# **Building Envelope** Water Intrusion

## **ICRI Concrete Repair Florida First Coast**

**Herbert University Center** Thursday September 12, 2024

The Pinnacle of Structural and Waterproofing Engineering







## 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





## **Learning Objectives**

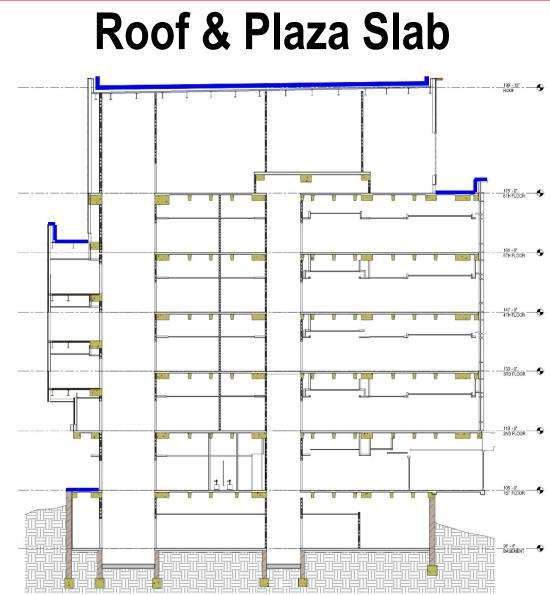
- Water Intrusion
  - Building Science
  - Impact on Structure
  - Why Does it Leak?
  - How to Fix It



## **Building Envelope - Definitions**

### Envelope

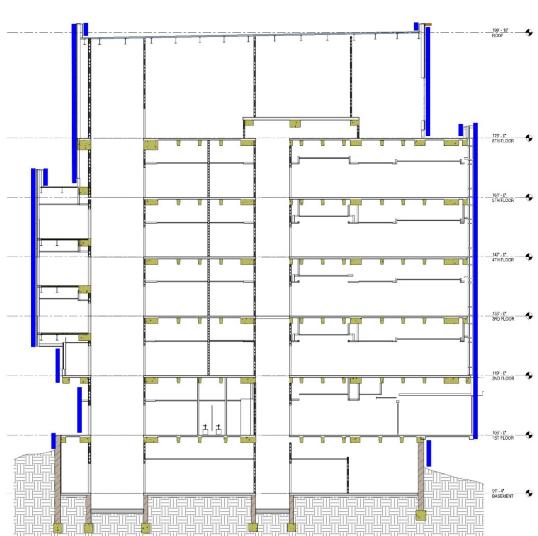




## **Building Envelope - Definitions**

### Envelope





Facade

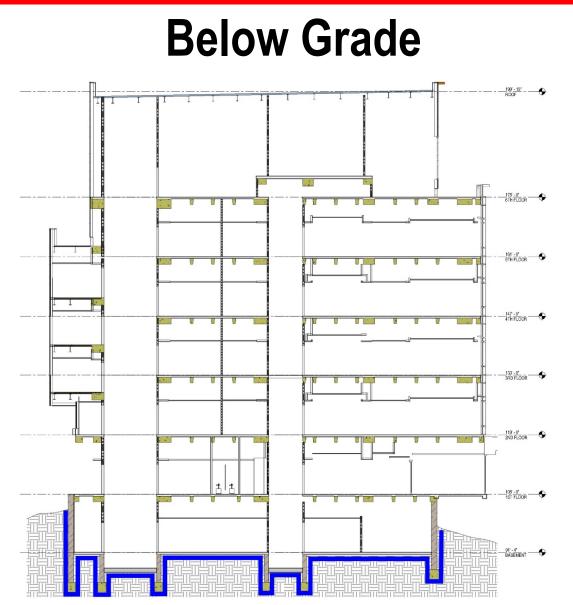
#### Water Intrusion

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## **Building Envelope - Definitions**

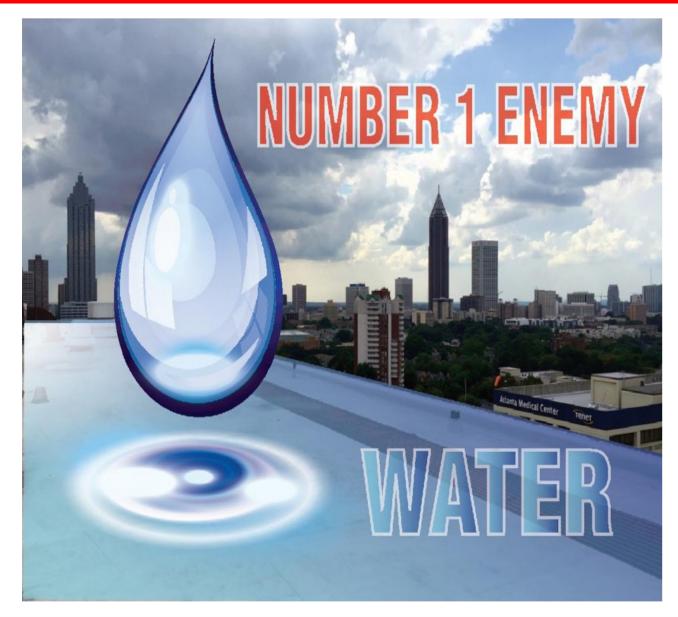
### Envelope





## **Building Science – 4 Primary Control Layers**

- Rain
- Air
- Vapor
- Thermal





## **Building Science – Moisture Exposure**

## Water Intrusion:

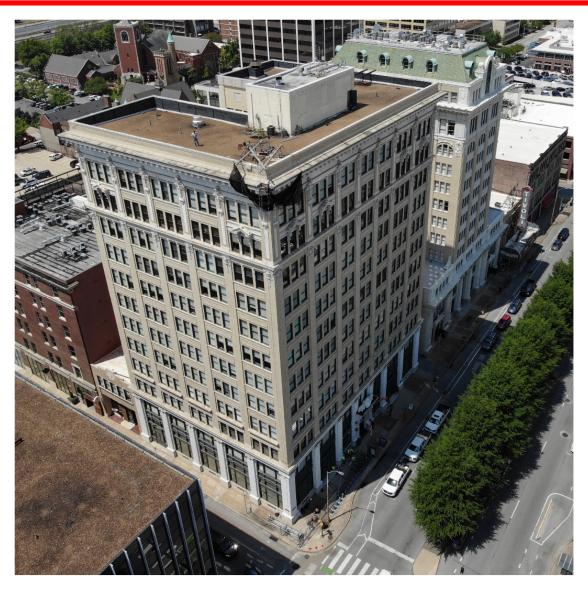
- 40% of construction problems
- 70% of construction litigation

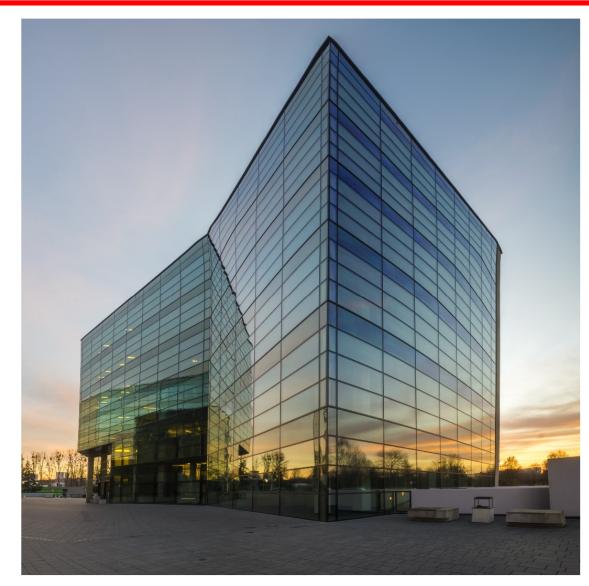
## Damage Functions

- Water
- Heat
- Ultra-Violet Radiation

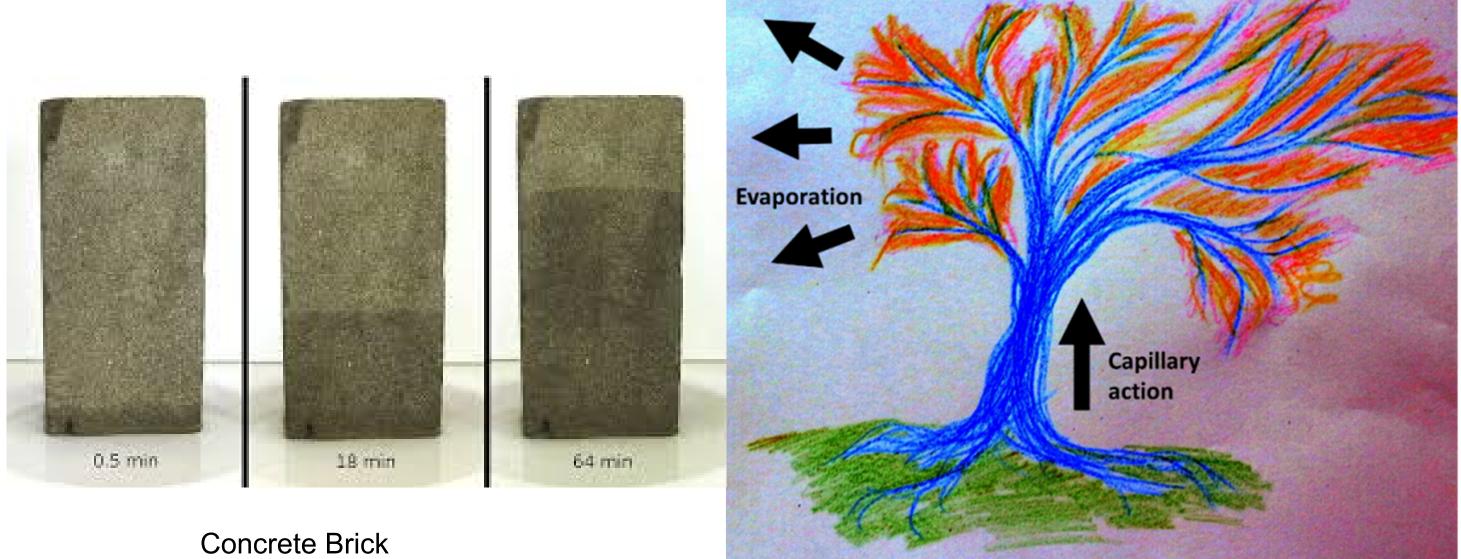


## **Building Science – Water Shedding**

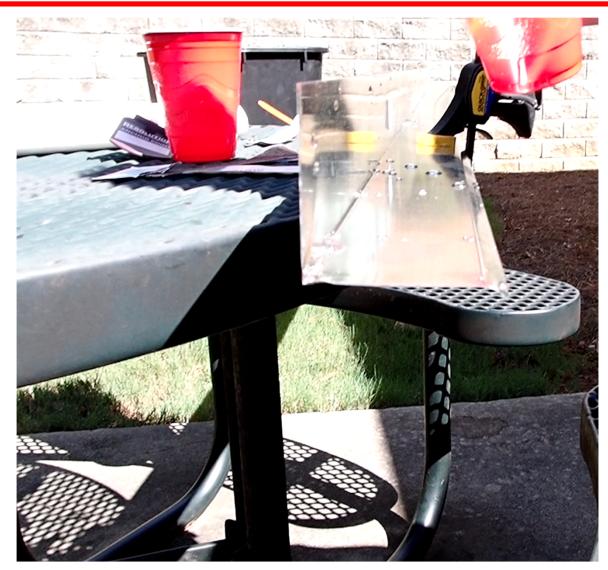




## **Building Science – Capillary Action – Porous Materials**



## **Building Science – Surface Tension**





Drip Edge

No Drip Edge

## **Building Science – Surface Tension**



### No Drip Edge



## Structural Damage – Masonry & Concrete





### **Brick Masonry**

### **Concrete Reinforcement Corrosion**



## Structural Damage – Steel & Wood



#### **Steel Corrosion**

#### Wood Rot



## **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 - Principals**

- Everything Leaks
- Everything Moves
- No One Maintains Their Building Envelope

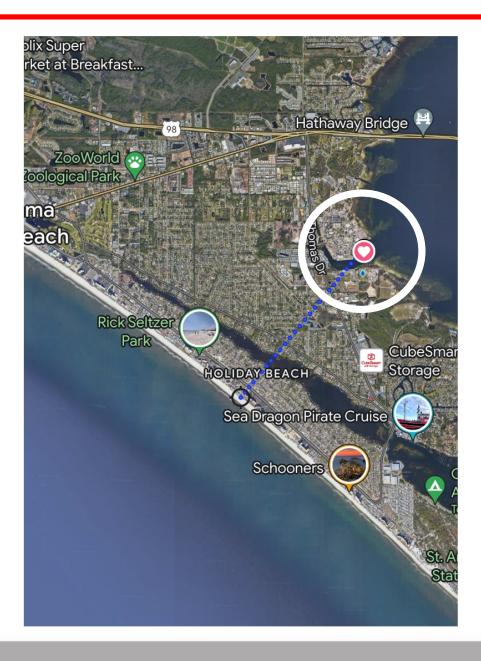


## **Maintenance Exception**



## **Case Study – NSA Panama City**





## Case Study – Mod-Bit Roof



### Modified Bitumen Roofing "The Lexus of Roofing"

## Other Popular Roofing

- **TPO**
- EPDM
- PVC

## **Roofing - Modified Bitumen**



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

## **Case Study – Roof Flashing**

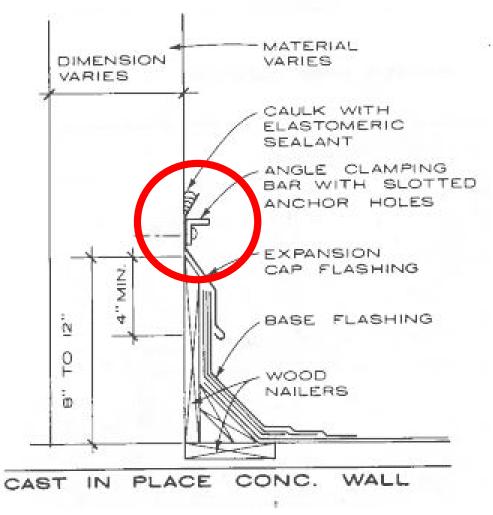




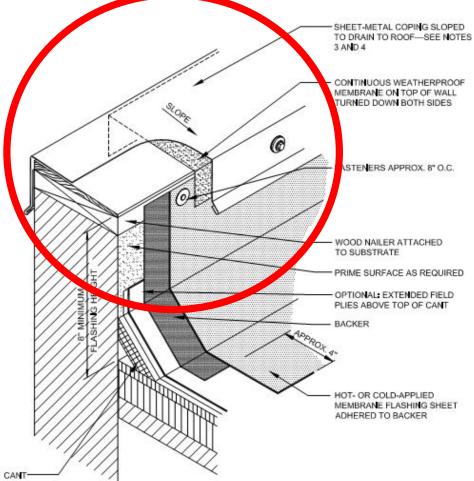
### Roof Flashing at Parapet

Stained Ceiling Tile

## **Case Study – Roof Flashing**



**1981** Architectural **Graphics Standards** 



**NRCA Detail** 

## **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 aggerate • Voids: Manufacturers warranty

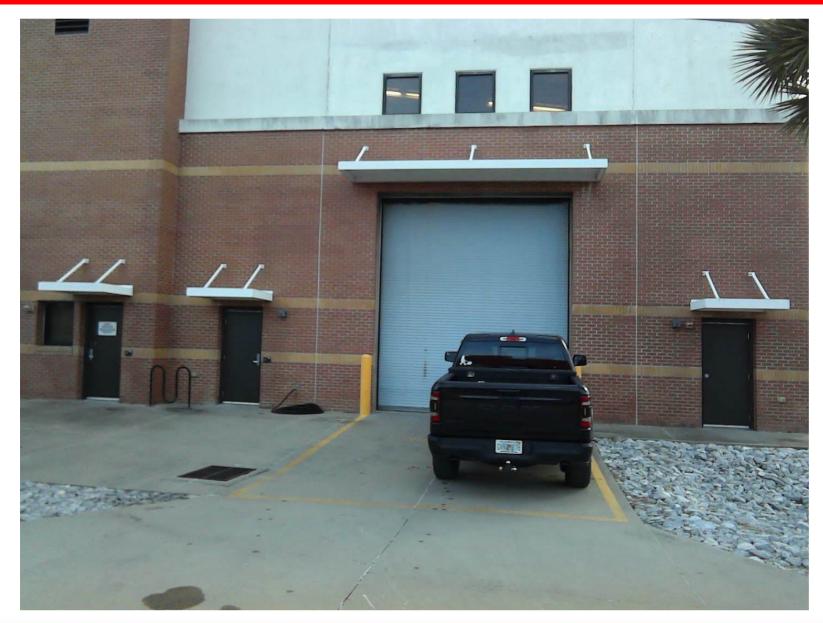
## **Roofing – Organic Growth**

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





## **Case Study - Canopy Roof**





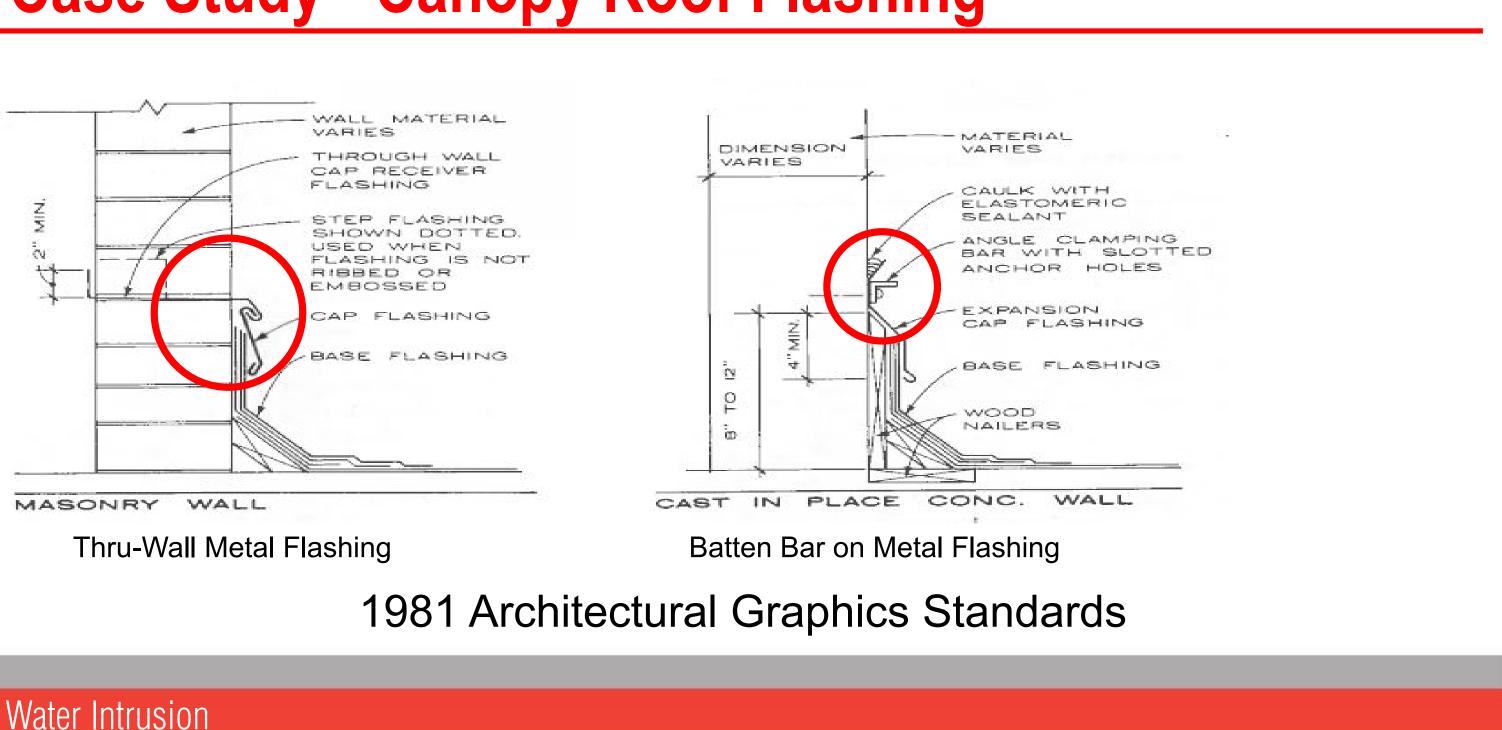
## **Case Study - Canopy Roof Flashing**



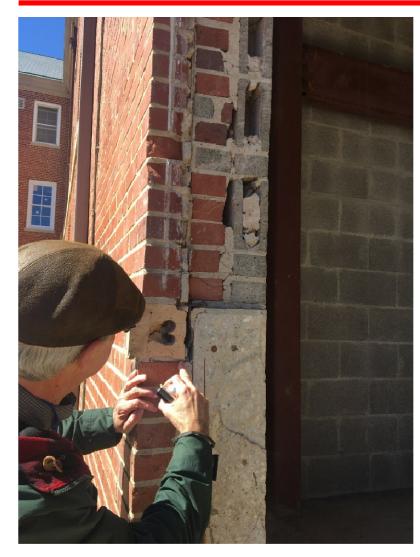
### Metal Flashing at Wall



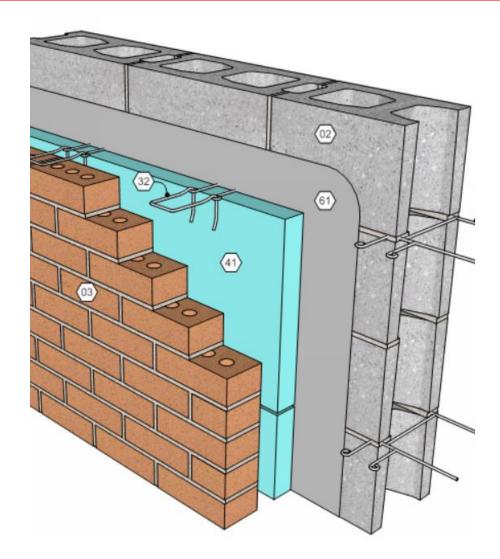
## **Case Study - Canopy Roof Flashing**



## Façade – Evolution of Wall Types







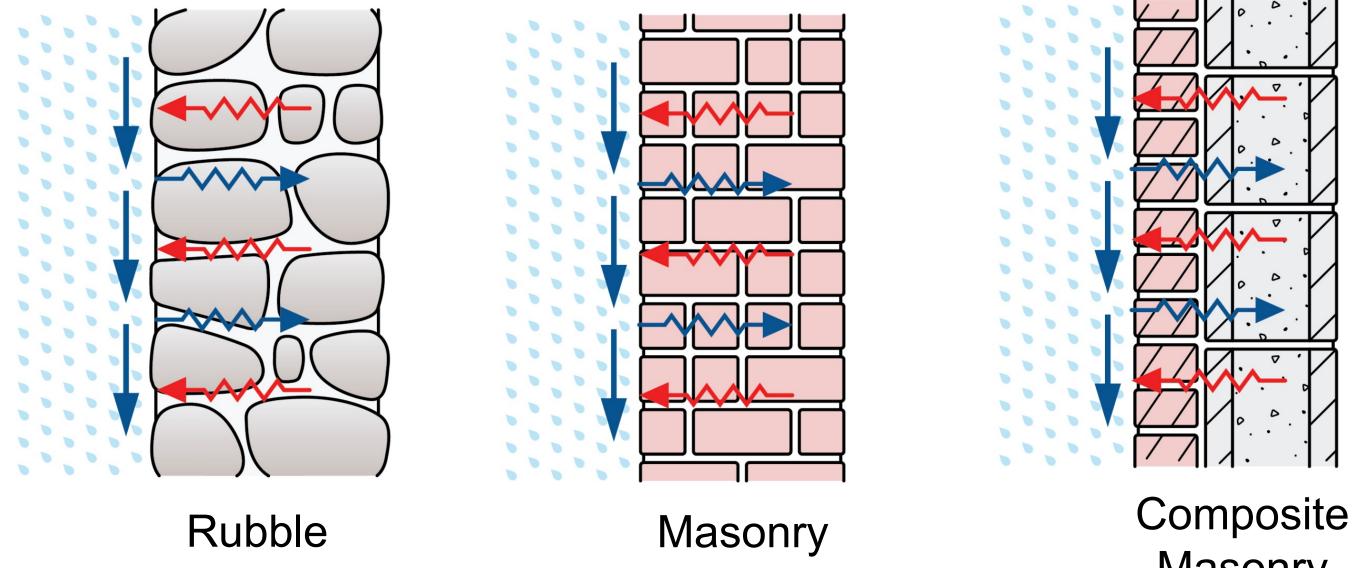
#### Mass Wall

**Barrier Wall** 



### **Cavity Wall**

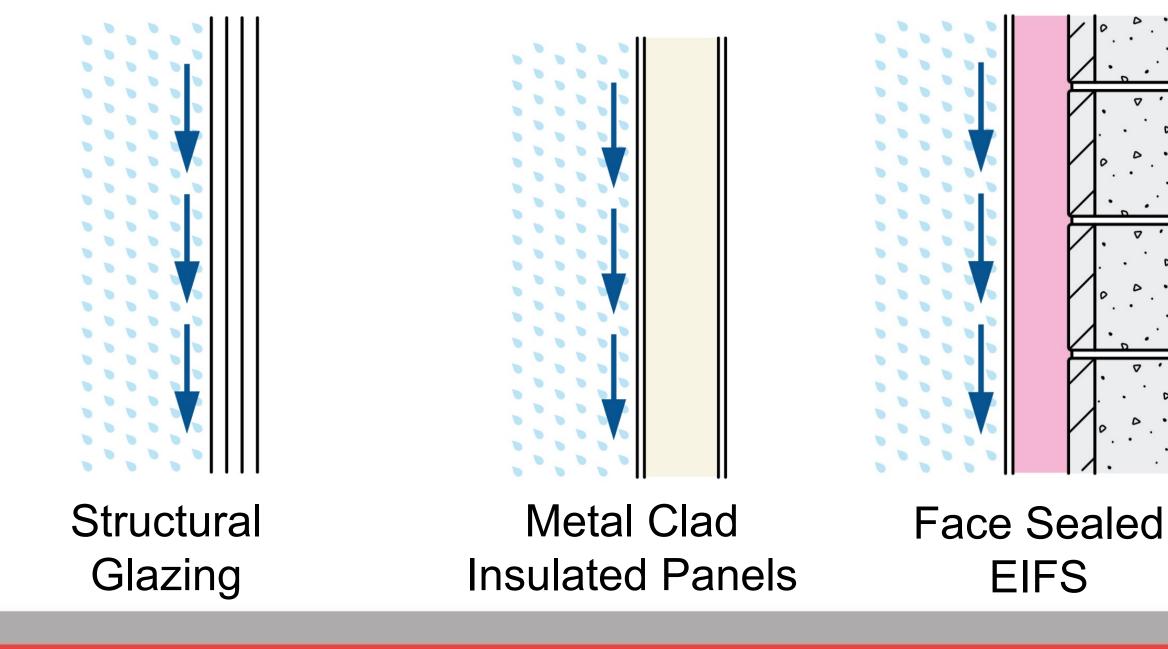
## Façade – Mass Walls

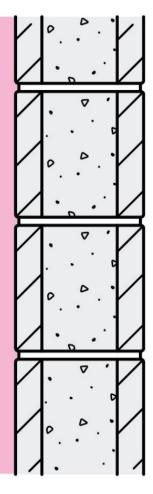


Water Intrusion

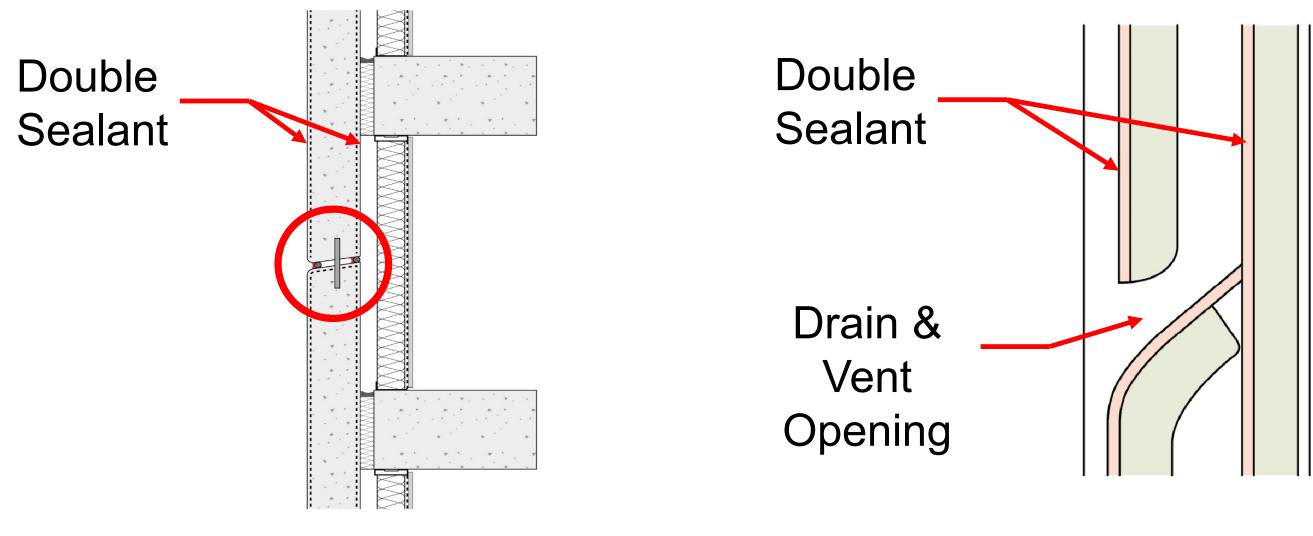
# Masonry

## **Façade – Barrier Walls**





## Façade – Barrier Walls – Precast/Tilt-Up

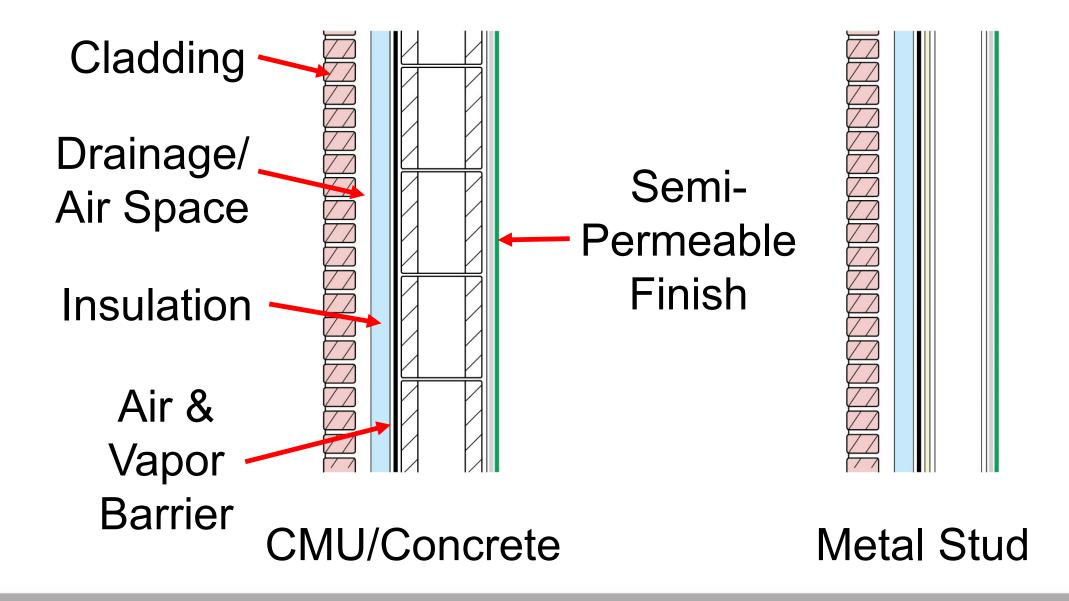


#### Precast/Tilt-Up Wall

Water Intrusion

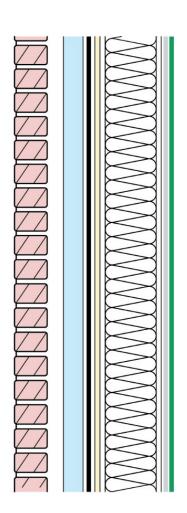
#### **Double Sealant**

## Facade – Cavity Wall – "The Perfect Wall"

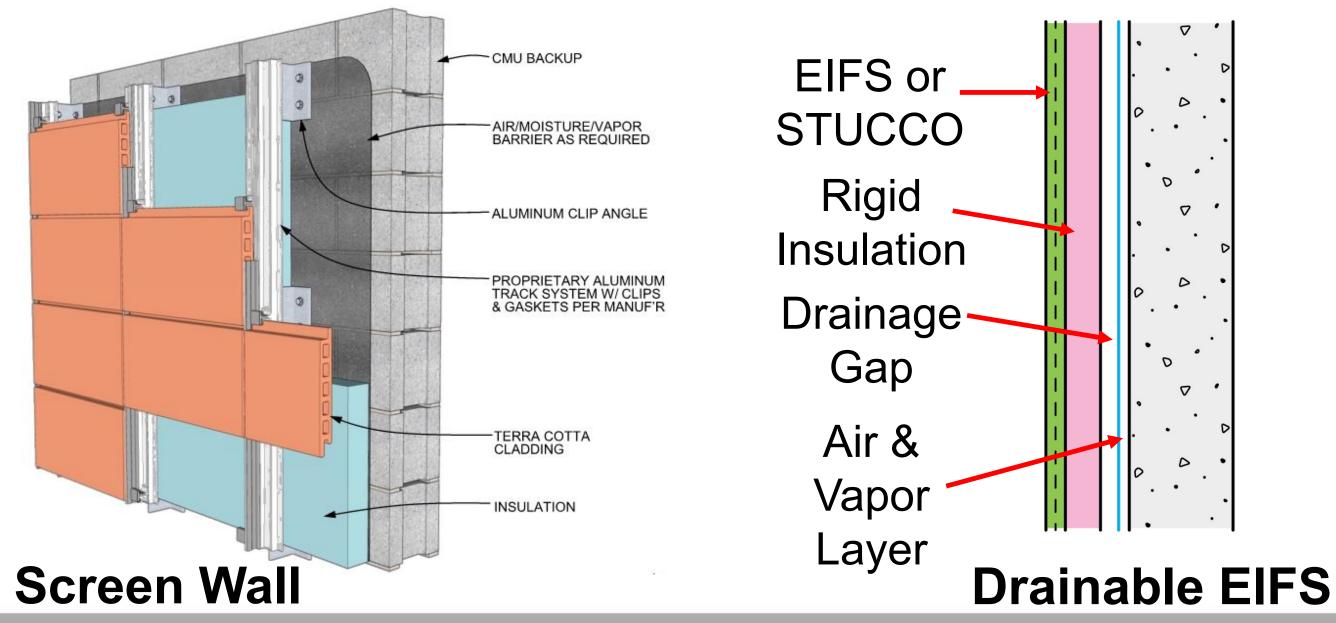


Water Intrusion

### Wood Stud



## Façade – Cavity Wall – "The Perfect Wall"



## **Case Study - Tilt-Up Parapet**



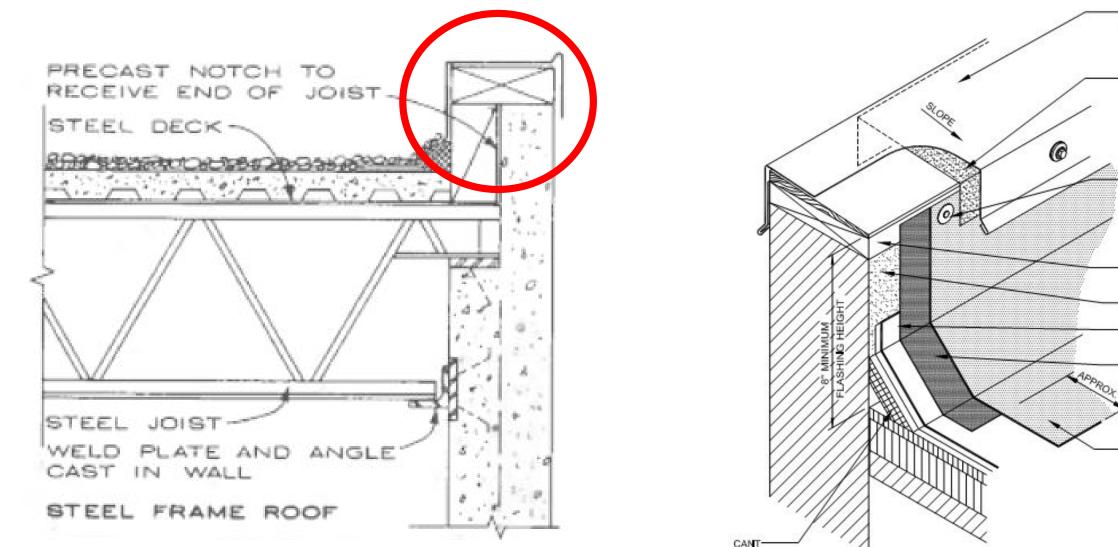


#### **Failed Sealant**

Water Intrusion

Leak at Joint

## **Case Study - Tilt-Up Parapet - Coping**



#### **1981 Architectural Graphics Standards**

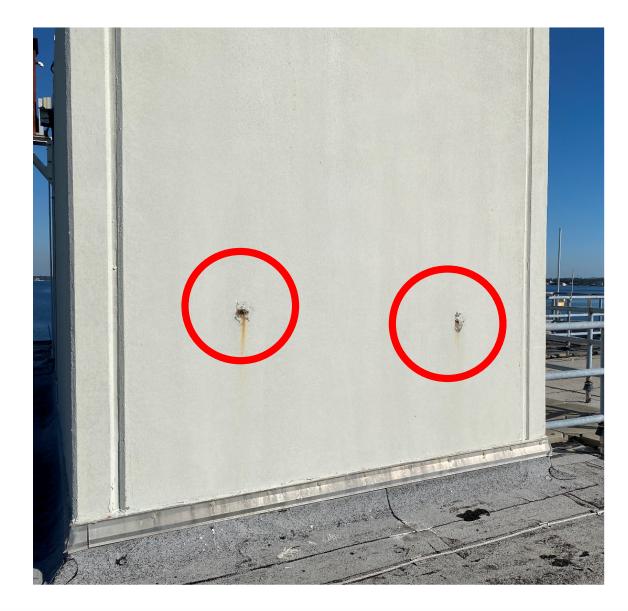
#### **NRCA** Parapet Detail

#### Water Intrusion

- SHEET-METAL COPING SLOPED TO DRAIN TO ROOF-SEE NOTES 3 AND 4
- CONTINUOUS WEATHERPROOF MEMBRANE ON TOP OF WALL TURNED DOWN BOTH SIDES
- FASTENERS APPROX. 8" O.C.
- WOOD NAILER ATTACHED TO SUBSTRATE
- PRIME SURFACE AS REQUIRED
- OPTIONAL: EXTENDED FIELD PLIES ABOVE TOP OF CANT
- BACKER

HOT- OR COLD-APPLIED MEMBRANE FLASHING SHEET ADHERED TO BACKER

## **Case Study - Tilt-Up Spalls**



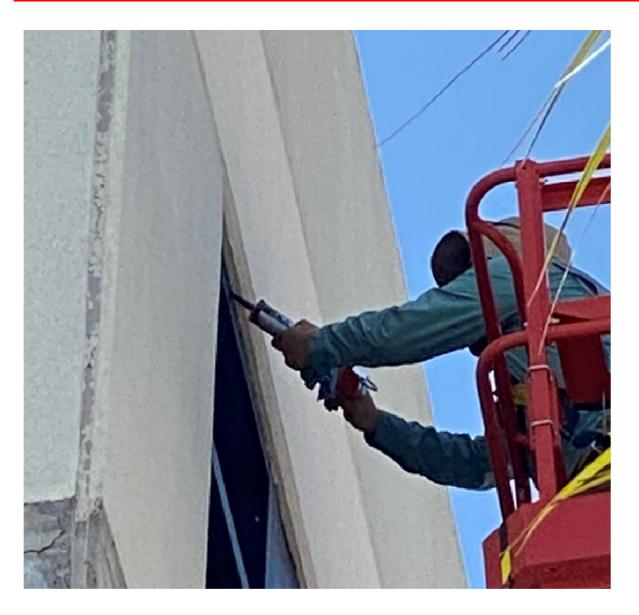


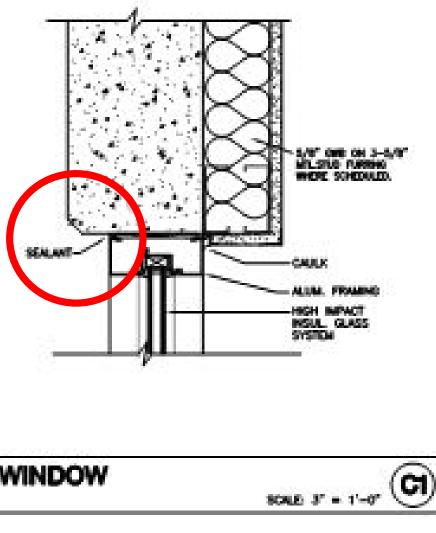
## **Case Study – Tilt-Up Coating**





# **Case Study - Tilt-Up Fenestration – No Drip Edge**

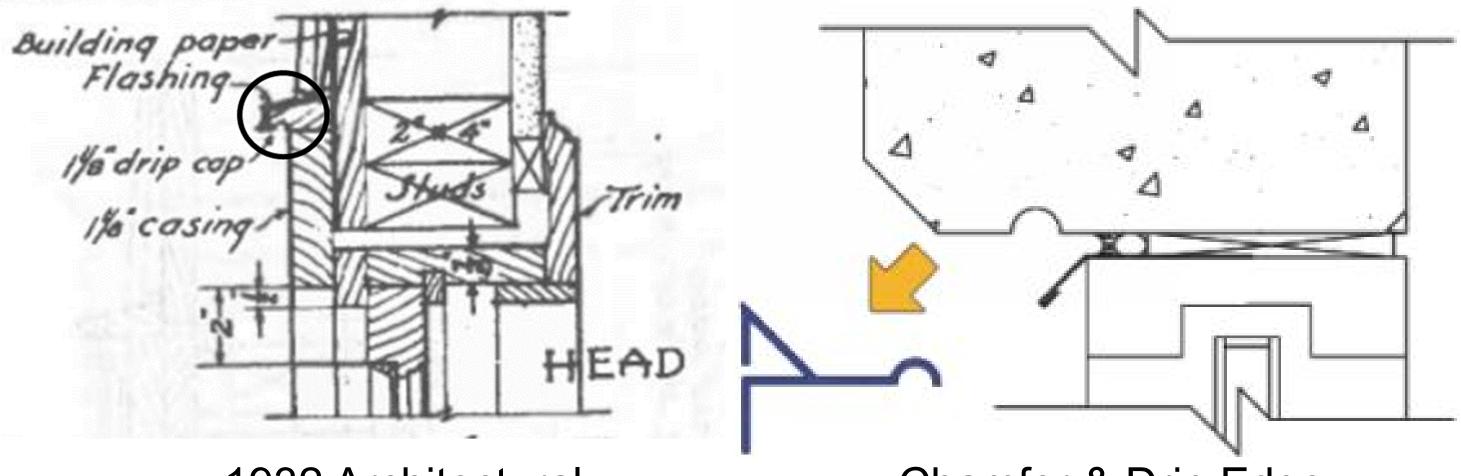




HEAD - WINDOW

As-Designed

# **Case Study - Tilt-Up Fenestration – Drip Edge**

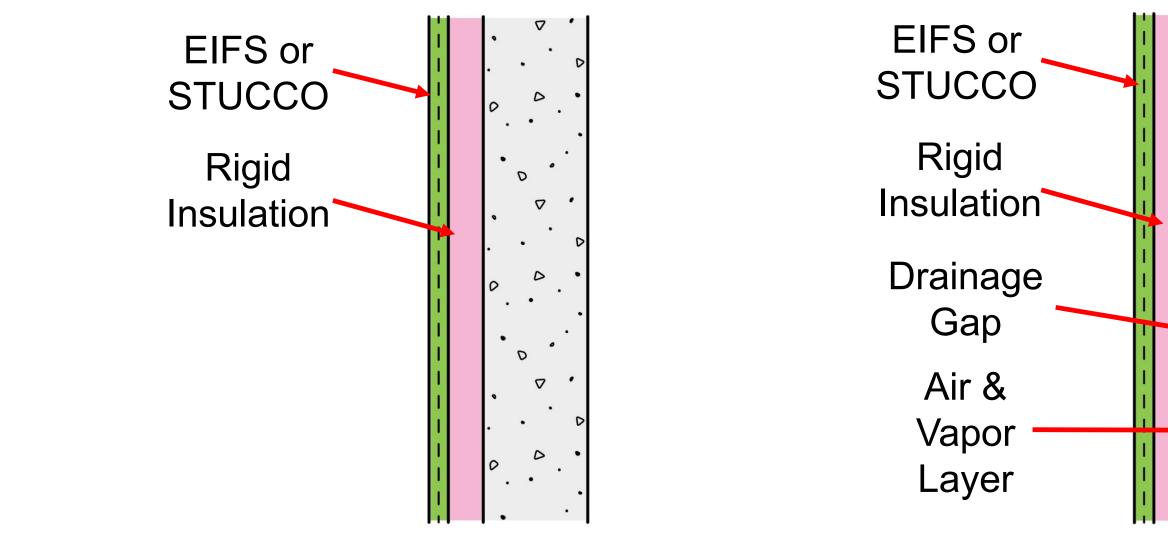


## **1932** Architectural **Graphics Standards**

Chamfer & Drip Edge Form

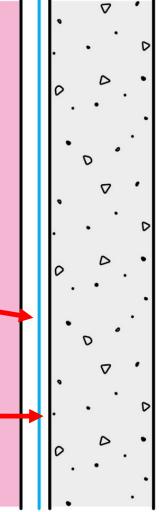


## **EIFS Walls**

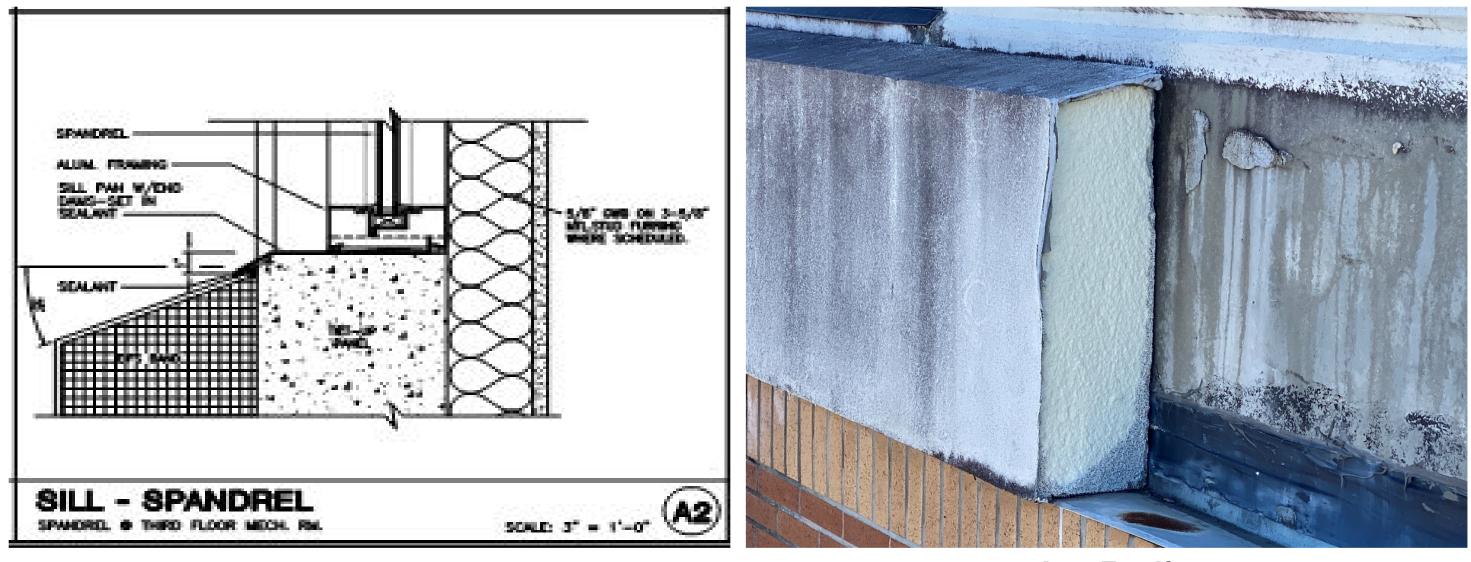


#### **Face Sealed Barrier System**

## **Drainable Cavity System**



## **Case Study - EIFS**



#### **As-Designed**

As-Built

## **Case Study - EIFS**



### **Intermittent Sealant**



Metal Flashing Slope

# **Case Study - EIFS**

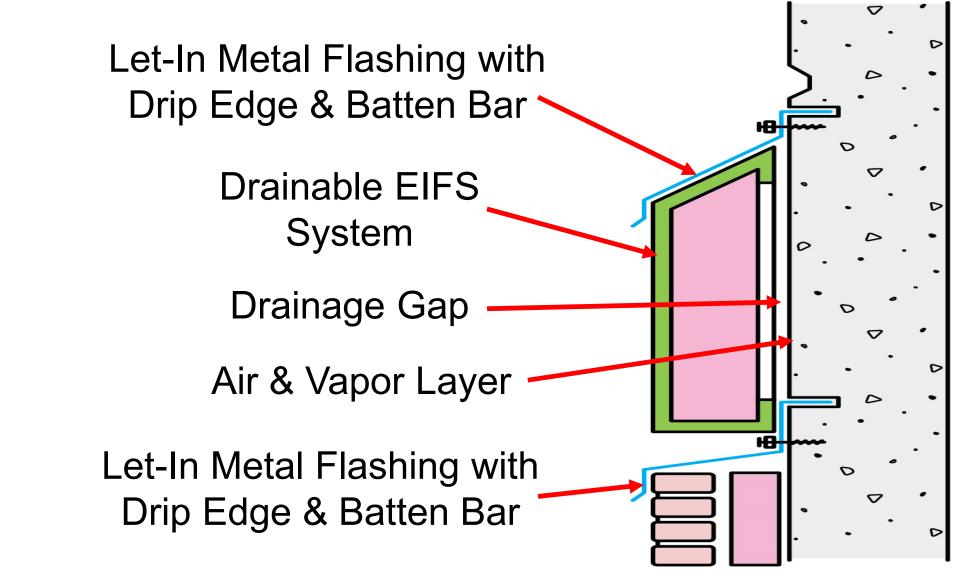




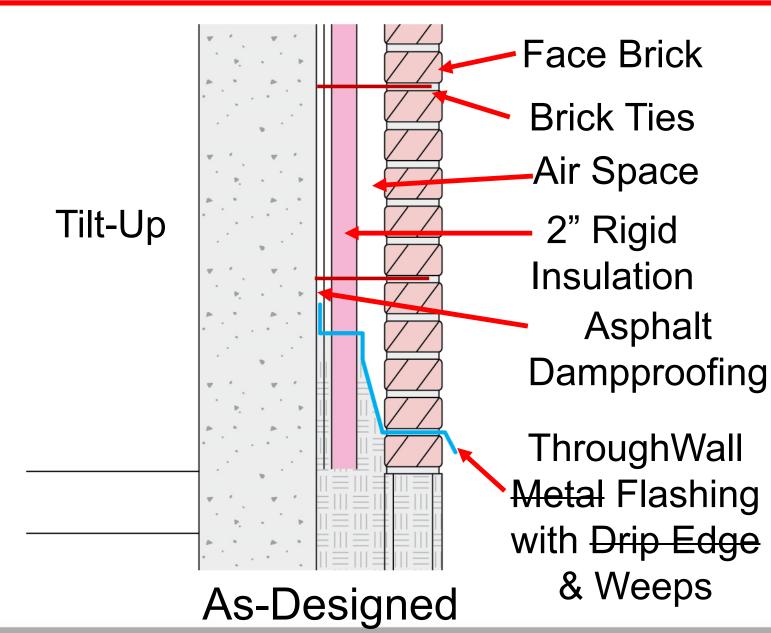
#### **Unsealed Lap Seams**

## **Unsealed Flashing**

## **Case Study – EIFS Repair Detail**



# **Case Study - Brick Veneer**



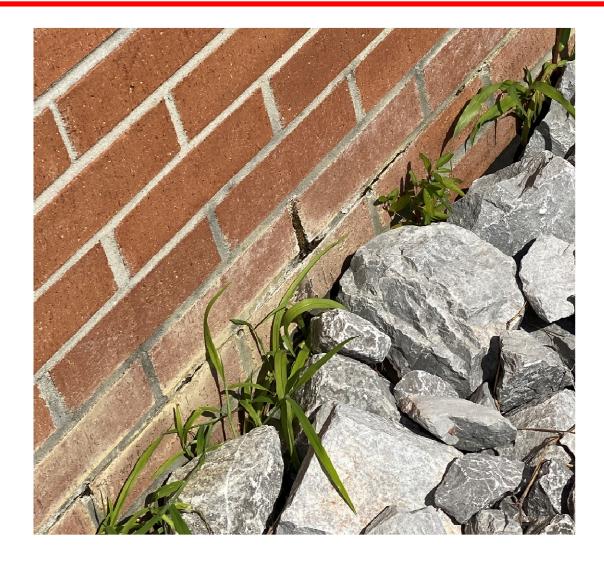
Water Intrusion



Probe

## **Case Study - Brick Veneer**

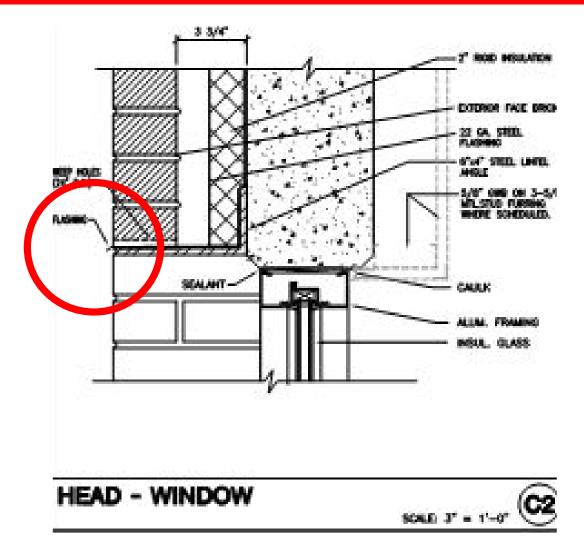




#### **Corroded Brick Tie**

#### No Drip Edge

# **Case Study - Brick Veneer Fenestration Head**



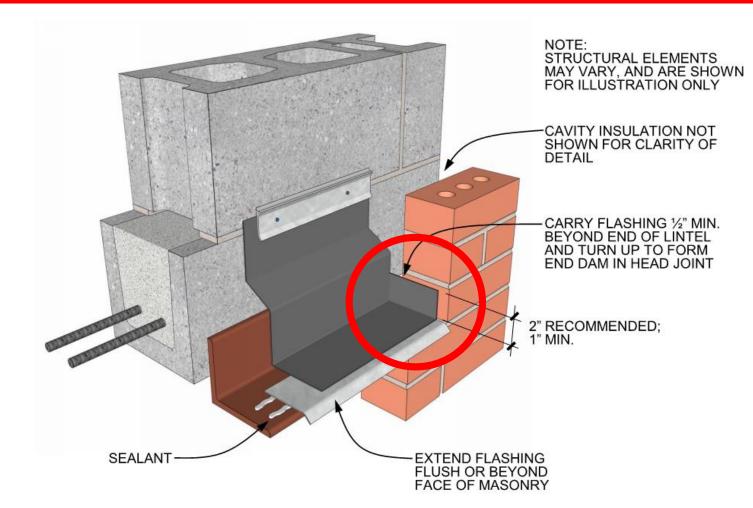


## No Metal Flashing

#### **As-Designed Head Detail**



# **Case Study - Brick Veneer Fenestration Head**



## Lintel Flashing with End Dam

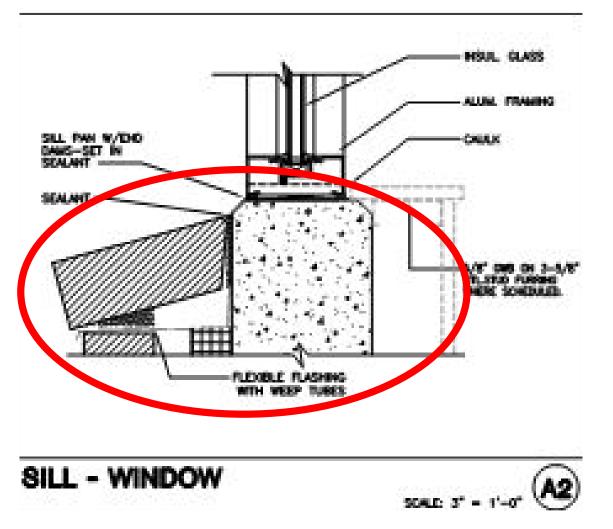
**International Masonry Institute** 



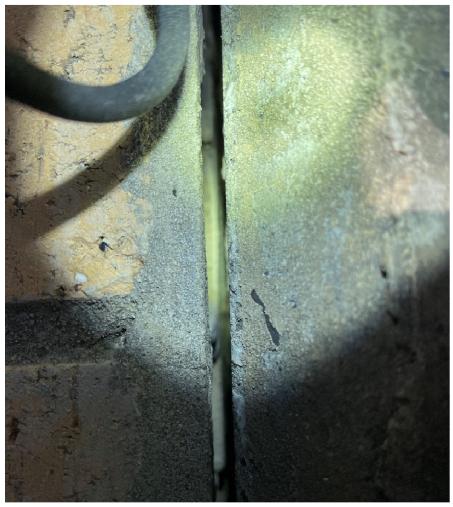
**Bore Scope Examination** 



# **Case Study - Brick Veneer Fenestration Sill**

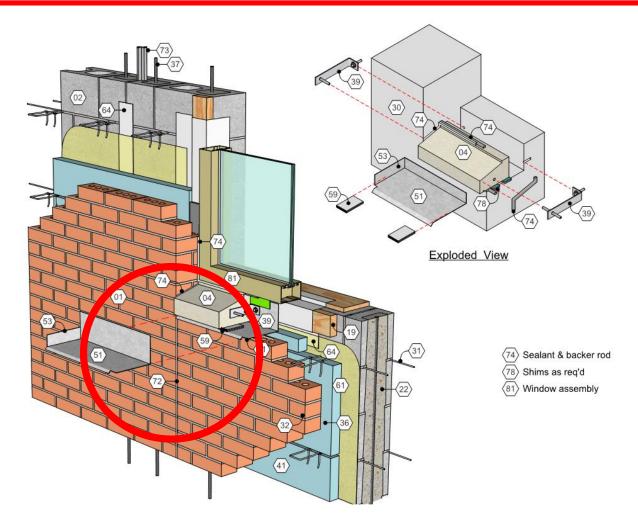


## **As-Designed Sill Detail**



No Flashing until **Bottom of Wall** 

# **Case Study - Brick Veneer Fenestration Sill**





## Sill Flashing with End Dam

International Masonry Institute

## **Typical Opening**

# **Case Study - Brick Veneer Louver Opening**



#### **Existing Louvers**

Water Intrusion

## No architectural detail

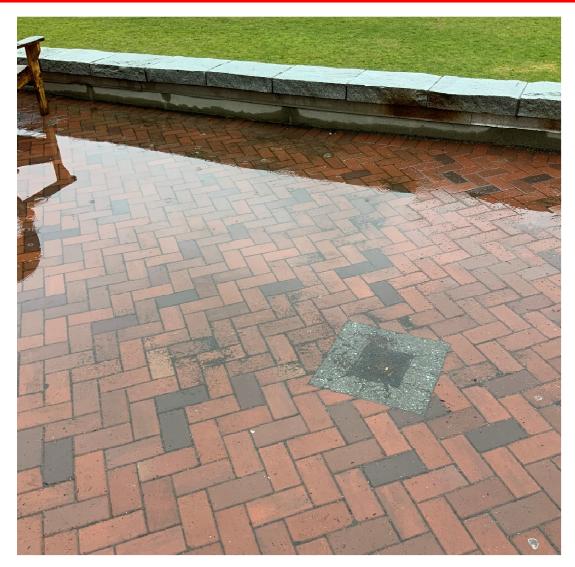
- Therefore:
  - No Lintel
  - No Flashing
  - No Sealant
  - No Weeps
  - No Sill Pan

## Plaza Slab Case Study – Housing Tower





## Plaza Slab Case Study – Drainage





#### Ponding

Two-Stage Drain

## Plaza Slab Case Study – As-Built Construction





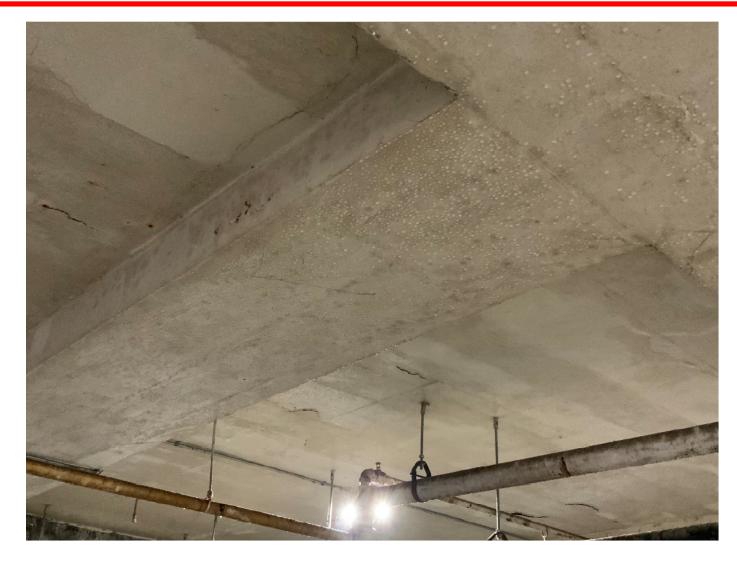
#### No Termination

**Control Layers** 



## Plaza Slab Case Study – Visible Water





#### Water Drops on Slab & Beams



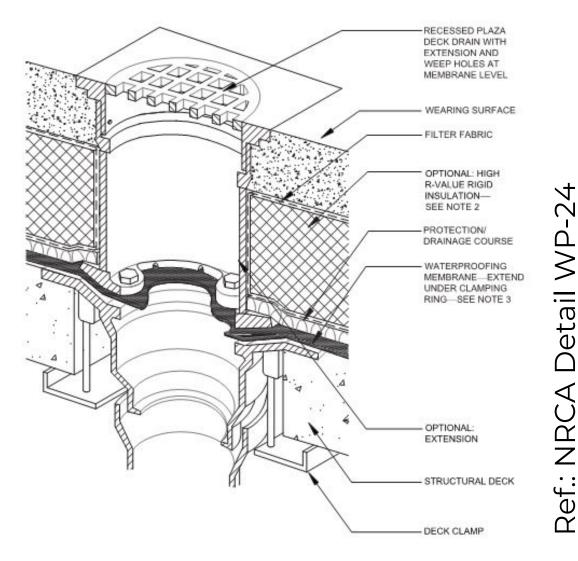
## Plaza Slab Case Study – Concrete Damage







## **Plaza Slabs – Protected Membranes**



WALL APPROPRIATE SEALANT AND BACKER ROD BACKER ROD DIAMETER 1.5 TIMES OPENING SIZE-SEE NOTE 3 OPTIONAL: TERMINATION BAR FASTENED WITH APPROPRIATE FASTENERS AT APPROXIMATELY 12" O.C. WATERPROOFING MEMBRANE WEARING SURFACE -4 PROTECTION/ORAINAGE/ INSULATION COURSE STRUCTURAL DECK

#### **Two-Stage Drain**

#### Termination

#### Water Intrusion



FILLET AS REQUIRED PER MANUFACTURER'S RECOMMENDATION

REINFORCING STRIP

# Ref.: NRCA Detail WP-30

## **Plaza Slab - Green Roof**

DRAIN STRAINER
NONCORROSIVE BOX OR PVC TUBE DRAIN INSPECTION CHAMBER
GRAVEL FILL WITH FILTER FABRIC CONTAINMENT
LOOSE-LAID RETENTION TEE
GROWTH MEDIUM
MOISTURE-RETENTION LAYER
THERMAL INSULATION //////
DRAINAGE LAYER
ROOT BARRIER / //// /
PROTECTION COURSE ////////////////////////////////////
FABRIC-REINFORCED HOT-FLUID-APPLIED WATERPROOFING
MEMBRANE FLASHING/ // /
STRUCTURAL DECK-PRIME AS REQUIRED // /
CLAMPING RING
DRAIN BOWL-PRIME AS REQUIRED

#### Vegetative Roof

## Plaza Slab Case Study – Grocery Store



#### Plaza Slab on Precast Deck

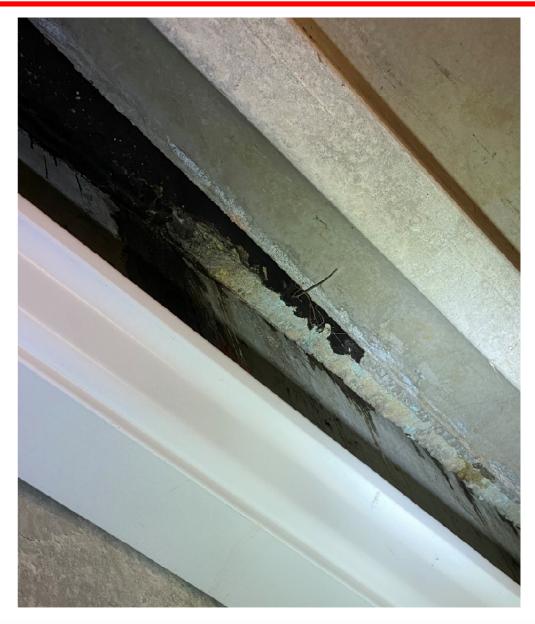
#### Water Intrusion



#### Two-Stage Drain

## Plaza Slab case Study – Internal Drainage

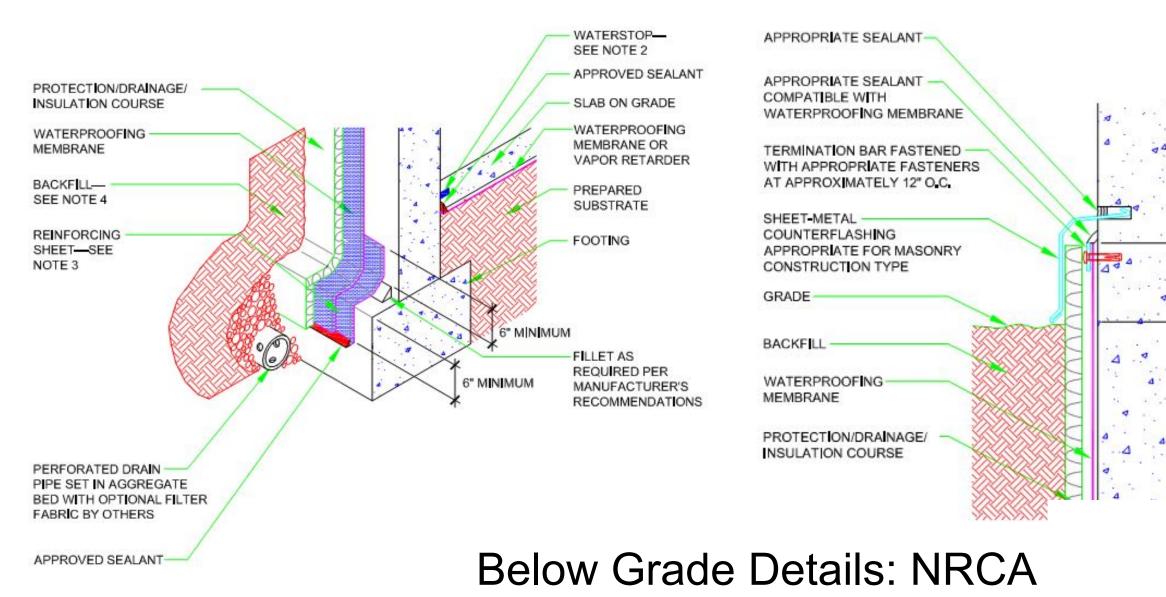


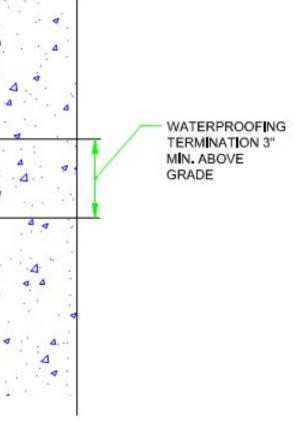


# **Below Grade Case Study – Maintenance Building**

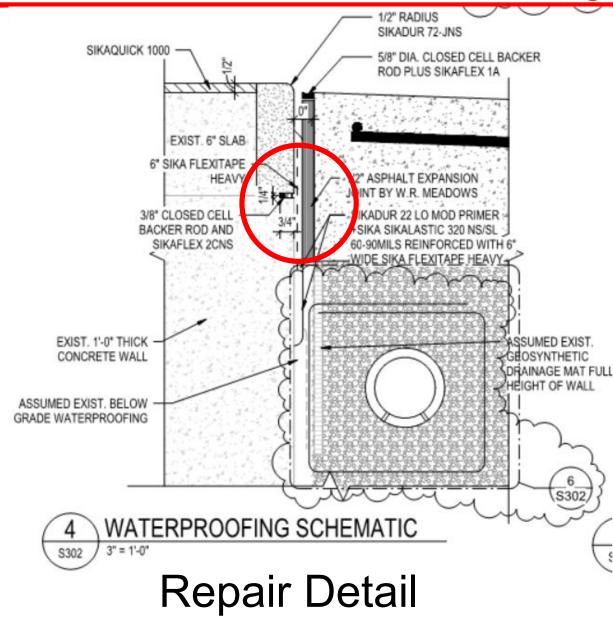


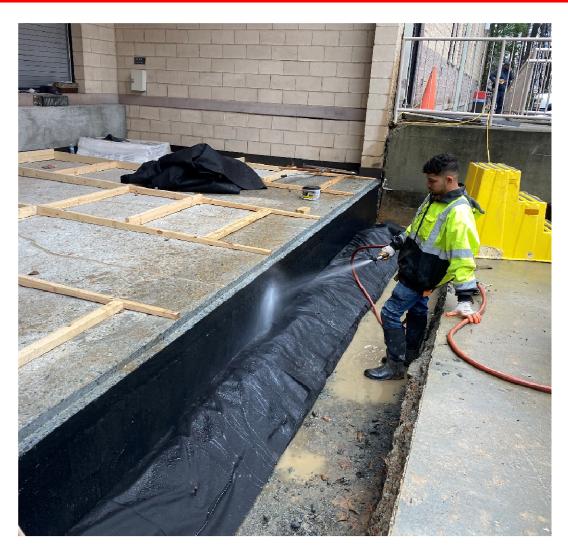
# **Below Grade Waterproofing**





## **Below Grade Case Study - Waterproofing**





Water Testing

# **Learning Objectives**

- Water Intrusion
  - Building Science
  - Impact on Structure
  - Why Does it Leak?
  - How to Fix It



## **Questions?**

## Scott L. Weiland PE SE sweiland@ieiusa.com

678-883-5868 (d)

## Atlanta Office

Innovative Engineering Inc. 3380 Trickum Road Bldg. 500, Suite 100 Woodstock, Georgia 30188 678-883-5868 (direct)



