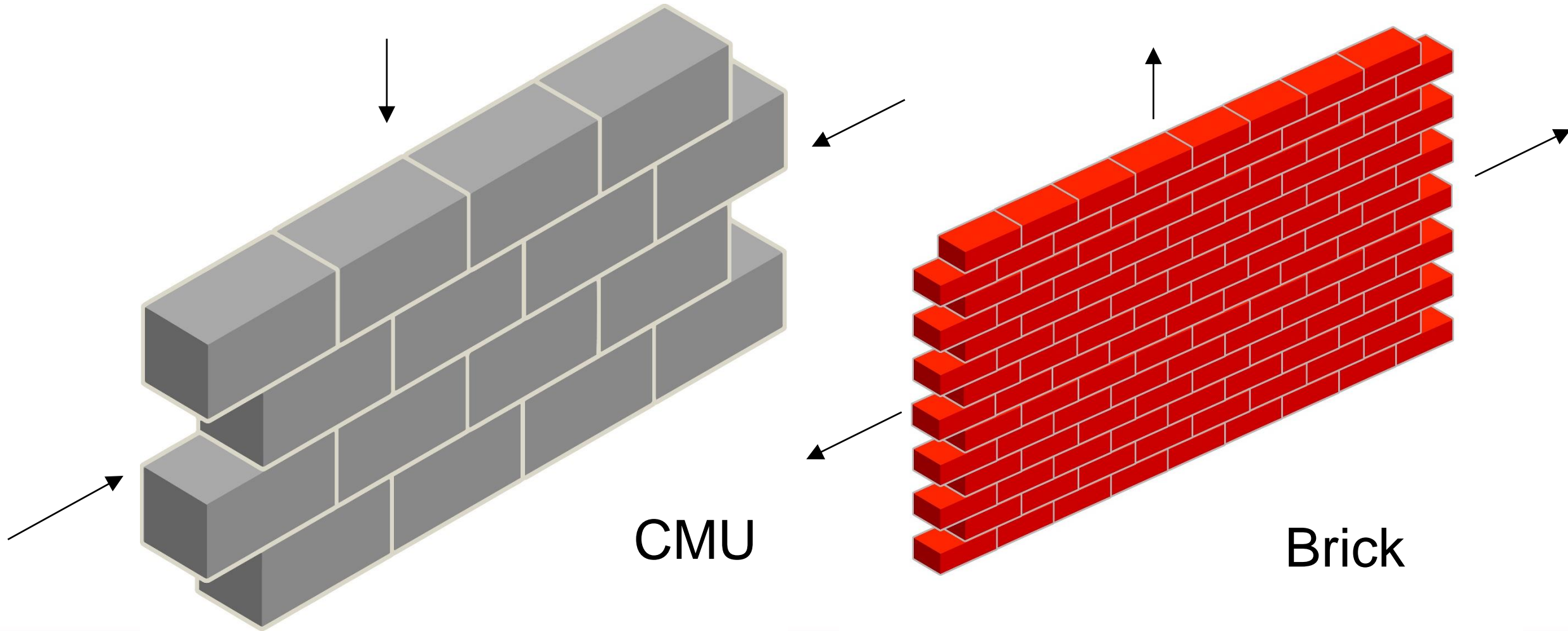
Cavity Wall

Facade - Thermal Expansion

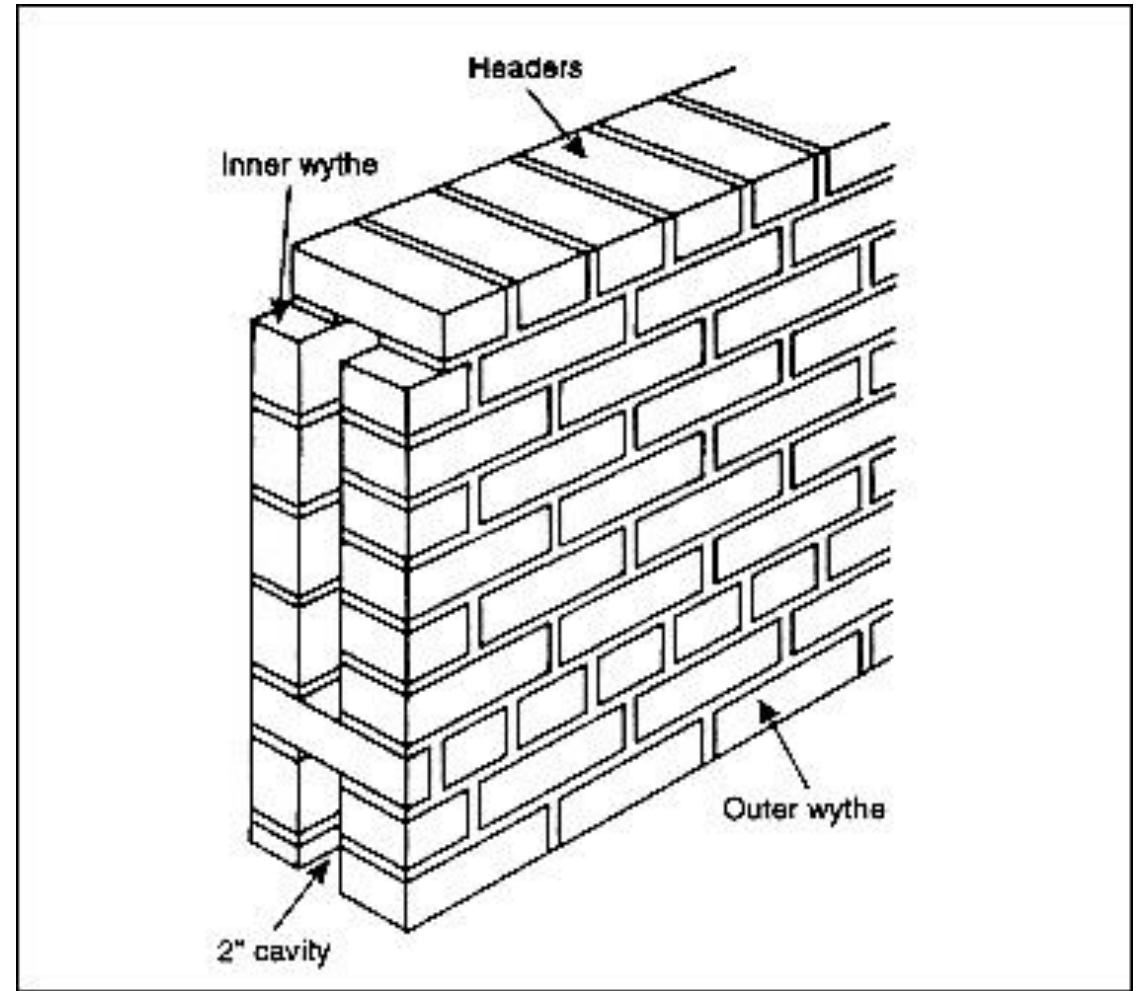


Coefficients of Thermal Expansion	
Material	in./in./°F x 10 ⁻⁶
Wood	
Pine (parallel to grain)	3.0
Pine (perpendicular to grain)	19.0
Masonry	
Brick	3.6
Limestone	4.4
Granite	4.7
Concrete Masonry Unit (CMU)	5.2
Marble	7.3
Concrete	
Concrete (Normal Weight)	5.5
Metals	
Steel	6.5
Copper	9.3
Aluminum	12.8
Finishes	
Glass	5.0
Gypsum Plaster, Sand	7.0
Gypsum Board	9.0

Facade - Moisture Expansion/Shrinkage



Façade – Moisture/Thermal Expansion/Contraction



Façade – Moisture & Thermal Expansion/Contraction



Façade – Corrosion Expansion



Facade – Elastic Deformation & Creep



Facade - Lightning Strike



Facade Inspection Protocol



- User Interviews
- Document Research
- Visual Inspection
- Closeup Inspection
- Minimally Invasive Inspection
- Water Testing
- Classifying Deficiencies
- Reporting
- Estimating

Façade Inspection - Visual



Building Envelope Inspection

Façade Inspection - Tactile Close-Up



Boom Lift



Rope Access

Façade Inspection - Bore Scope (Brick Veneer)



Façade Inspection – Minimally Invasive Inspection

- **Multiple Water Control Layers**
 - Water Shedding
 - Water Drainage
 - Waterproofing
- **Can't be afraid to dismantle small portion of wall.**



Façade Inspection - Testing

- **Water Testing**

- Duplicate a Leak
- Work from Bottom to Top
- Observer on Inside
- AAMA 501.2 Spray Wand



Below Grade Waterproofing

- One chance to get it right
- Three things required for a Leak
 - Water
 - Hole(s)
 - Pressure
- Difficult to diagnose



Below Grade Waterproofing - Membrane

- **External Membranes**
 - Fluid-Applied
 - Sheet Applied
- **System Requirements**
 - Embedded Waterstop at Joints
 - Wrap Entire Foundation
 - Protection Board
 - Drainage System



Below Grade Waterproofing - Integral

- **Internal “Integral” Waterproofing**
 - Crystalline Admixtures
 - Reduced Permeability
 - Self Sealing
 - Chemical reaction which grows crystals that fill capillaries and cracks in concrete



Kryton

Below Grade Waterproofing – Leak Detection & Repairs

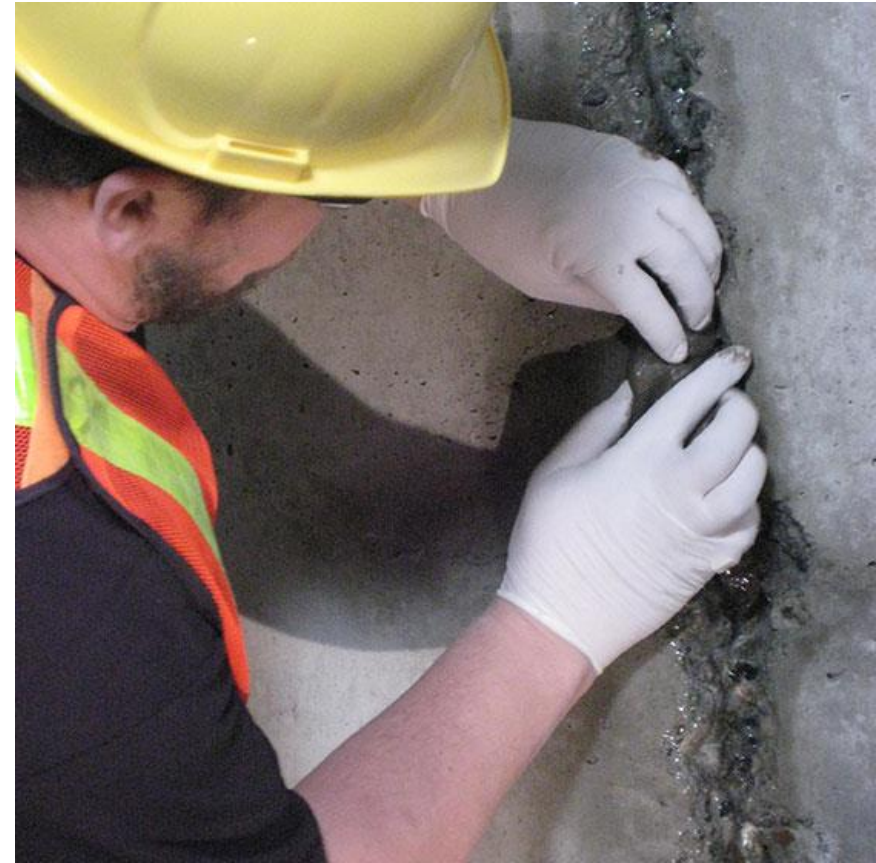
- **External**

- Manage Source of Water
- Repair/Replace Positive Side Waterproofing System
- Inject soil with Polyurethane Grout

- **Internal**

- Seal cracks with Hydraulic Grout
- Surface Coatings
- Drill weep holes at base of wall
- Install perimeter under slab drains to sump or daylight.

- **Crystalline Repair Grout**



Kryton

Reporting

- **Project Information**
- **General Building Description**
 - Original Construction
 - Renovations
 - Additions
- **General Building Condition**
- **Findings & Recommendations by Deficiency level**
- **Detailed Description of Building Structural, Façade & Waterproofing Systems**
- **Methods Used to Conduct Investigation**
- **Building Footprint & Elevations w/ Deficiencies**
- **Deficiency Photos**
- **Detailed Findings & Recommendations**
- **Estimate**
- **Classification of Deficiencies**
 - Unsafe Condition
 - Requires Repair/Stabilization
 - Ordinary Maintenance

Learning Objectives

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 - Inspection Protocol
 - Roofing/Façade/Below Grade Construction
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Questions?

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