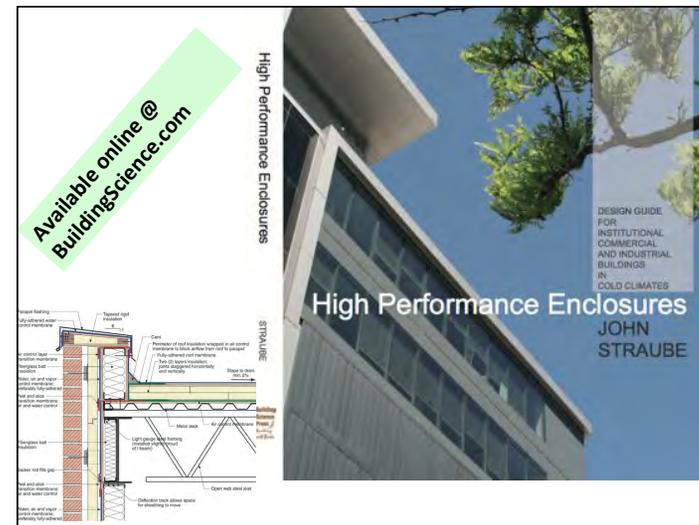


## www.BuildingScience.com

- Download / read from website
  - BSD-108: Investigating and Diagnosing Moisture Problems
  - BSD-114: Interior Insulation Retrofits for Load-bearing Masonry Walls in Cold Climates
  - BSI-004: Drainage, Holes and Moderation
  - BSI-013: Face Lift for Old Buildings
  - BSD-013: Rain Control in Buildings
  - BSI-001: The Perfect Wall
  - BSI-049: Confusion About Diffusion
  - BSD-146: EIFS - Problems and Solutions
  - BSI-054: Risky Business: High Risk Walls
  - BSI-038: Mind the Gap, Eh?
  - BSI-047: Thick as a Brick



## Repair, Renewal, Rehabilitations of Commercial Buildings

Dr John Straube, P.Eng.  
Associate Professor  
School of Architecture / Dept. of Civil Engineering  
University of Waterloo  
Building Science Corporation



BuildingScience.com

## Outline

- Enclosure Design Fundamentals
  - Rain control
  - Air Control
  - Thermal Control
- Windows/Storefronts Curtainwalls
- Masonry
- Precast / Tiltup
- EIFS

## What does the skin do?

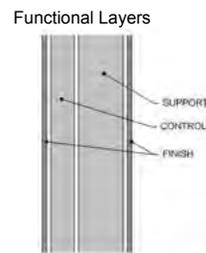
- Please call it the “enclosure”
- Important for image of owners
  - Front of factory, retail
- Critical for energy use and comfort

## Renewal

- Enclosure is designed assuming maintenance and renewal
  - E.g., sealant, paintings, coatings
- Roofs are removed and replaced
- Needs renewal at intervals

## Basic Functions of the Enclosure

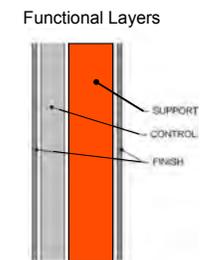
- 1. Support
  - Resist and transfer physical forces from inside and out
- 2. Control
  - Control mass and energy flows
- 3. Finish
  - Interior and exterior surfaces for people
- Distribution – a building function



Building Science

## Basic Enclosure Functions

- **Support**
  - **Resist & transfer physical forces from inside and out**
    - Lateral (wind, earthquake)
    - Gravity (snow, dead, use)
    - Rheological (shrink, swell)
    - Impact, wear, abrasion
- **Control**
  - Control mass and energy flows
- **Finish**
  - Interior and exterior surfaces for people



Building Science

Enclosures No. 8 /

## Basic Enclosure Functions

- **Support**
  - Resist & transfer physical forces from inside and out
- **Control**
  - **Control mass and energy flows**
    - **Rain** (and soil moisture)
      - Drainage plane, capillary break, etc.
    - **Air**
      - Continuous air barrier
    - **Heat**
      - Continuous layer of insulation
    - **Vapor**
      - Balance of wetting/drying
- **Finish**
  - Interior and exterior surfaces for people

Functional Layers

Building Science.com Enclosures No. 9 /

## Other Control . . .

- **Support**
- **Control**
  - **Fire**
    - Penetration
    - Propagation
  - **Sound**
    - Penetration
    - Reflection
  - **Light**
    - Diffuse/glare
    - View
- **Finish**

Functional Layers

Building Science.com Enclosures No. 10 /

## Basic Enclosure Functions

- **Support**
  - Resist & transfer physical forces from inside and out
- **Control**
  - Control mass and energy flows
- **Finish**
  - **Interior & exterior surfaces for people**
    - Color, specularance
    - Pattern, texture

Functional Layers

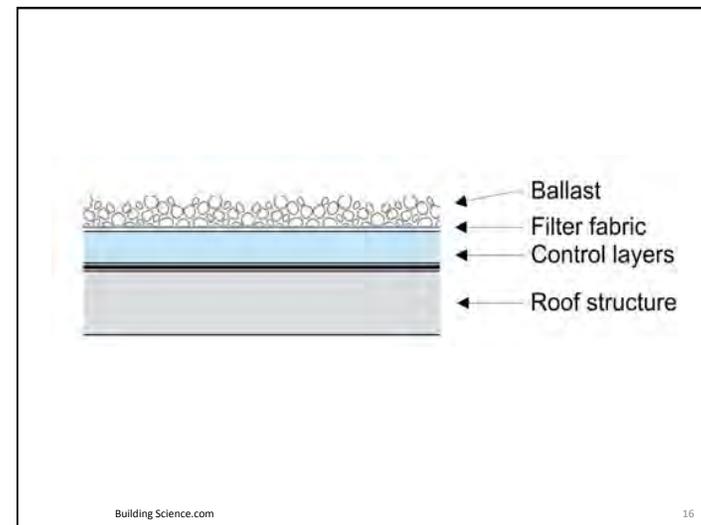
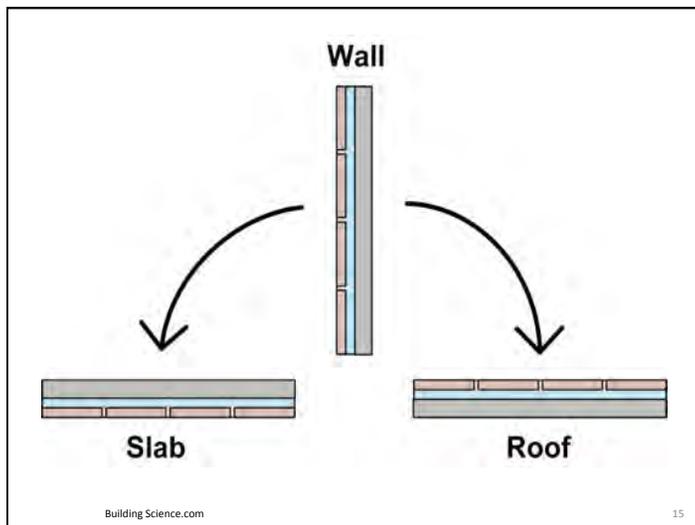
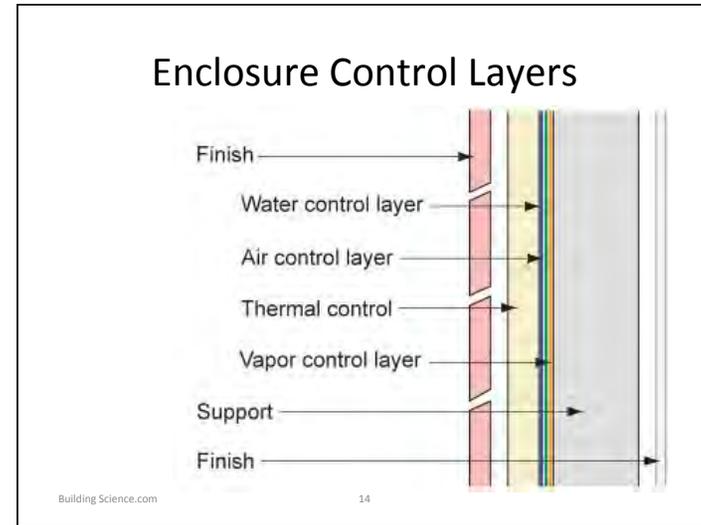
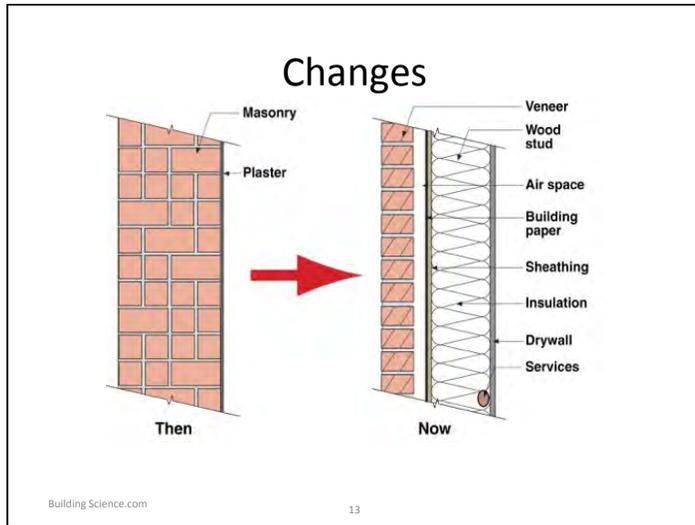
Building Science.com

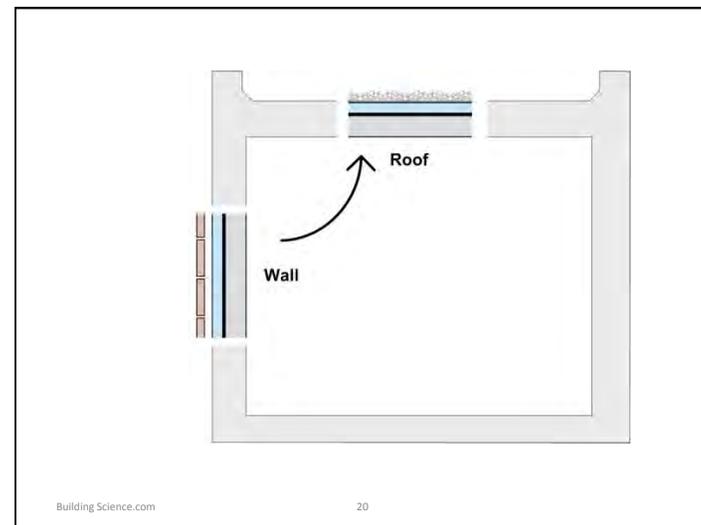
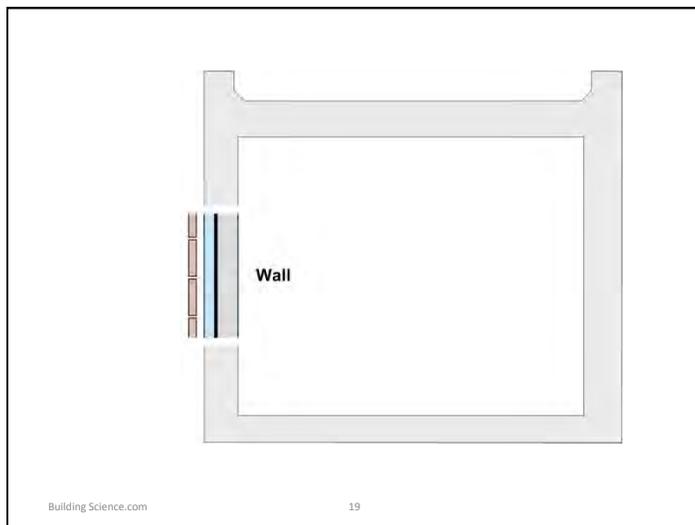
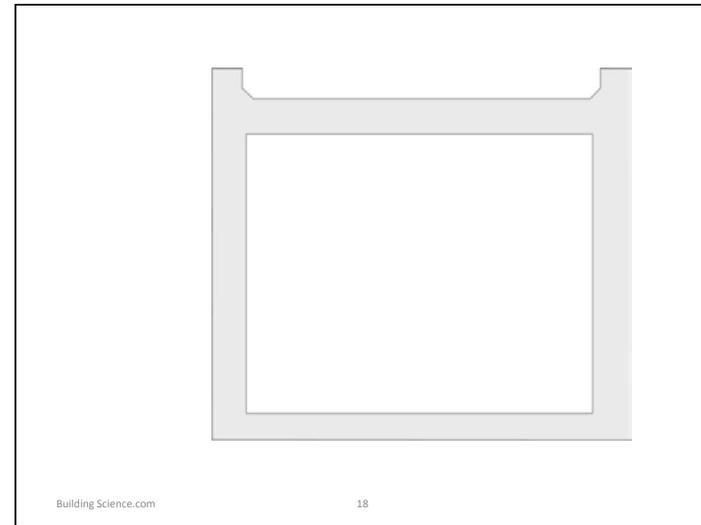
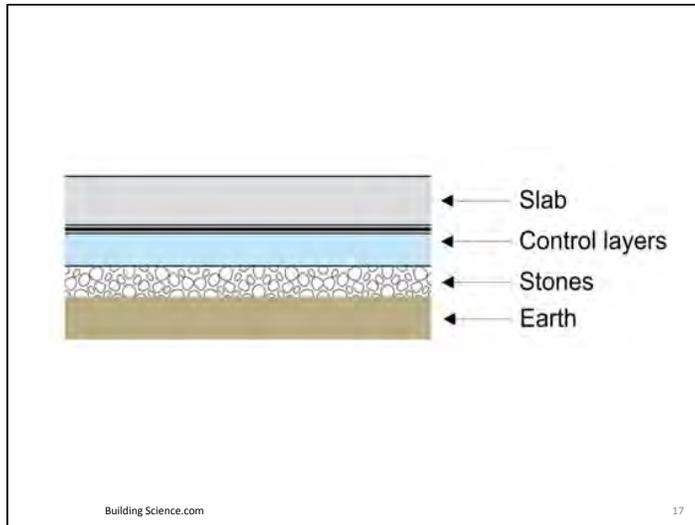
## History of Control Functions

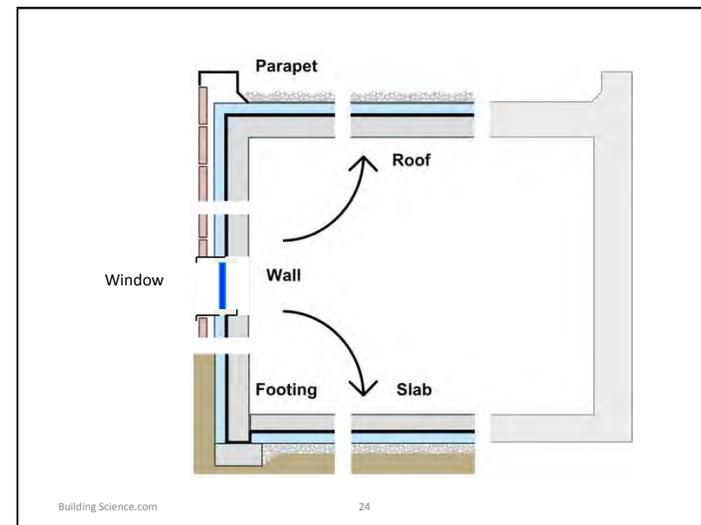
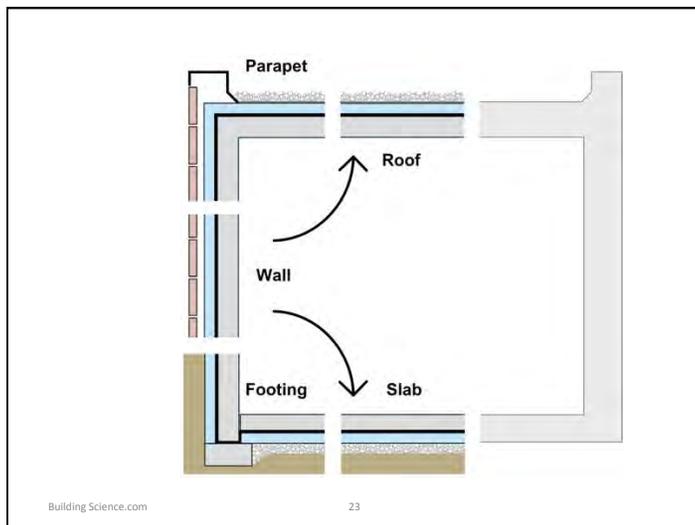
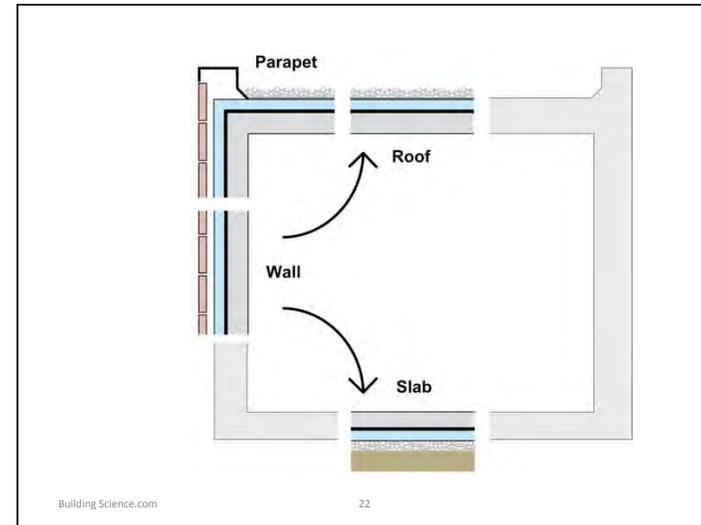
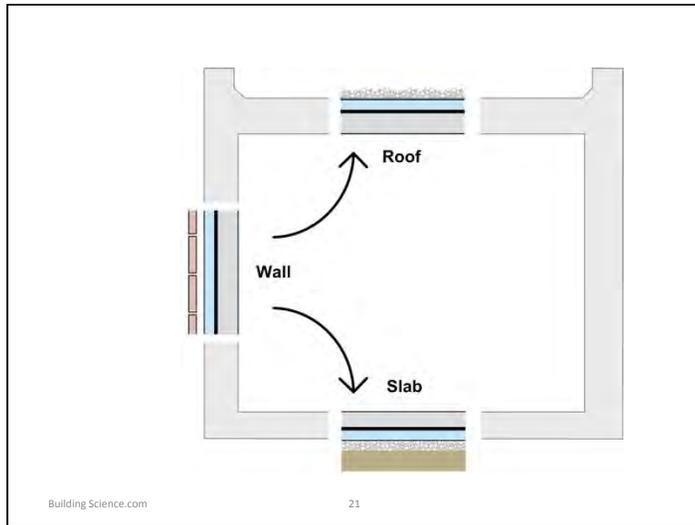
- **Older Buildings**
  - One layer does everything
- **Newer Building**
  - Separate layers, . . . separate functions

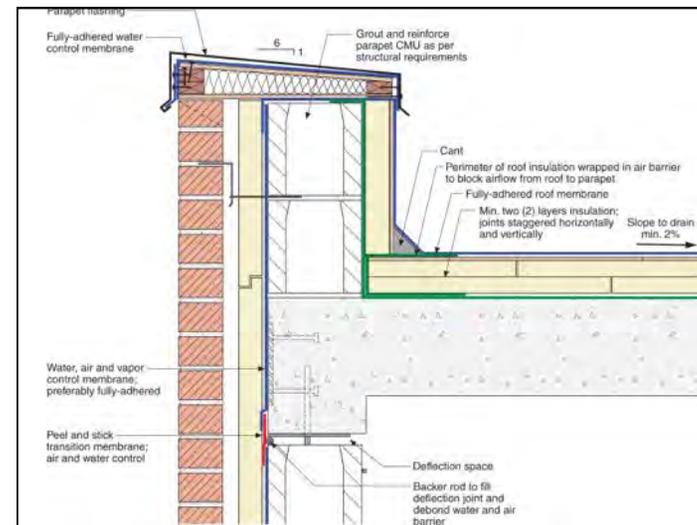
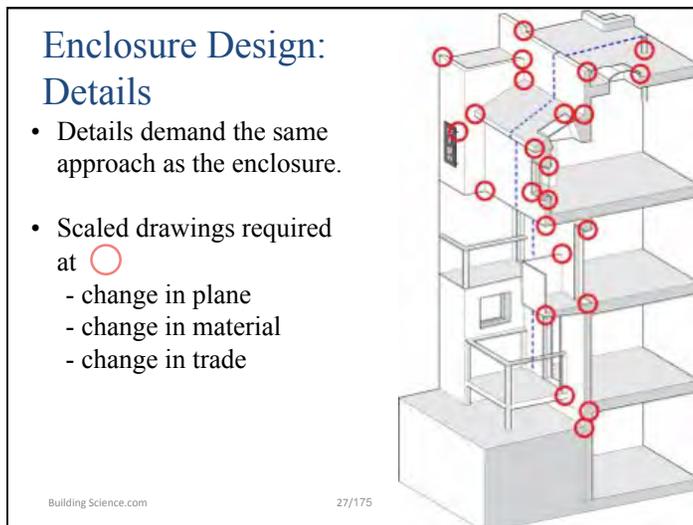
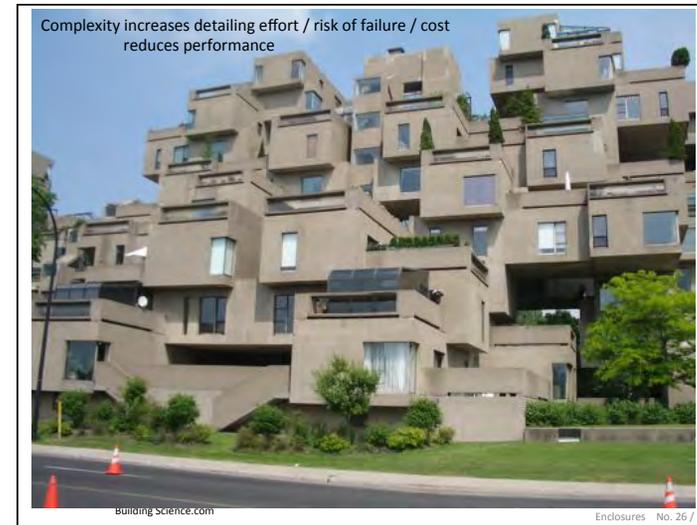
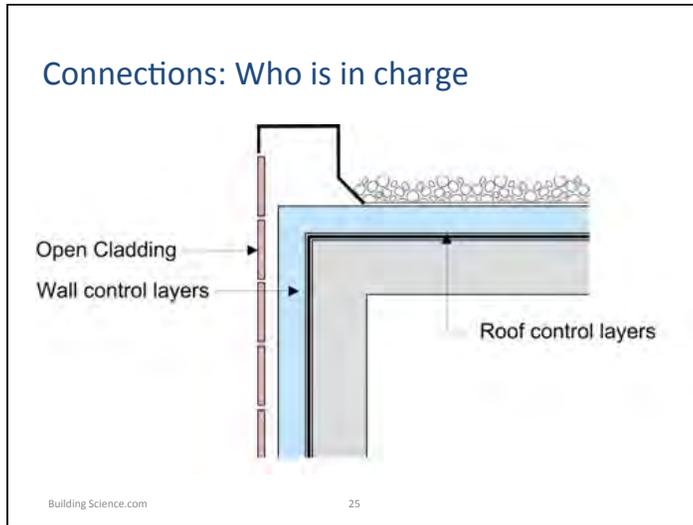


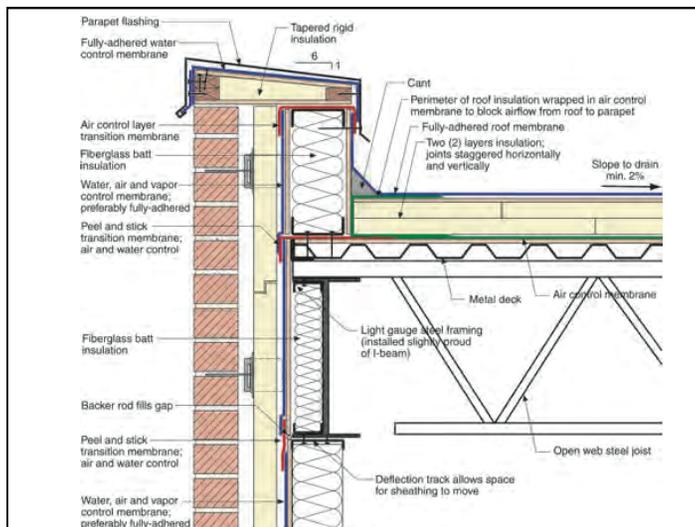
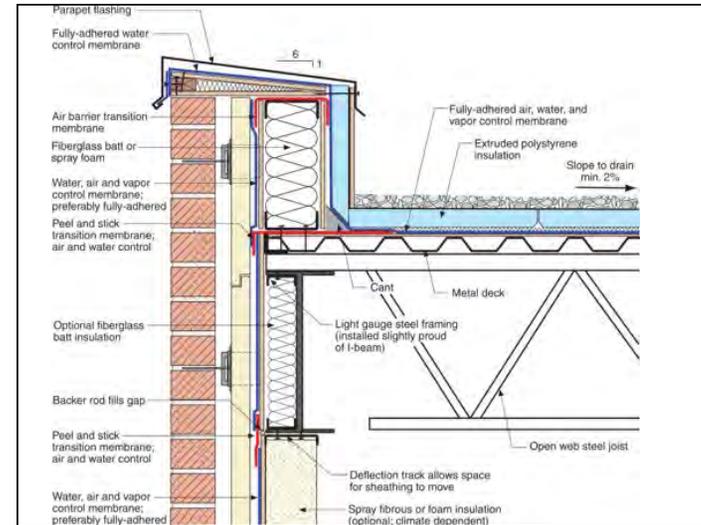
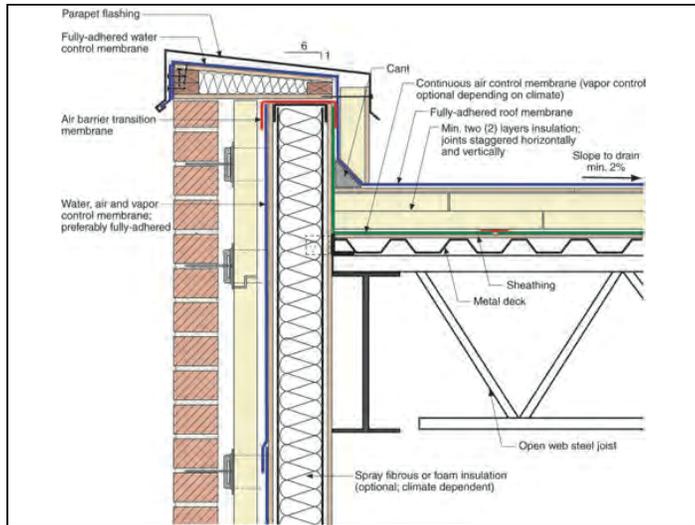

Building Science.com No. 12











# Rain Control

www.buildingscience.com



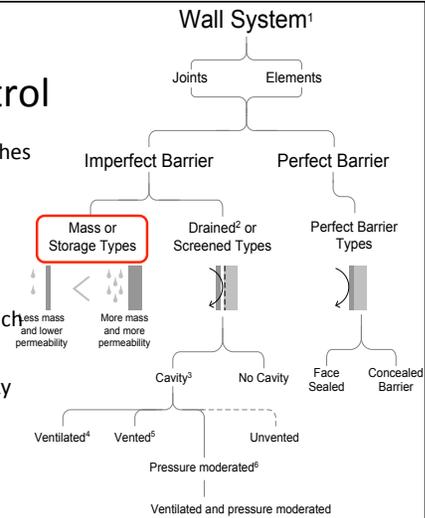
## Rain Control

- Next to structure, the most important, fundamental requirement
- Source of many serious building problems
- Major impact on durability
- Low-energy buildings & rain
  - Different enclosure assemblies
  - Reduced drying ability= need for better control!

www.BuildingScience.com

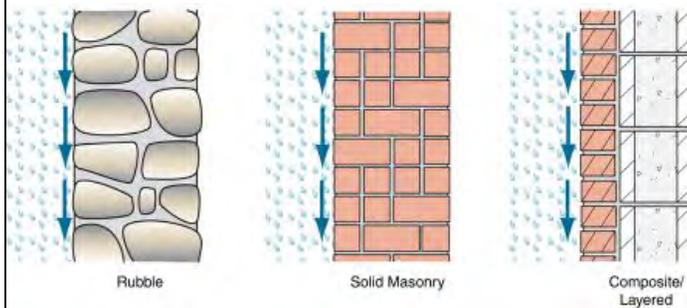
## 1. Rain Control

- Three possible approaches
  - Mass
  - Drained
  - Perfect Barriers



- Element and joint can be different approach
- Perfect Barriers are risky

## Mass/Storage/Reservoir Walls



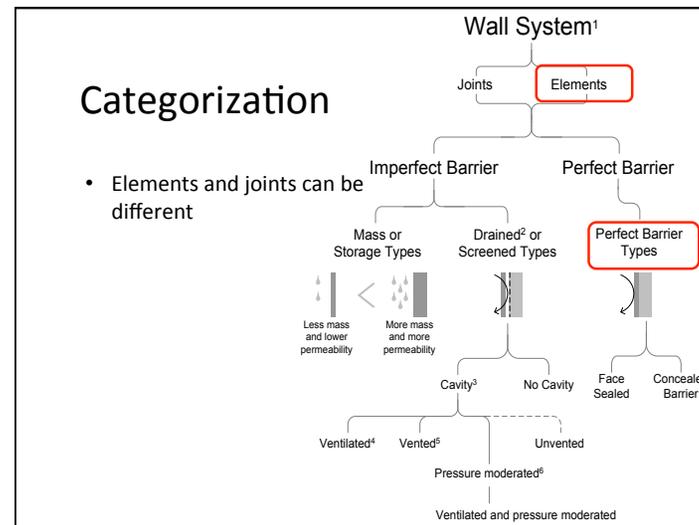
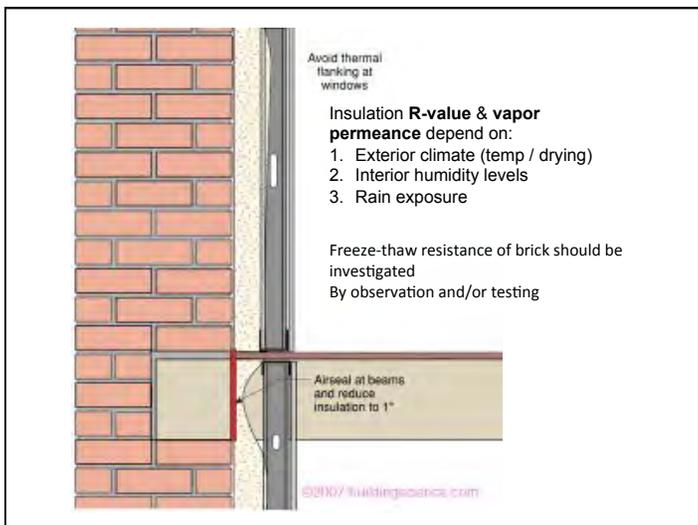
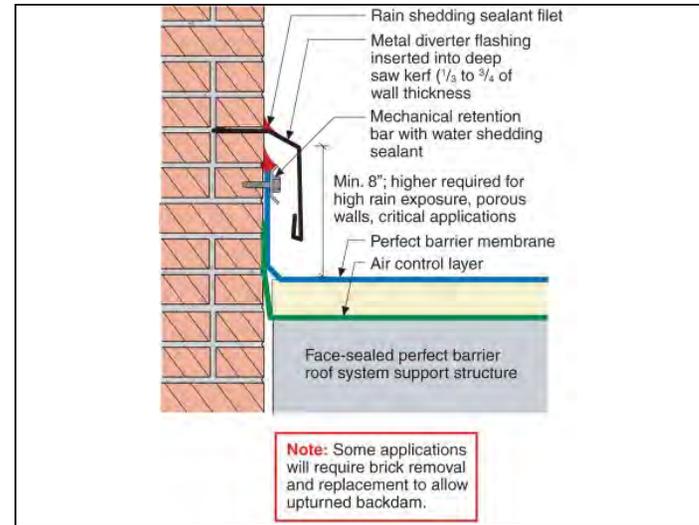
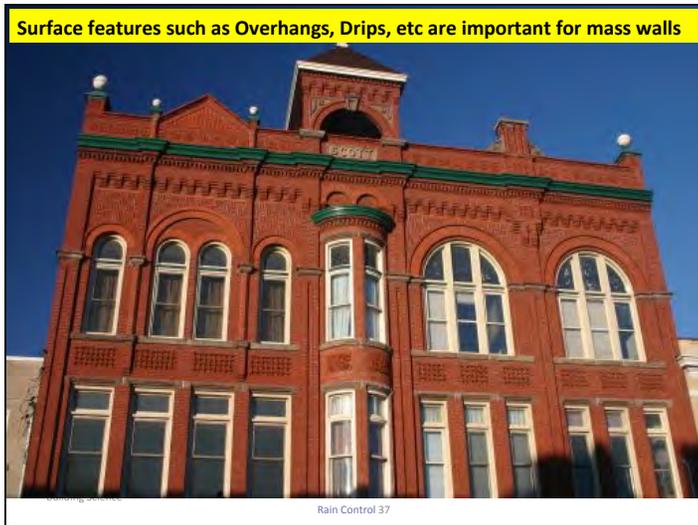
John Straube

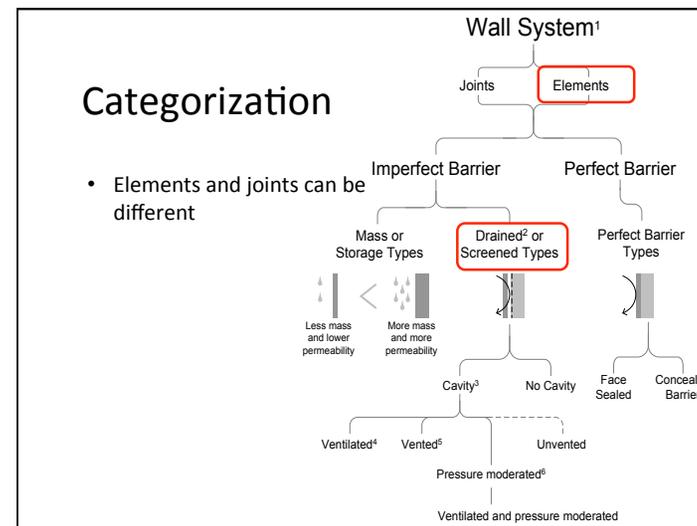
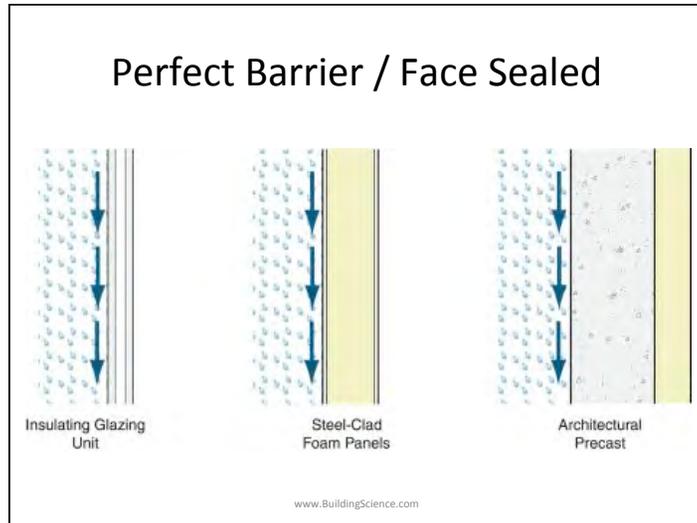
## No building paper, flashing, weepholes

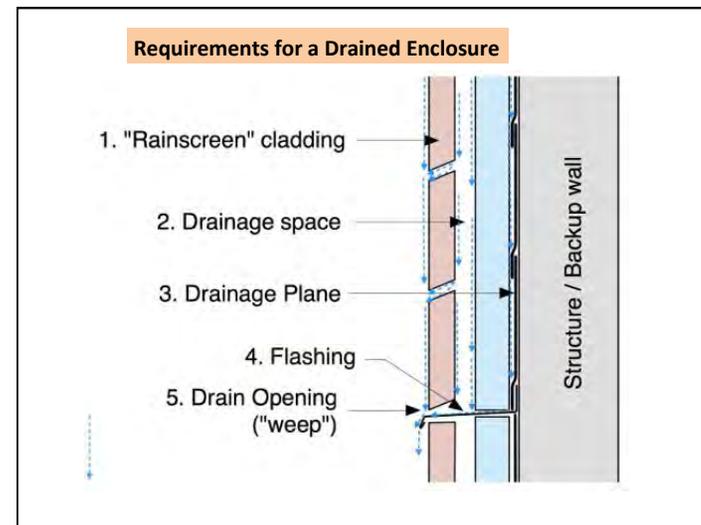
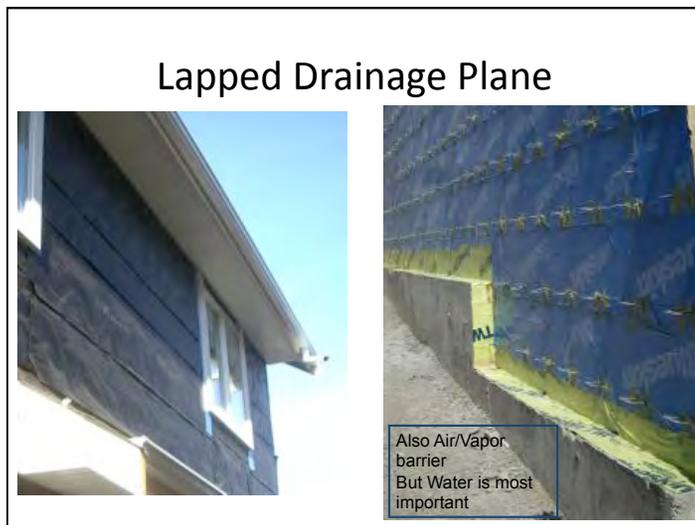
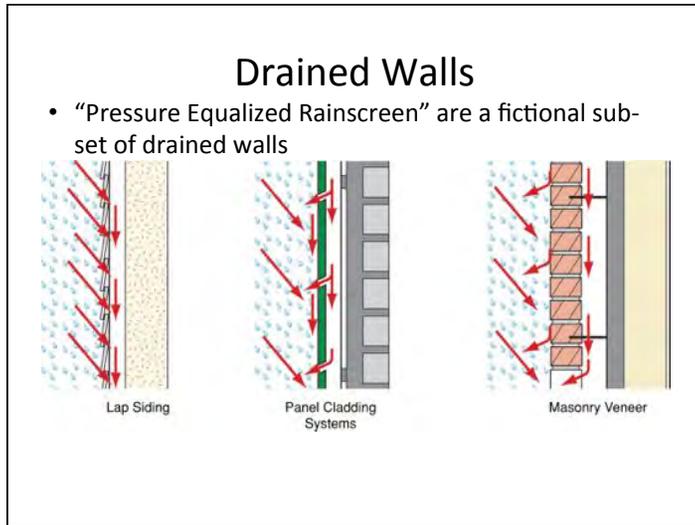


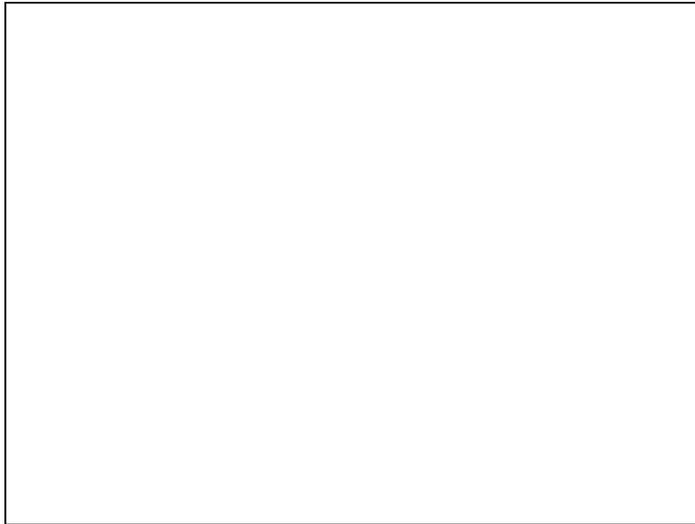
Build

John Straube



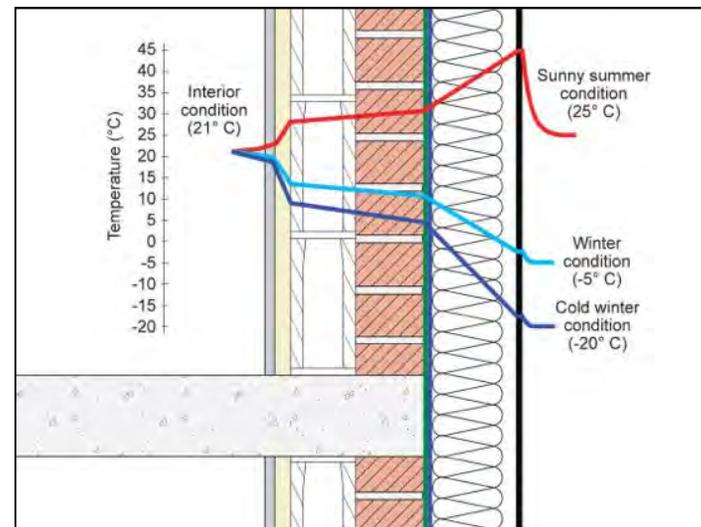
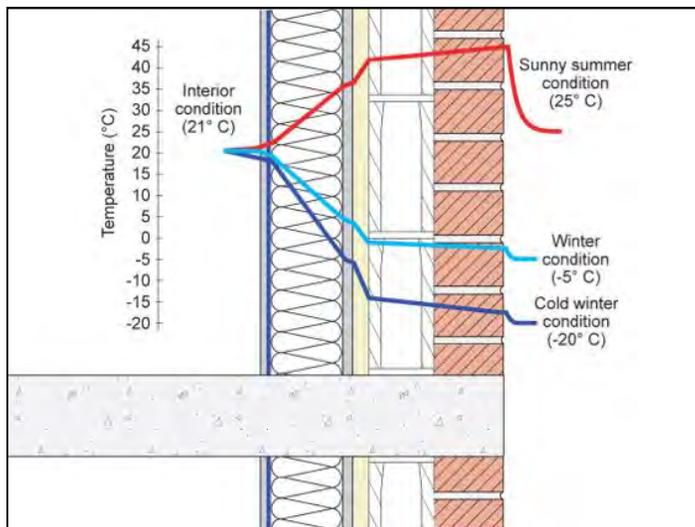


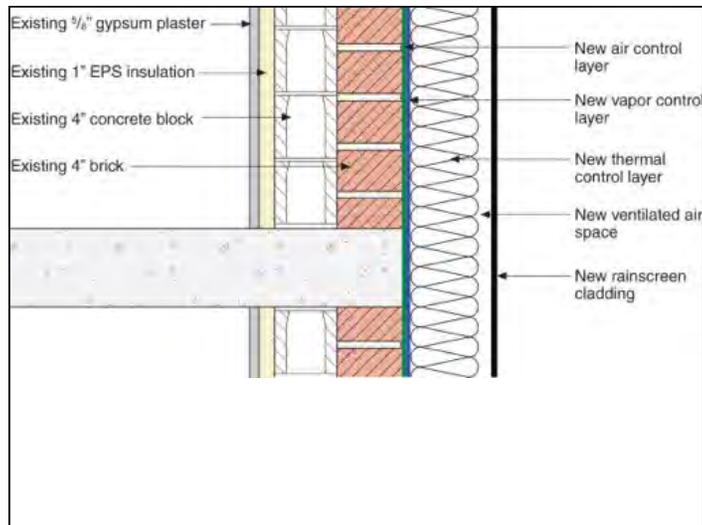




## Retrofits

- Exterior vs Interior

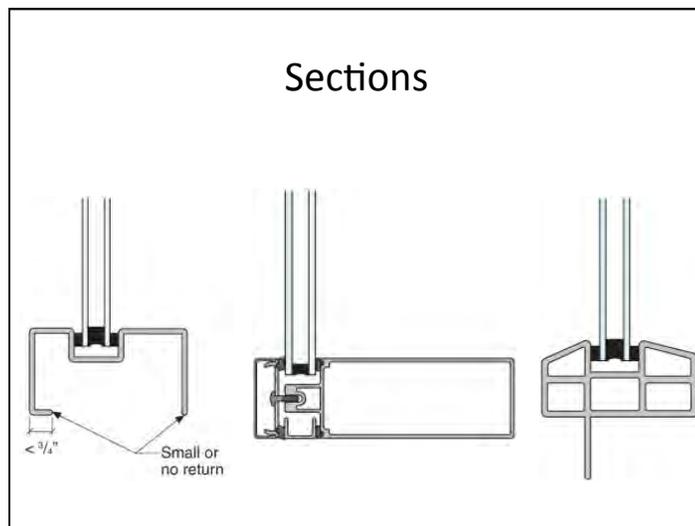




## Windows

- Windows and “Storefronts” are not curtainwalls
- Replacement
- Retrofit
  - Storms
  - Gaskets, caulking

## Sections

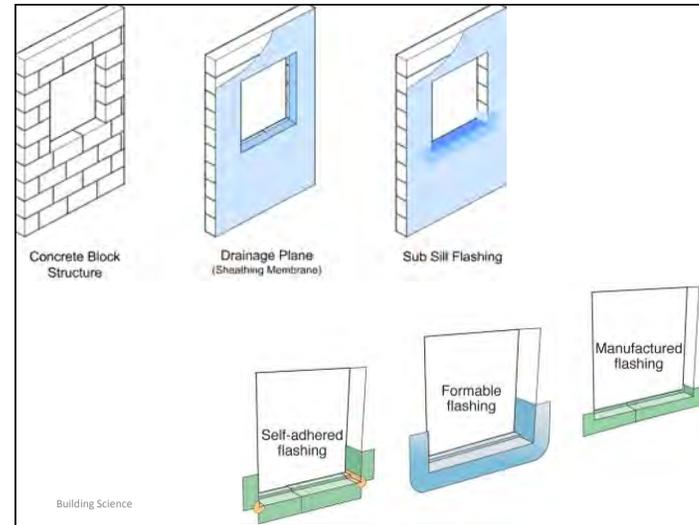


## Window Retrofit

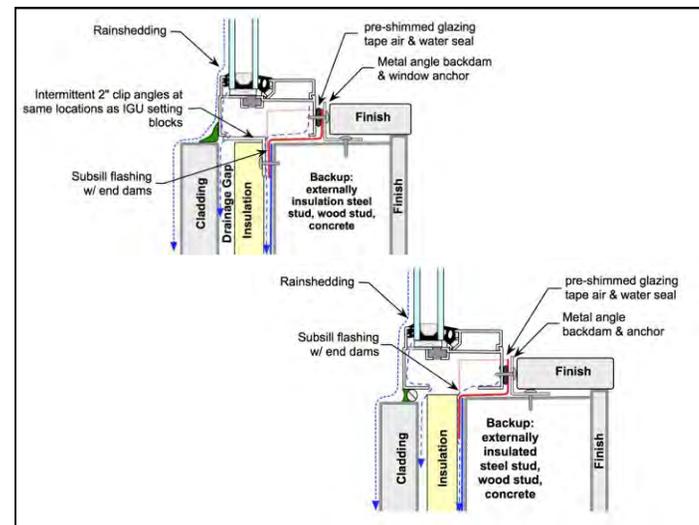
- “Caulk and walk”
- Replace gaskets, sealants, hardware
- Replace IGU
- Replace window
- Upgrade rough opening

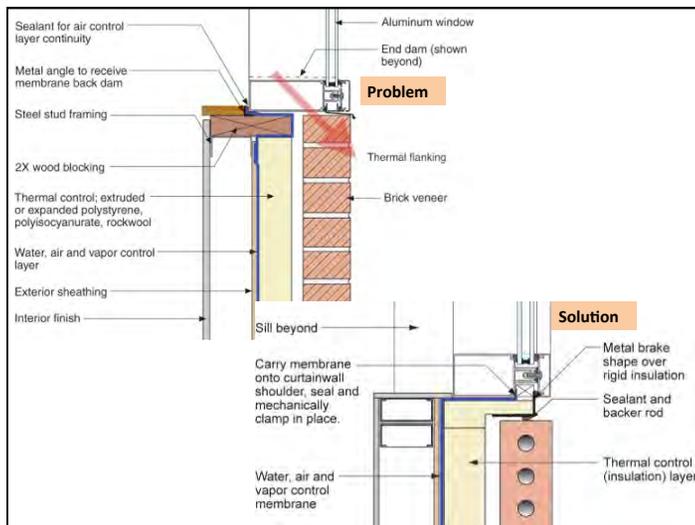
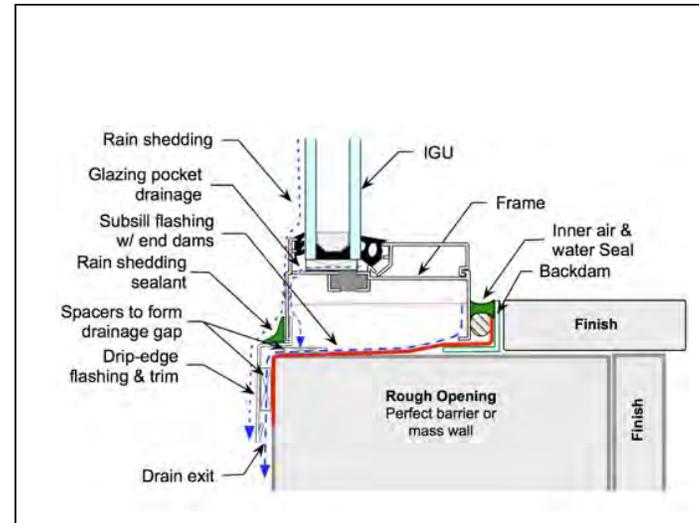
## Leaky windows

- Windows / openings leak



## Backdams / Slopes are Important





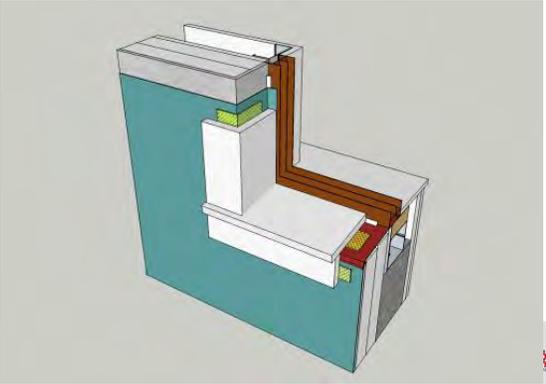
### Deep Energy Retrofit Details

- Windows
  - Replacement in brick wall

DSC Building Science Corporation

### Deep Energy Retrofit Details

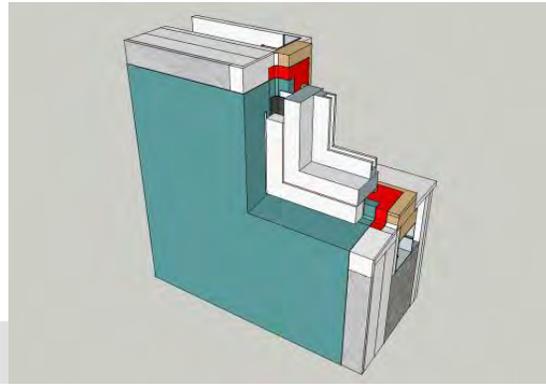
- Windows
  - Replacement in EIFS wall



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### Deep Energy Retrofit Details

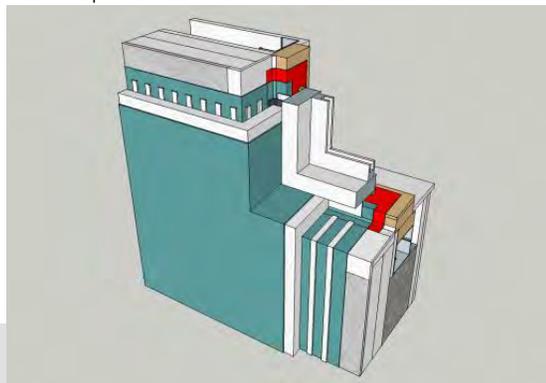
- Windows
  - Replacement in EIFS wall



DSC Building Science Corporation

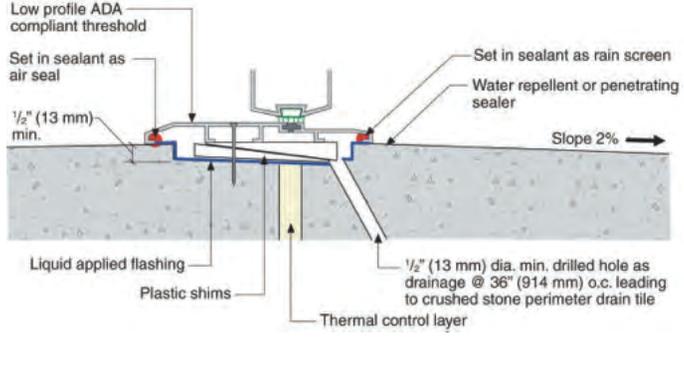
### Deep Energy Retrofit Details

- Windows
  - Replacement in EIFS wall

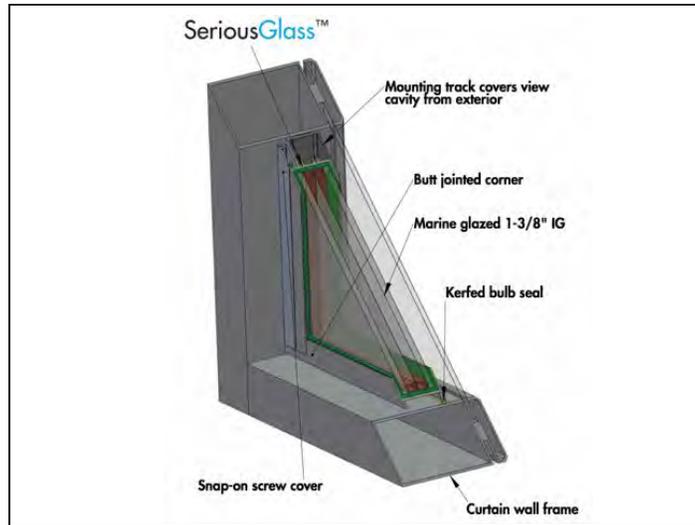


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### Add drainage below thresholds



Low profile ADA compliant threshold  
 Set in sealant as air seal  
 1/2" (13 mm) min.  
 Liquid applied flashing  
 Plastic shims  
 Thermal control layer  
 1/2" (13 mm) dia. min. drilled hole as drainage @ 36" (914 mm) o.c. leading to crushed stone perimeter drain tile  
 Set in sealant as rain screen  
 Water repellent or penetrating sealer  
 Slope 2%

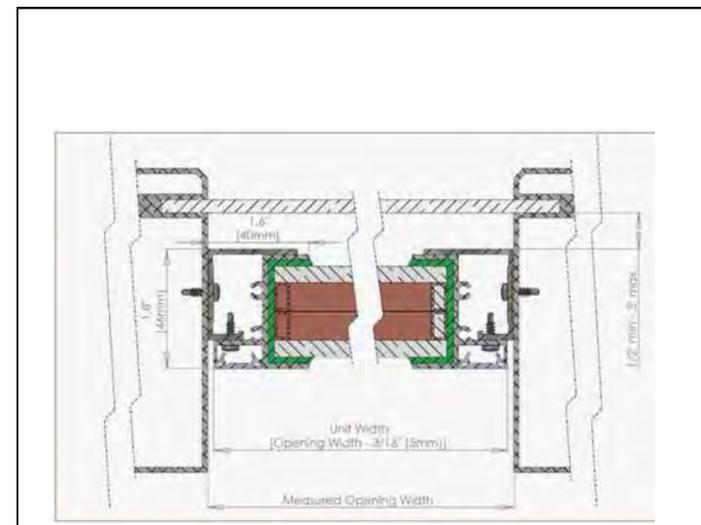


## Storms

- Interior and Exterior
- Key issue is operability
  - Fixed are easy and high performance
- Can improve R1 single glazing to R3 with low-e interior storms
- Storms on interior must be tight
- Exterior must be leaky (5:1 ratio)

## Storms

- Airtight interior low-e storms preferred



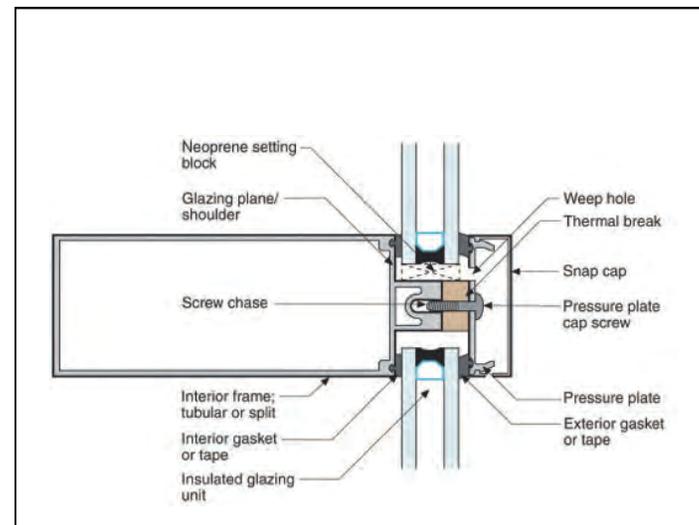


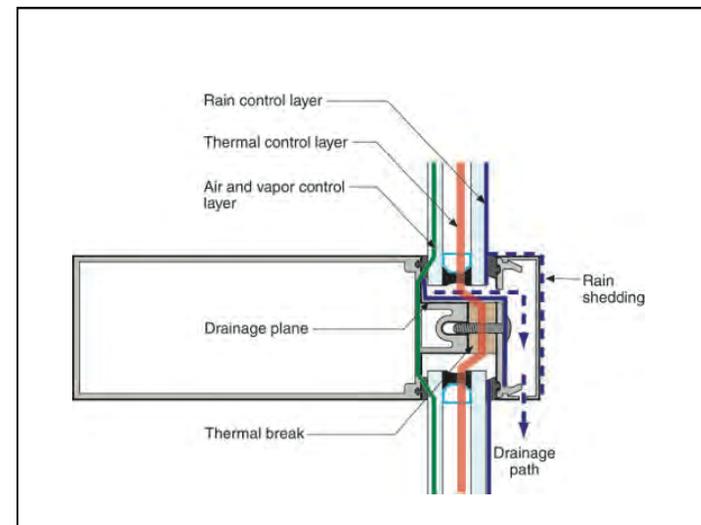
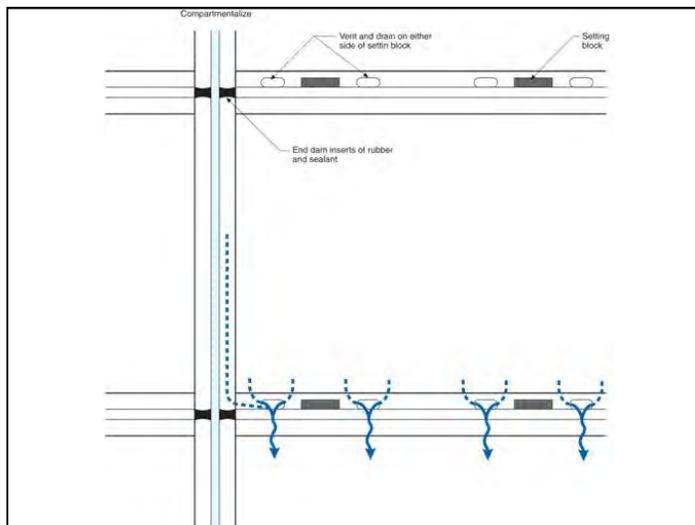
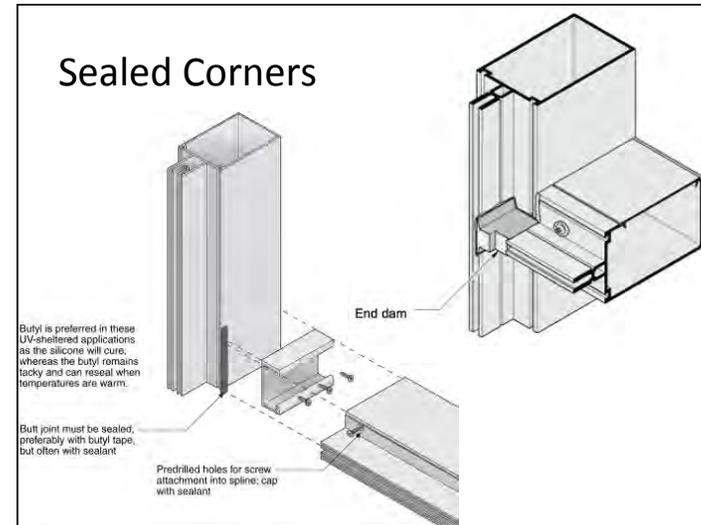
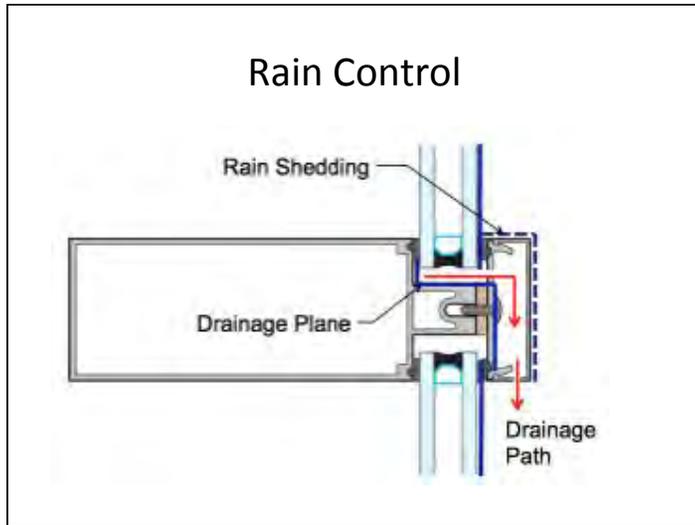
### Vent Ratios

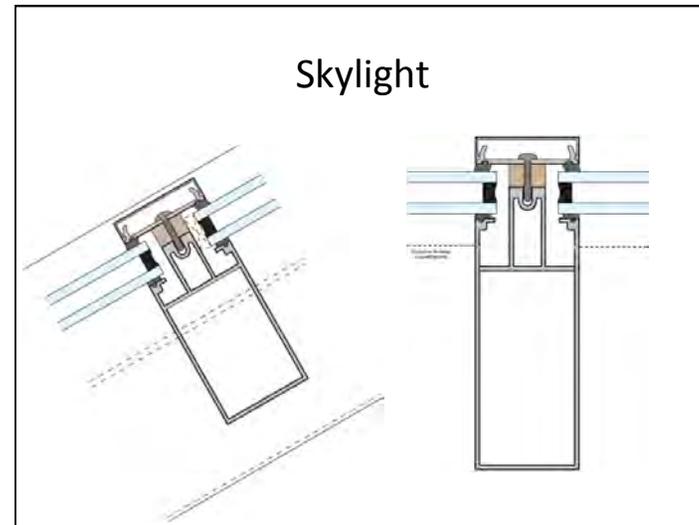
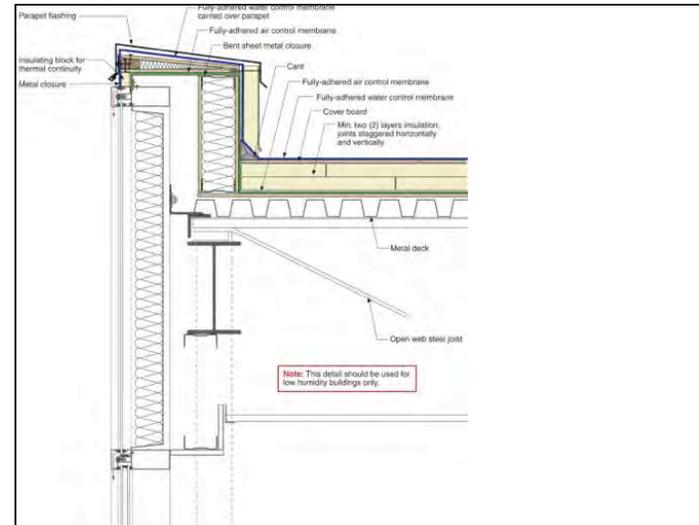
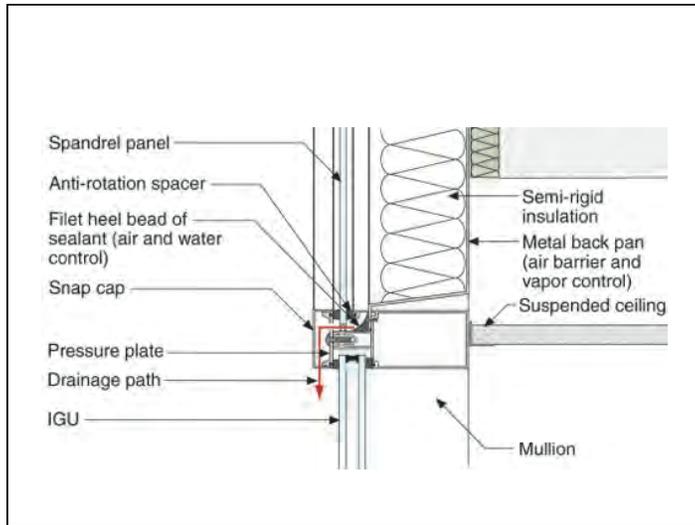
Outside Temp. °F	Minimum Ratio of Outside to Inside Air Flow to Window Space
40	7
20	9
0	16
-20	25
-40	41

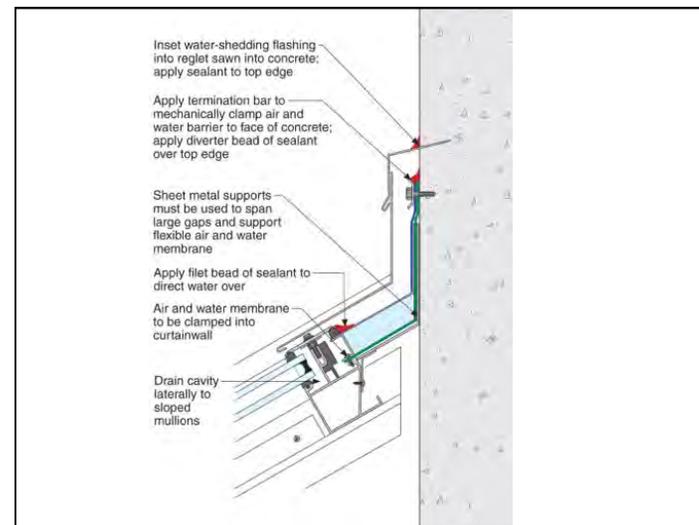
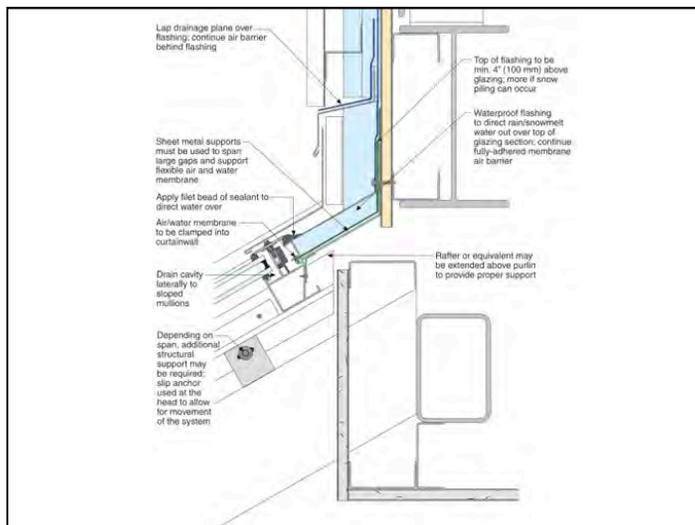
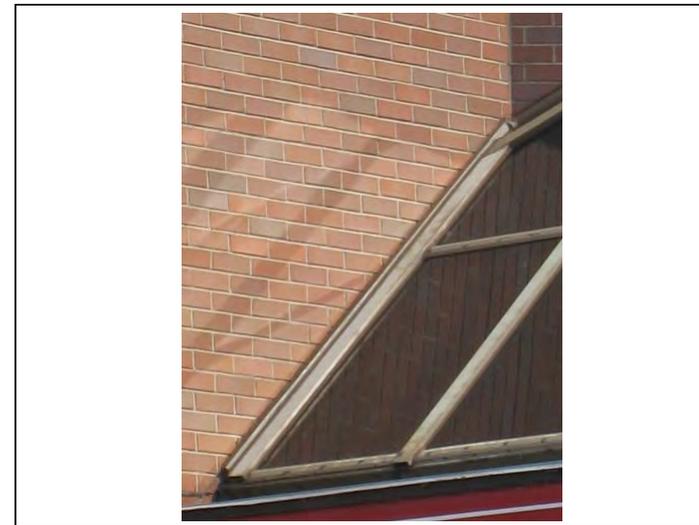
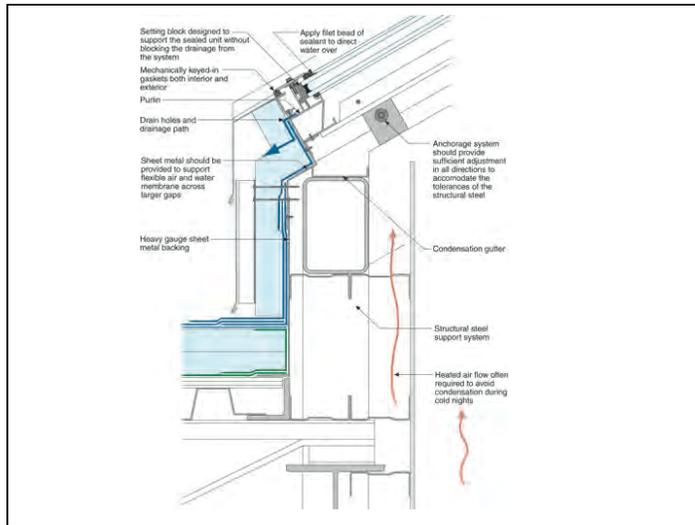
### Curtainwalls

- Larger spans, higher loads
- Different attachment and rain control

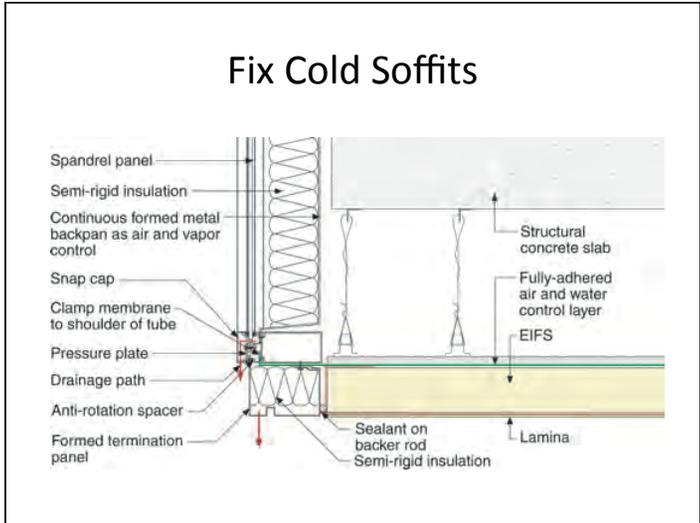






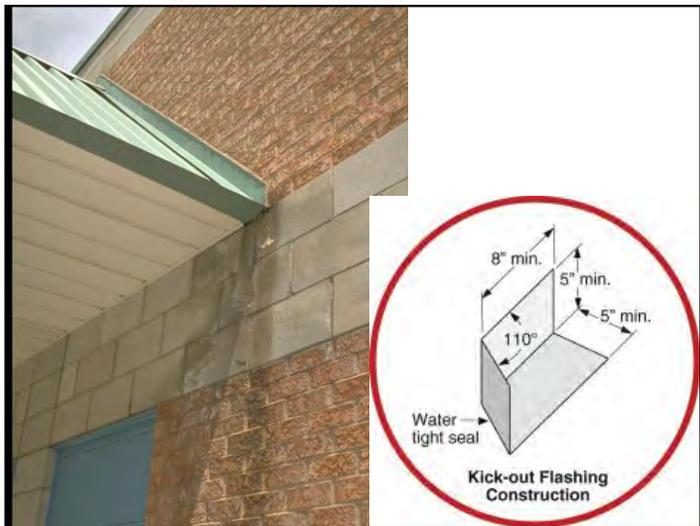


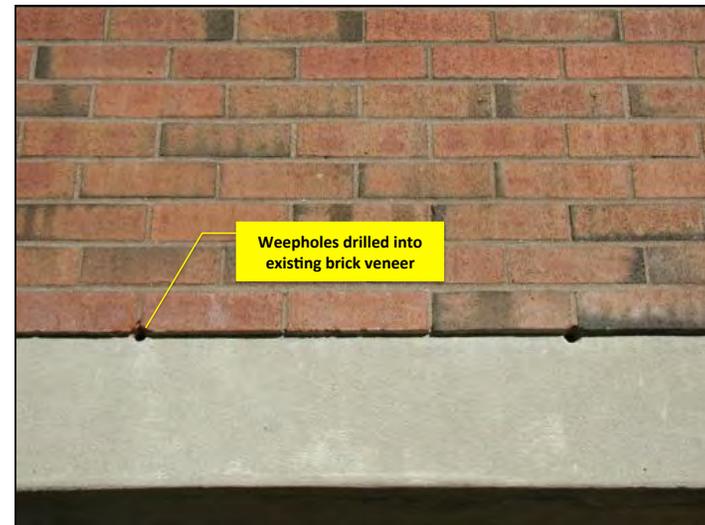
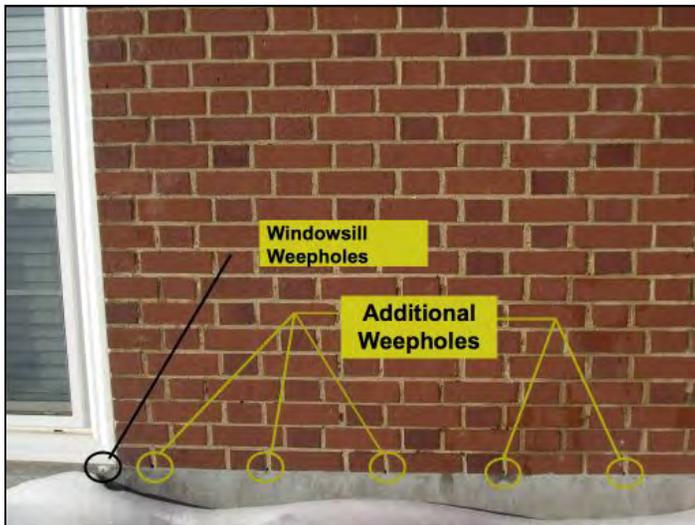
### Fix Cold Soffits

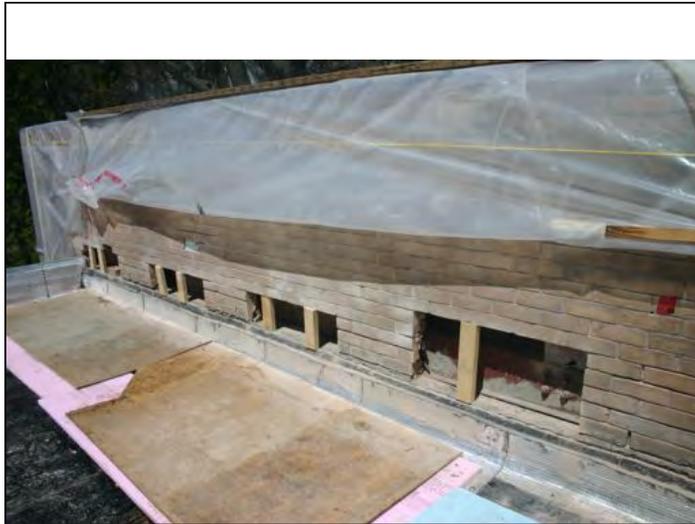


### Masonry Veneer

- Often solving leakage problems
  - Need to ensure flashing and drainage
- Updating window and expansion joints







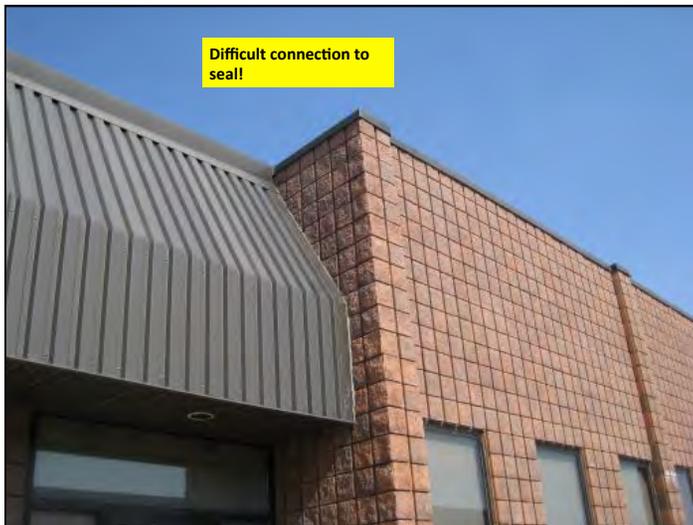
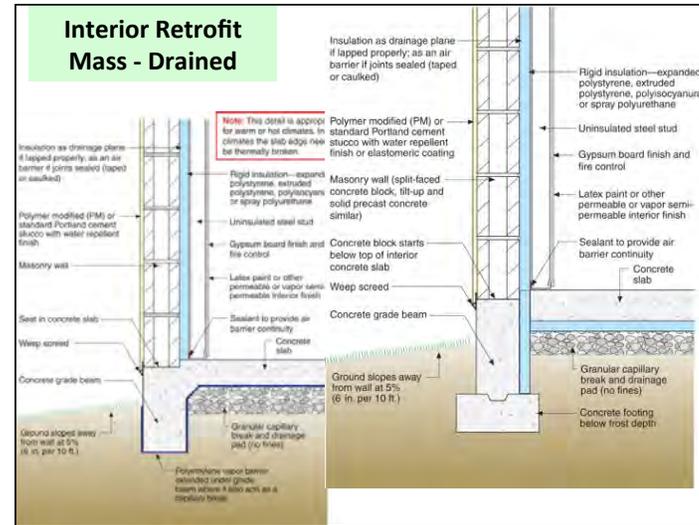
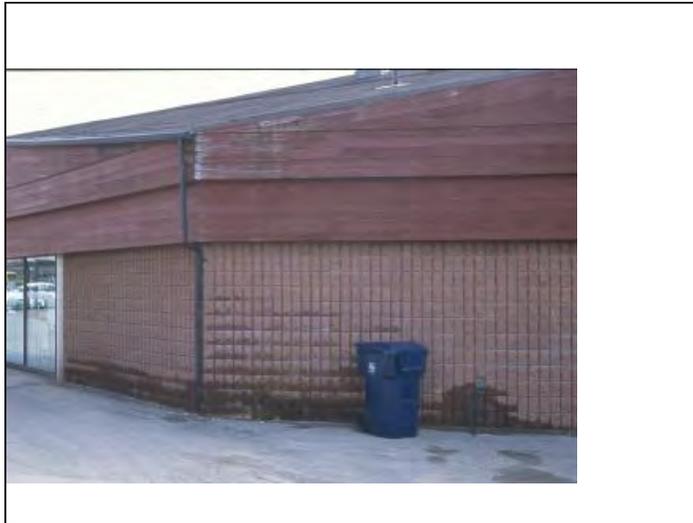
## Corroded Lintels



## Sealers

## Solid Masonry

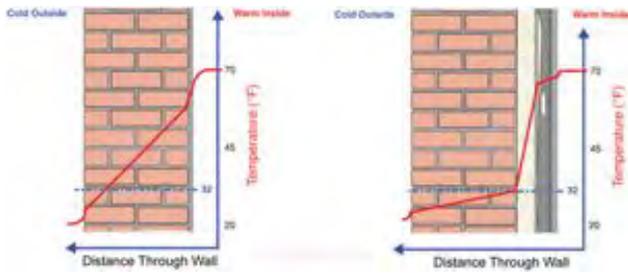
- Multi-wythe brick,
  - single wythe CMU, coated or not
  - Split-face concrete block
- 
- Fix in place
  - Interior Retrofit
  - Exterior Retrofit



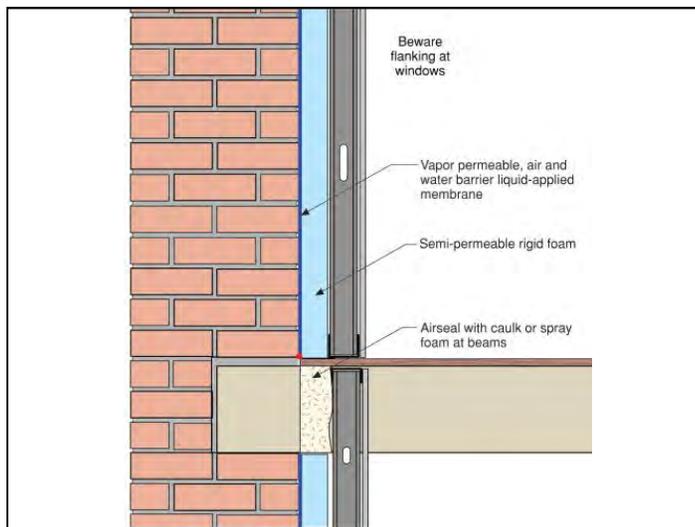
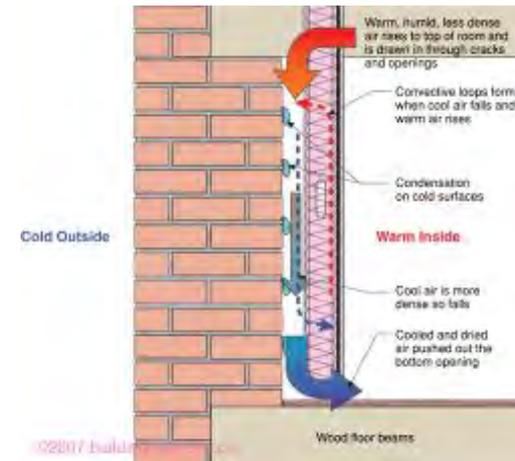
## Retrofit Sprayfoams

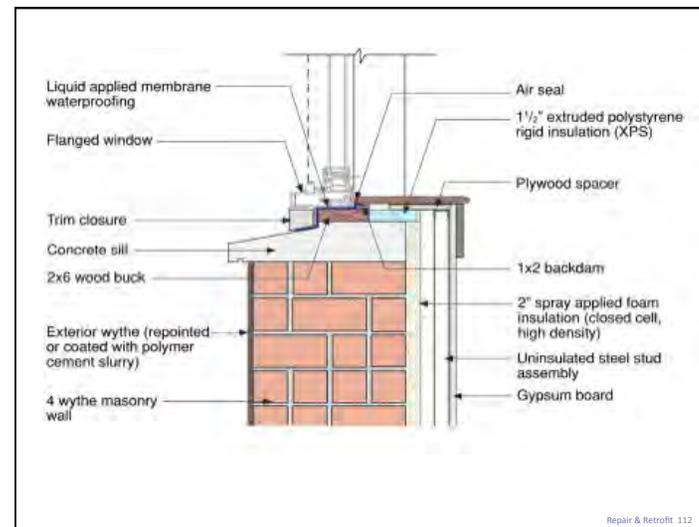
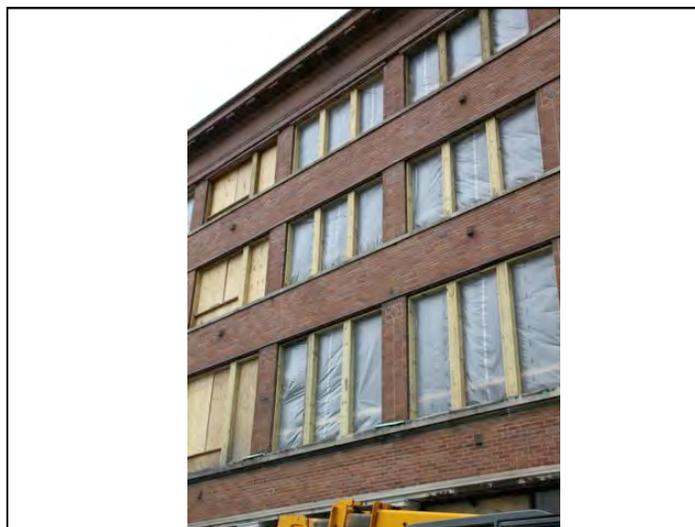
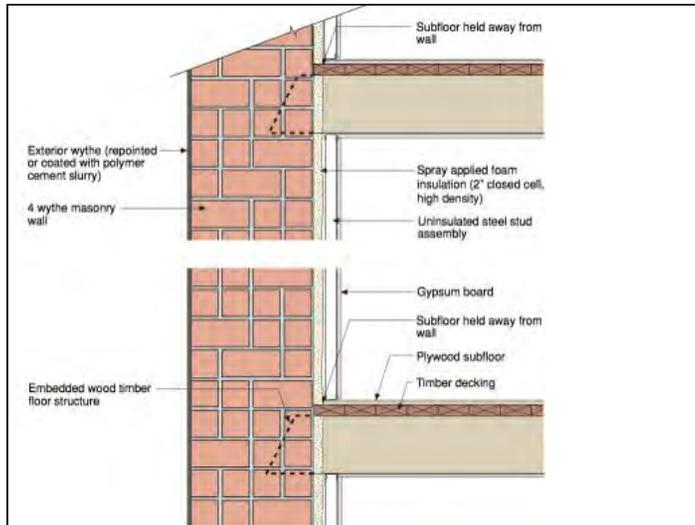
- Medium density foams now available
  - 0.75 pcf (R4+/inch) 5 perms / 5 inch
    - Demilec, AgriBalance
  - 1.2 pcf (R4.8/inch) 3 perms / 3.5 inch
    - Spray Foam Polymers, Thermoseal 1200
  - 2.0 pcf oc (R5.1/inch) 1.3 perms/3 inch
    - Icynene MD-R-200

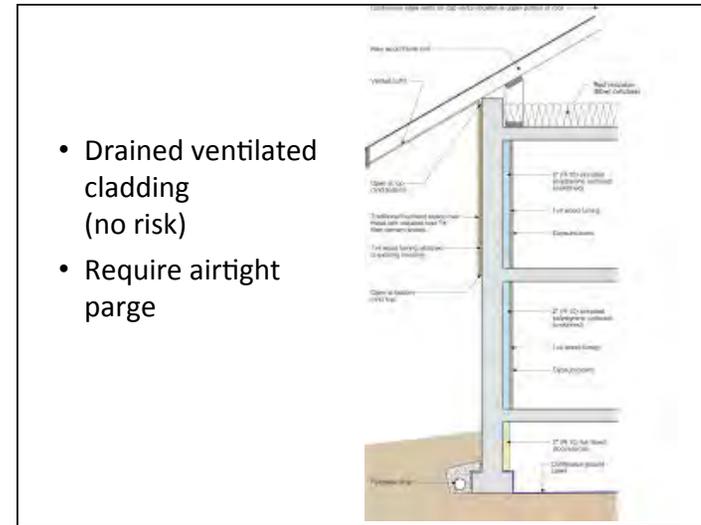
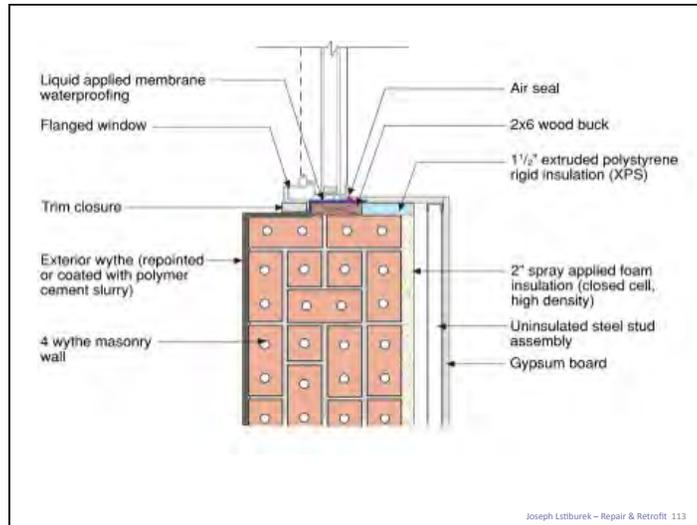
### Interior Insulation



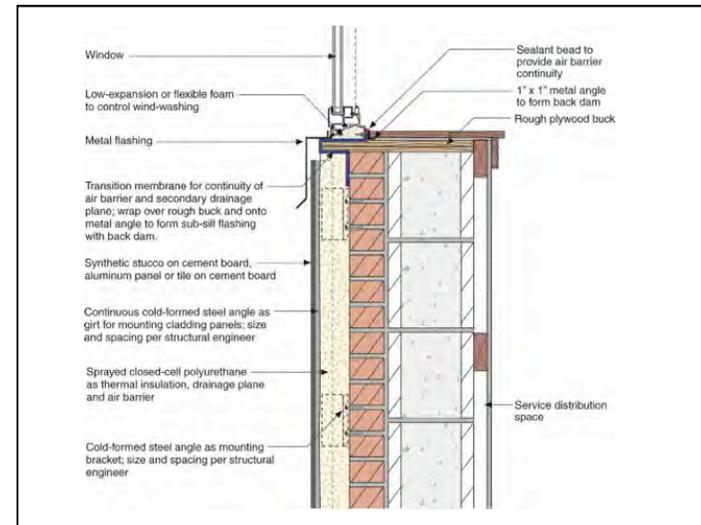
### Most common failure mode

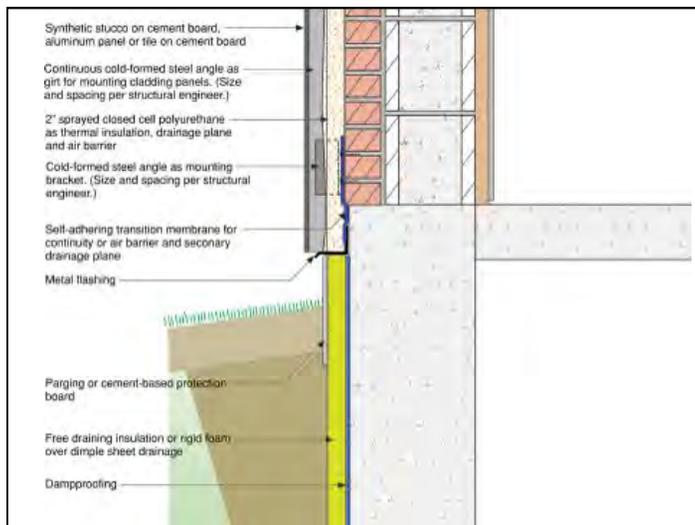
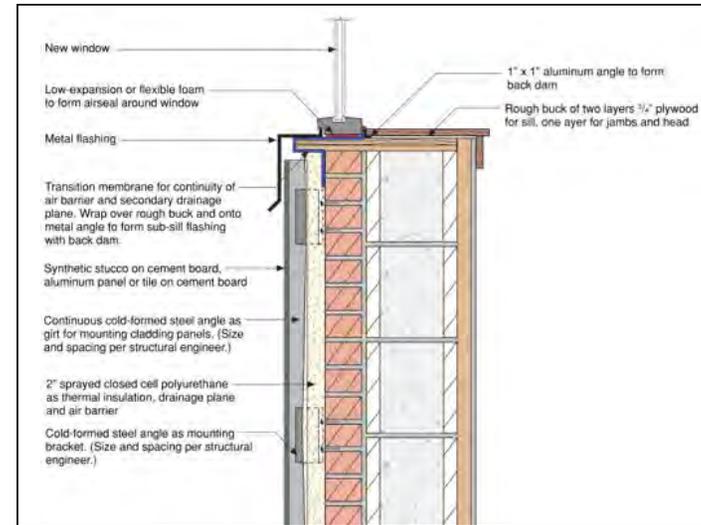
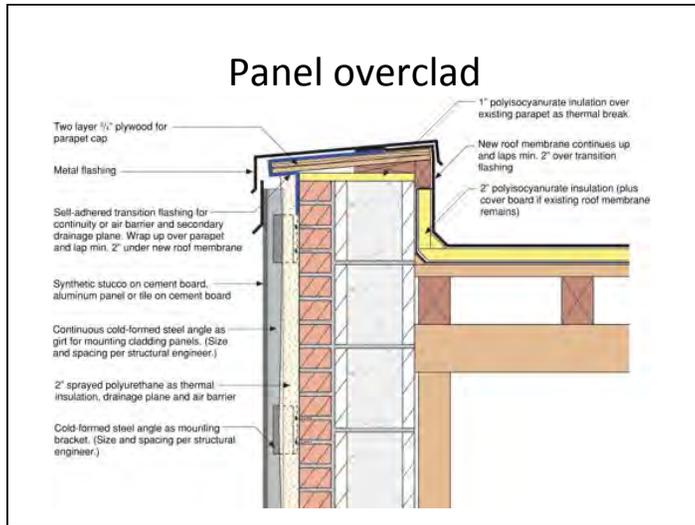






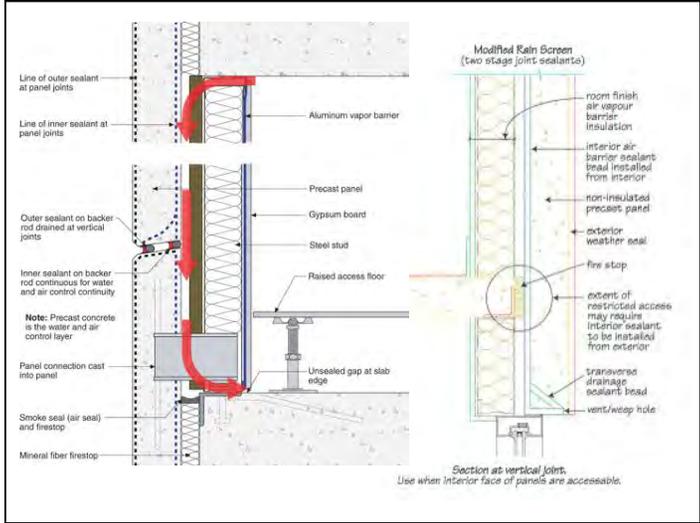
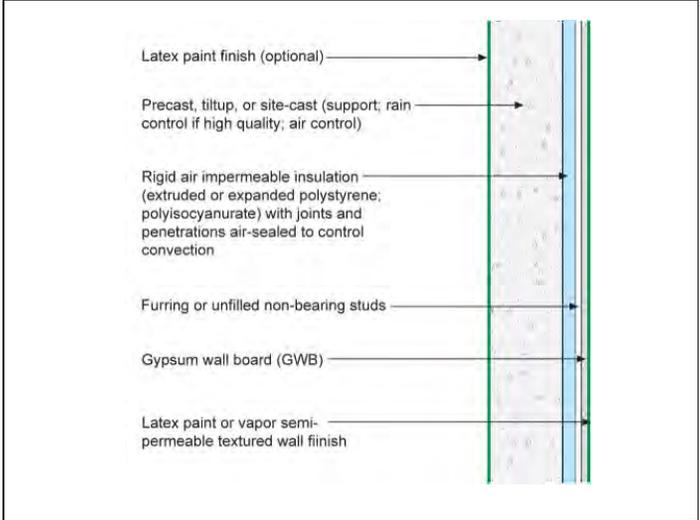
- Drained ventilated cladding (no risk)
- Require airtight parge

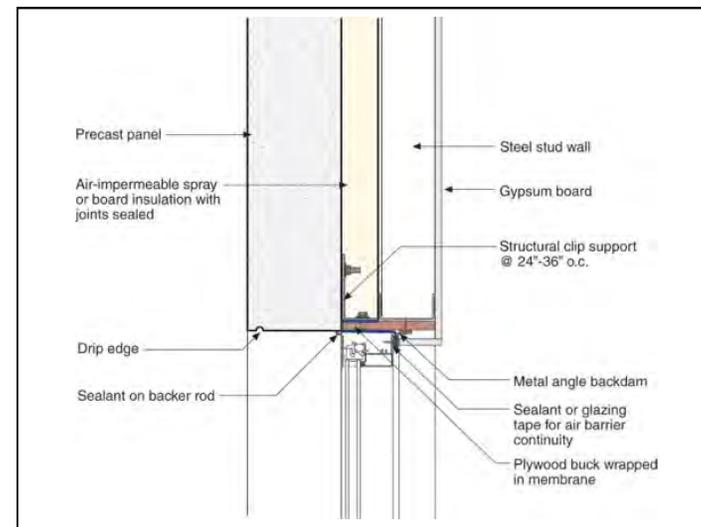
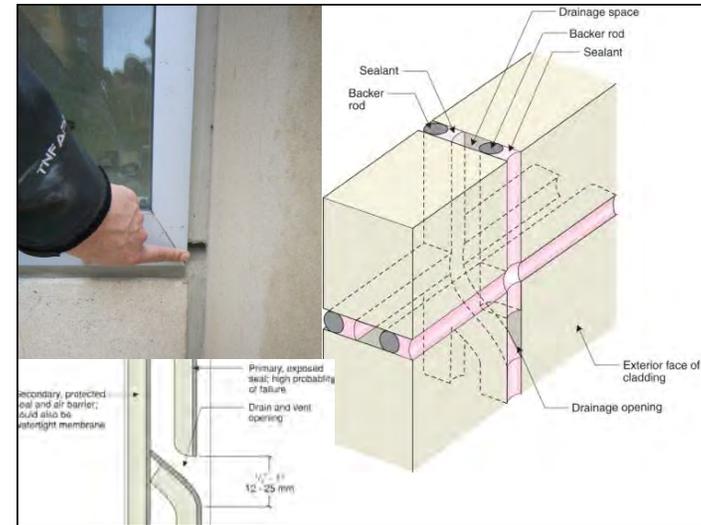
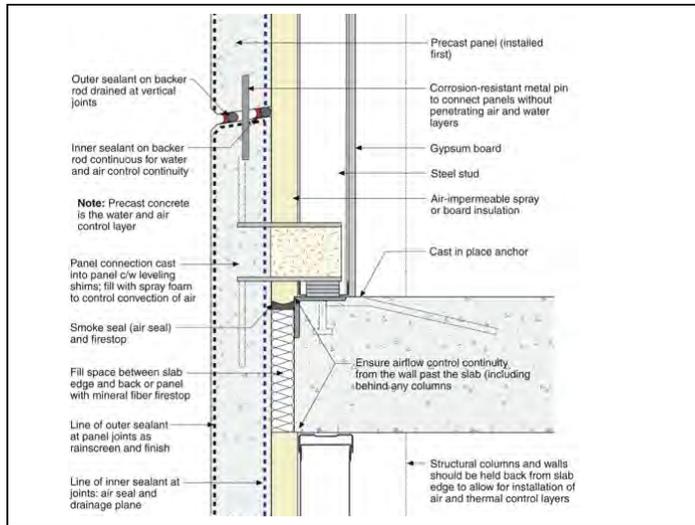


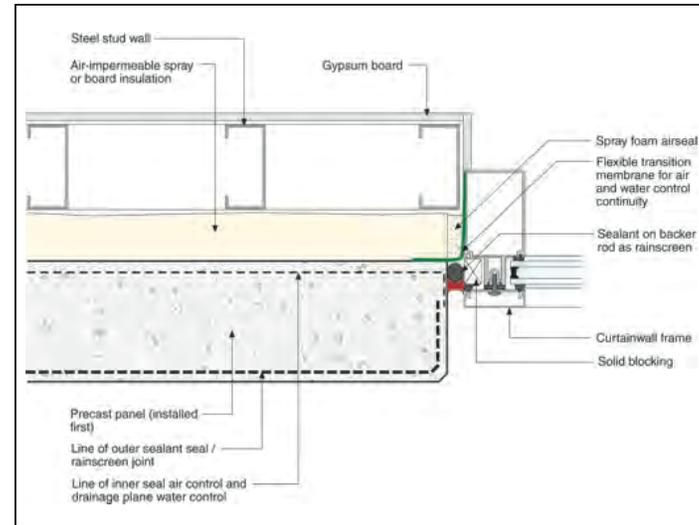
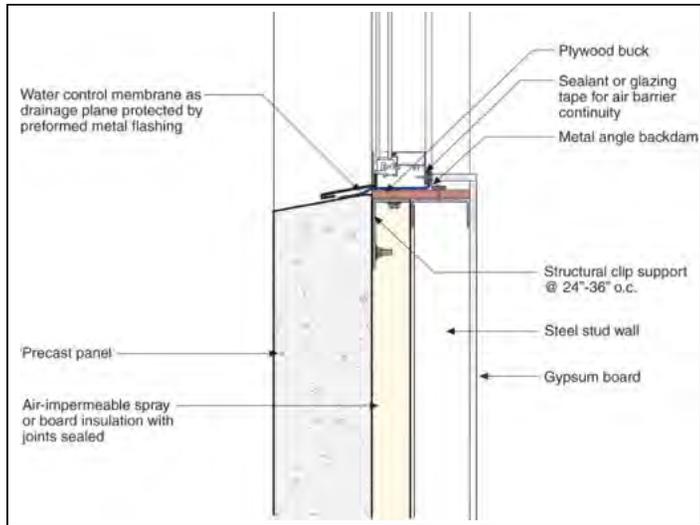


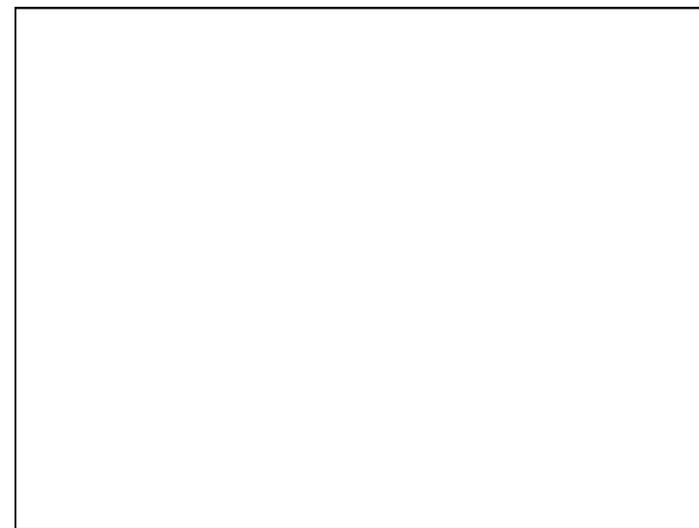
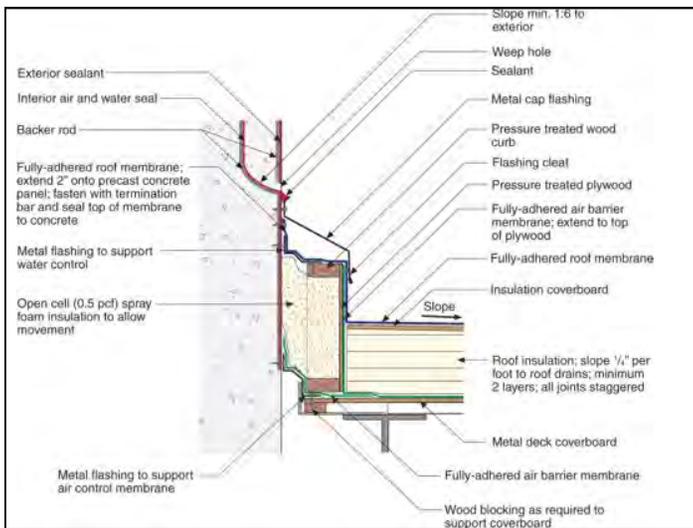
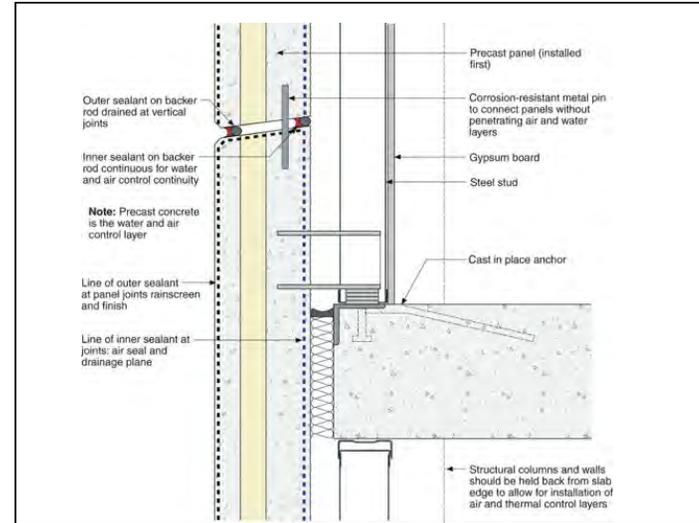
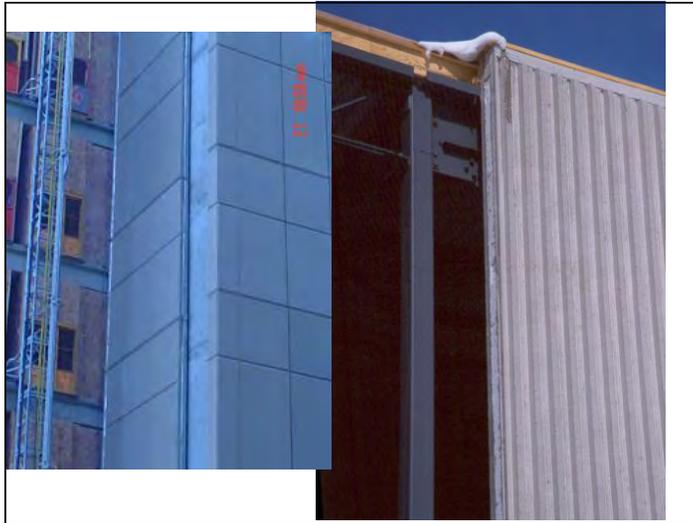
## Precast / Tiltup/ Sitecast

- Solid concrete elements
- Almost always waterproof
  - Perfect barrier rain control
- Joints and penetrations leak
  - Sealant replacement needed over time
- Windows often need replacement
- Metal anchors can corrode



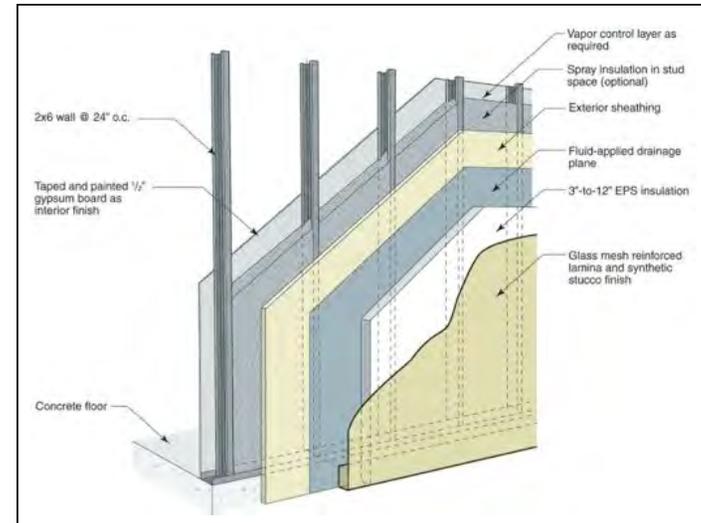






## EIFS Retrofit

- Eeffss
- Exterior Insulated Finish System
- “Synthetic stucco”
- Developed as a retrofit system for masonry walls
- Problems with rain penetration in the 90’s.

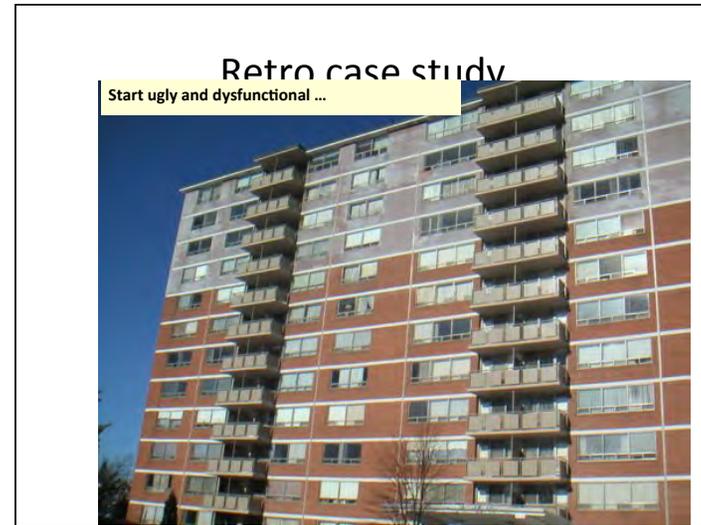


## EIFS Application



Drained EIFS: nice but not always needed





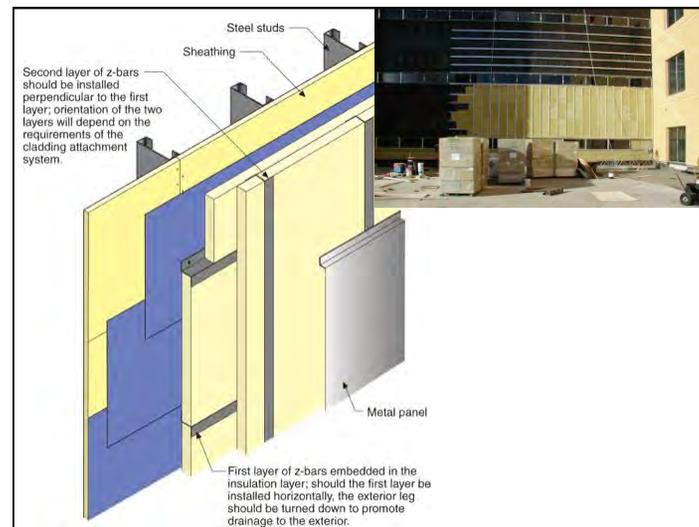
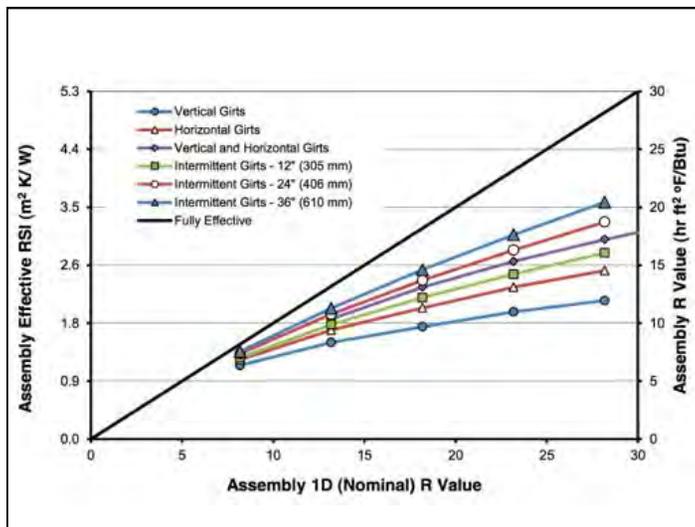
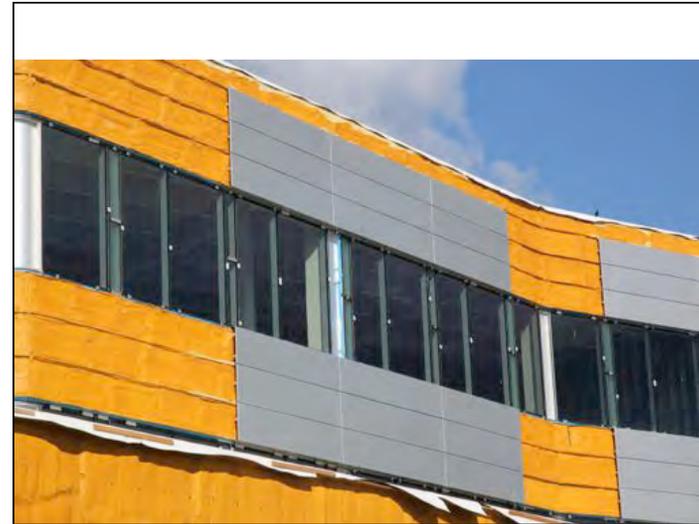




## Metal Sheet / Panel

- Thermal bridging
- Cascadia





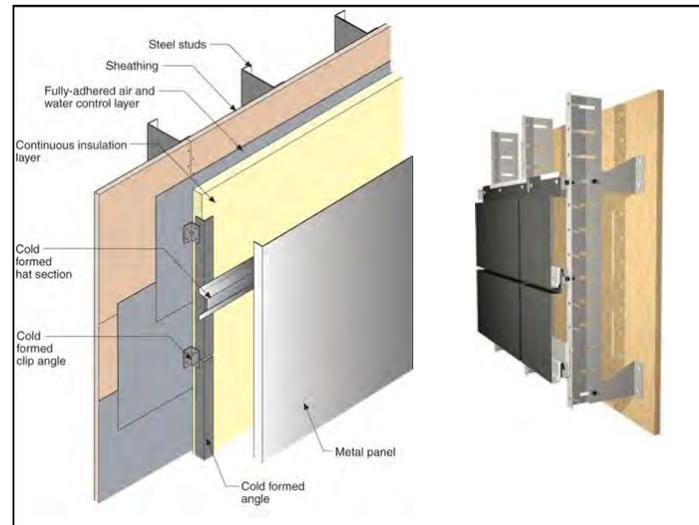


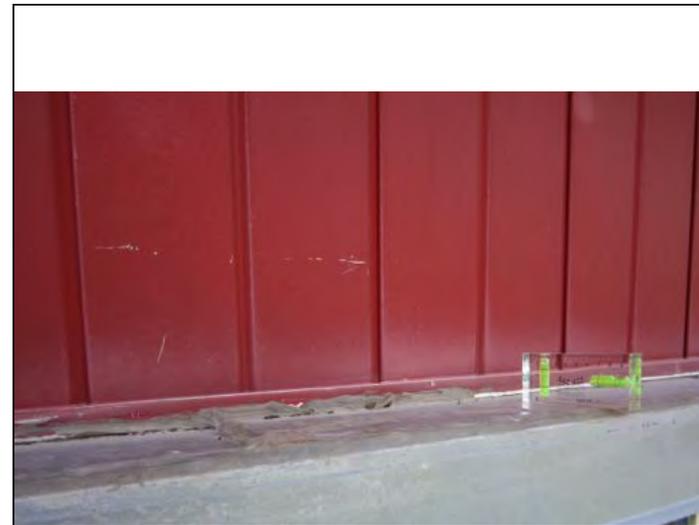
Furring Strips: least thermal performance impact

Just screws meets "ci" requirement of ASHRAE 90.1

www.buildingscience.com

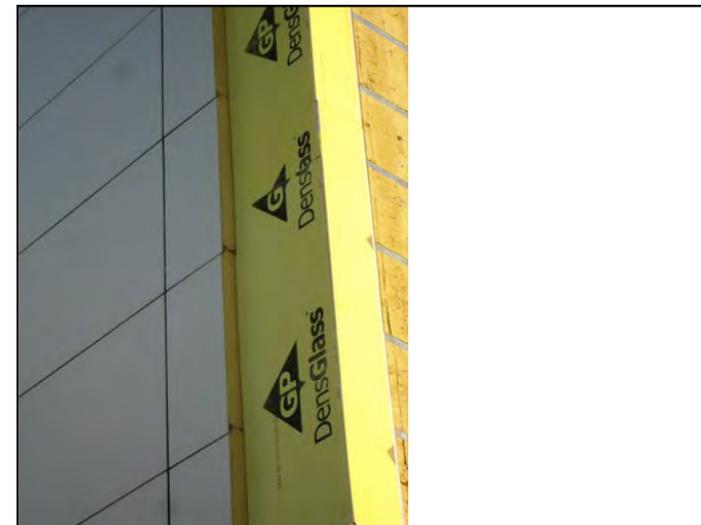
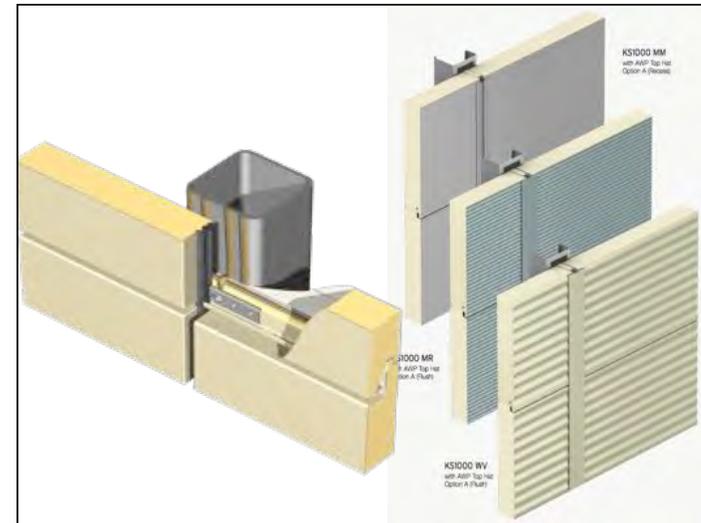
The diagram shows a cross-section of a wall assembly. It features a red metal panel on the left, a blue furring strip in the middle, and a grey metal panel on the right. The furring strip is attached to the wall with screws. The text "Just screws meets 'ci' requirement of ASHRAE 90.1" is written below the diagram. The website "www.buildingscience.com" is also visible.





## Insulated Panels as Overclad

- Metal panel SIPS
- Add insulation , air and water tightness, and finish in one layer



## Retrofit and Condensation

Case 1: Thinner IMP      Case 2: Thicker IMP

Note: Condensation will not occur provided dewpoint temperature of the interior air is below the temperature at the condensing surface

## Building Enclosure

Designed wall      The "perfect wall"

ACI New England  
6 October 2010

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## Building Enclosure

ACI New England  
6 October 2010

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## Building Enclosure

ACI New England  
6 October 2010

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### Building Enclosure

- Foam sealant between window and membrane/flashing
- Plastic shims
- Backer rod and sealant
- Membrane sill flashing; extend over panel cap and turn up jambs
- Trim flashing
- Panel cap
- Line of existing brick sill to be removed
- Continuous air/water barrier/membrane turns in at opening
- Insulated metal cladding panel
- Continuous mineral wool air flow control and dimensional mitigation layer behind insulated cladding panel
- Existing brick and concrete wall assembly

ACI New England  
6 October 2010

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### Castle Square Mid-Rise Retrofit

Boston, MA

Winn Development, CSTO  
29 September 2011

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### Castle Square Mid-Rise Retrofit

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