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NESEA BE12: Deep Energy Retrofits: Exterior Cladding Research

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Learning Objectives

- Review benefits of exterior insulation strategies
- Examine different methods and materials that can be used in exterior insulation applications
- Focus on cladding attachment issues with exterior insulation approaches
- Examine system limitations (both real and perceived)

Overview

- Building Insulation Retrofit Strategies
- Exterior Insulation Approaches
  - Insulation and Separate Cladding
    - Cladding Attachment
      - Brick Veneer
      - Other claddings
  - Exterior Insulation and Finish System (EIFS)
  - Insulated Metal Panels
- Castle Square Deep Energy Retrofit

Insulation Retrofit Options

Insulation Retrofit

- Existing buildings are often un-insulated/poorly insulated
- Insulation options are:
  - Cavity fill
  - Interior insulation
  - Exterior insulation

Cavity Fill Insulation

- Cavity fill insulation is most common retrofit – but has limitations
  - 4" cavity for older wood frame
  - ¾" cavity for mass masonry

Interior Insulation

- Interior insulation retrofit concerns
  - Continuity of insulation (partition walls, floors, etc.)
  - Loss of floor space
  - Occupant disruption
- Desirable if exterior appearance is needed/wanted to be maintained
- Often the best approach for historic buildings
- Not ideal from a building physics perspective

Exterior Insulation

- Exterior insulation retrofit
  - Ideal from a building physics perspective
  - Can be completed with less disruption to occupants
  - May come at a higher cost than other approaches

Exterior Insulation

- New approach!
- New approach?
- Not a new approach…
- Pesky Canadians…

- Benefits discussed in Canadian Building Digests produced by the National Research Council of Canada in the 1960's

Exterior Insulation

- CBD 44 (W.P. Brown, A.G. Wilson) – Published in 1963

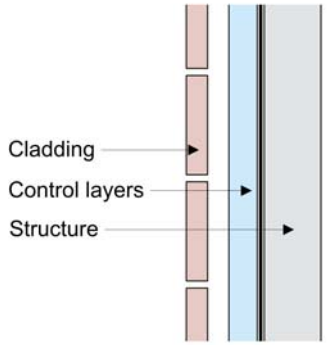
"Application of insulation over the entire exterior of a wall provides an ideal solution to the problems presented by thermal bridges."

"It should be stressed that many of the thermal bridges occurring in present-day construction can be avoided, or their effects minimized, if they are recognized in the early stages of design."

Exterior Insulation

- The "Perfect" Wall

- Increase overall thermal performance
- Minimize thermal bridges
- Minimize potential for air leakage condensation
- Improve air tightness?
- Improve rainwater management?



1980s ON – a “weird” builder

1990s ON – a “good” builder

2000s ON – a “typical” builder

2000s MA – a “High-R” assembly

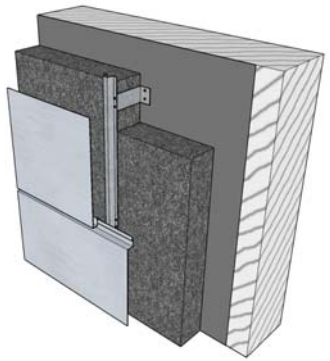
1990s – “modest” retrofit

2000s – “High-R” retrofit

Exterior Insulation Approaches

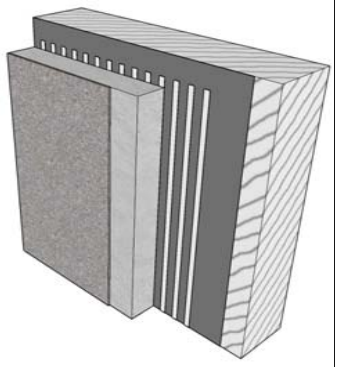
Exterior Insulation Approaches

- Insulation and cladding (discrete components)



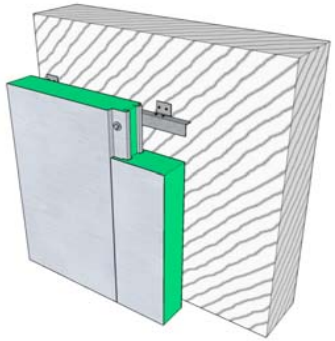
Exterior Insulation Approaches

- Insulation and cladding (discrete components)
- Exterior Insulation and Finish System (EIFS)



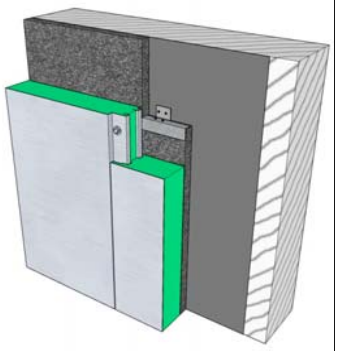
Exterior Insulation Approaches

- Insulation and cladding (discrete components)
- Exterior Insulation and Finish System (EIFS)
- Insulated Metal Panels (IMP)
  - Used as a complete enclosure



Exterior Insulation Approaches

- Insulation and cladding (discrete components)
- Exterior Insulation and Finish System (EIFS)
- Insulated Metal Panels (IMP)
  - Used as a complete enclosure
  - Used as an insulated cladding

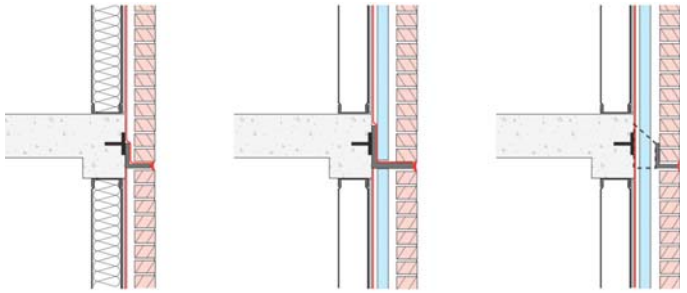


Cladding Attachment

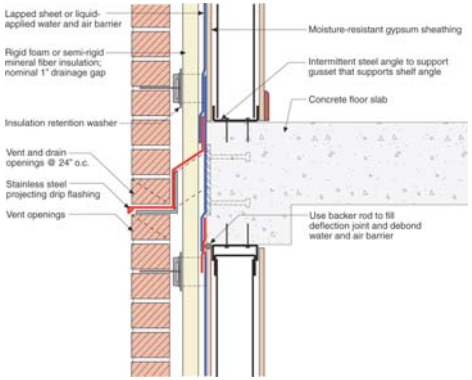
Brick Veneer

- Brick veneer has some of the longest history with exterior insulation
  - Long history = more common
  - More common = less questions
- Not always well done

Brick Veneer



Brick Veneer Cladding



Brick Veneer Cladding

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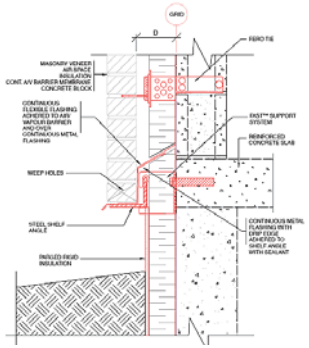
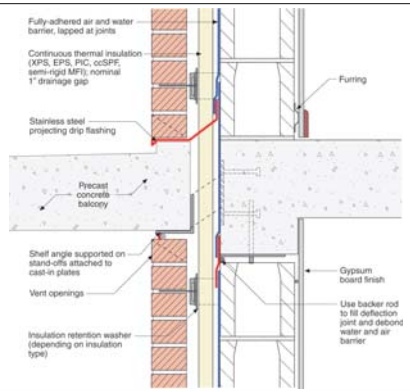


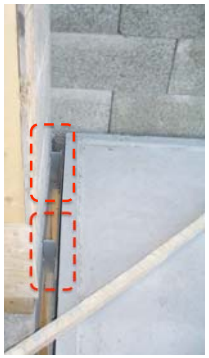
Brick Veneer Cladding

- Alternate details and support options exist
- Support systems for brick can be modified for other building elements
  - Decks
  - Balconies
  - Canopies
  - Etc.

Brick Veneer Cladding



Brick Veneer Cladding



Other Claddings

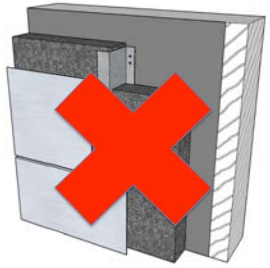
- For insulation less than 1.5” – direct attachment of cladding though insulation back to the structure is practical
- For insulation greater than 2” – a secondary cladding support structure is often needed.

Other Claddings

- Lighter weight claddings (metal/wood/fiber cement)
  - Less common = less experience
  - Less experience = more questions
- Cladding support systems historically done poorly
- Systems are getting better

Other Claddings

- Single “z-furring”
  - Poor thermal performance (steel stud wall on the exterior – why bother?)



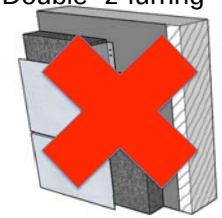
Other Claddings

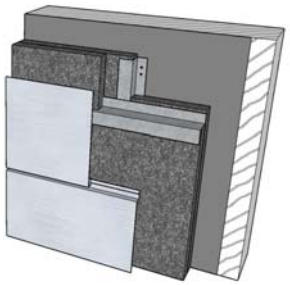
Other Claddings

- Single "z-furring"
- Double "z-furring"
  - Can be made to function reasonably well provided that two layers of insulation are used.
  - Often designed with first layer bridging insulation and second layer creating a gap behind the cladding = single "z-furring"

Other Claddings

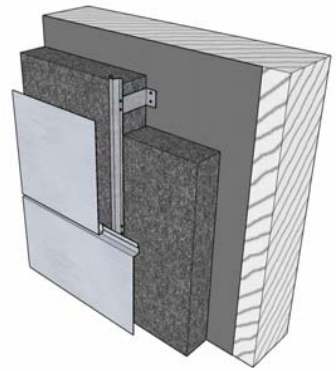
- Single "z-furring"
- Double "z-furring"



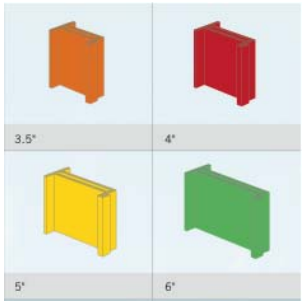


Other Claddings

- Single "z-furring"
- Double "z-furring"
- Clip and "z-furring" or hat channel
  - Metal clip
  - Fiberglass clip

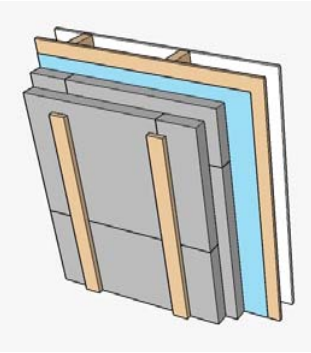


Other Claddings

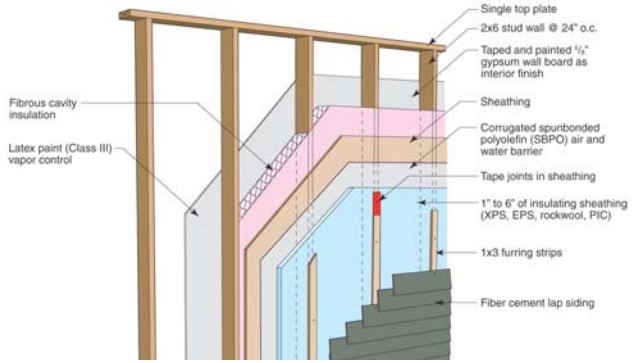


Other Claddings

- Single “z-furring”
- Double “z-furring”
- Clip and “z-furring” or hat channel
  - Metal clip
  - Fiberglass clip
- Attach furring directly back to structure through insulation



Other Claddings



Other Claddings

Direct Cladding Attachment Through Insulation

Direct Attachment Through Insulation

- Lots of practical experience with this approach for lightweight cladding systems over thick layers of insulation (several decades).
- Approach has demonstrated very good long term performance
- High resistance from industry

Direct Attachment Through Insulation

- "Does the insulation provide any additional capacity for the system?"
- BSC staff test

Direct Attachment Through Insulation

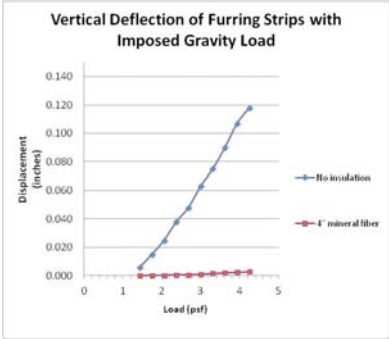
- System loaded with air gap between furring and wall

Direct Attachment Through Insulation

- System loaded with 4" of rigid mineral fiber insulation between furring and wall

Direct Attachment Through Insulation

- The answer is yes!



Direct Attachment Through Insulation

- "Does the insulation crush under load?"
- The answer is yes!...
- Loading a system until failure (500lbs to 1000lbs or more per screw fastener) will crush most rigid insulations

…..Unfortunately it is the wrong question

Direct Attachment Through Insulation

- "Does the insulation crush under a load similar to what will be imposed on it in a cladding support application?"
- The answer is no!...

Context is important

Direct Attachment Through Insulation

- Typical cladding weights (psf)

	low	high
Vinyl	0.6	1.0
wood	1.0	1.5
fiber cement	3.0	5.0
stucco	10.0	12.0
adhered stone veneers	17.0	25.0

Direct Attachment Through Insulation

- Typical weights per fastener (lbs)

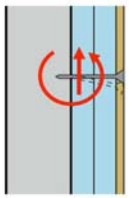
fastener spacing (in)	16" x 16"	16" x 24"	24" x 24"
area/fastener (ft2)	1.78	2.67	4
vinyl	1.8	2.7	4.0
wood	2.7	4.0	6.0
fibercement	8.9	13.3	20.0
stucco	21.3	32.0	48.0
adhered stone veneers	44.4	66.7	100.0

Direct Attachment Through Insulation

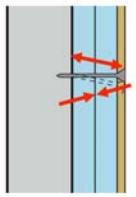
- Acceptable deflection not ultimate capacity governs
- What is acceptable deflection?
  - Movement a cladding system can accommodate without physical damage or exceeding aesthetic tolerances
- Proposed limits
  - Lap sidings and panel cladding ~ 1/16”
  - Brittle claddings ~1/64” (after initial deflection)

Direct Attachment Through Insulation

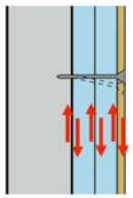
- Typical forces developed in the system



Shear and rotational resistance provided by fastener to wood connections



Rotational resistance provided by tension in fastener and compression of the insulation



Vertical movement resistance provided by friction between layers

Gravity Load Response Testing

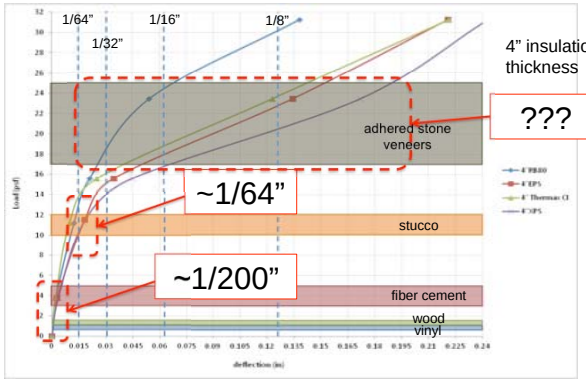
- BSC Research (Supported by DOE Building America Program)
- Short Term and Long Term Deflection Testing
- Multiple insulation types
  - EPS
  - XPS
  - Foil faced polyisocyanurate
  - Rigid mineral fiber

Direct Attachment Through Insulation

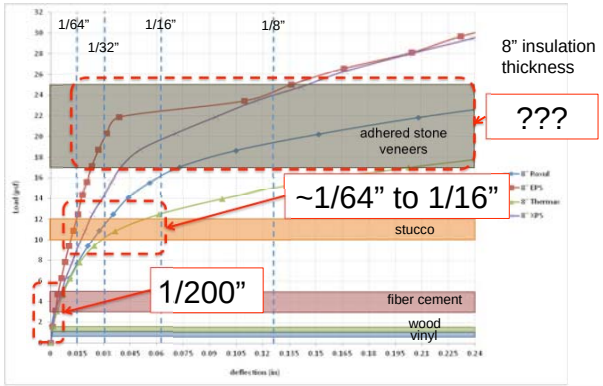
- Short term testing
- Test panels
  - 4'x8'
  - 1x3 furring spaced 24" oc
  - 16" vertical spacing of fasteners
- Multiple thicknesses
  - 4" and 8" tests

Short-term Gravity Load Response

Short-term Gravity Load Response



Short-term Gravity Load Response

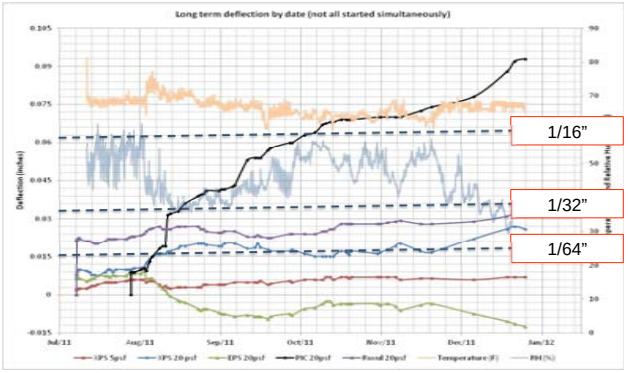


Long-term Gravity Load Response

- Long term testing
- Test panels
  - 2'x8'
  - 1x3 furring
  - 16" vertical spacing of fasteners
- Load
  - 13 psf if 24" oc
  - 20 psf if 16" oc

Long-term Gravity Load Response

Long-term Gravity Load Response



Testing Results

- Lightweight claddings (vinyl, wood, fiber cement) have very little movement both under initial loading and long term loading (~1/200")
- For lightweight claddings deflection does not even approach proposed deflection limit (1/16")
- Testing results in line with long history of performance of buildings constructed with this assembly

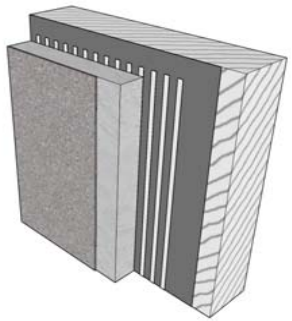
Testing Results

- Heavier brittle claddings (stucco, adhered stone veneers) initial deflection is not as important as long term deflection
- For stucco claddings (10psf), long term deflection after initial deflection is within proposed deflection limit in stable environmental conditions
- For adhered stone veneer (17psf to 25psf), capacity could be increased with increased fastener spacing.
- More research is needed to examine the performance of these systems in exposed environments

…Back to Exterior Insulation Approaches

EIFS

- Exterior Insulation and Finish System (EIFS)
  - Lightweight
  - Cost effective
  - Water managed
- Minimal Thermal Bridging
- R-4 per inch
- System has a tainted history



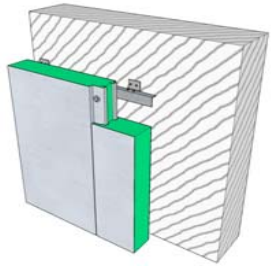
EIFS

- Commonly installed using adhesive
- The adhesive can also form the drainage gap in water managed systems

EIFS

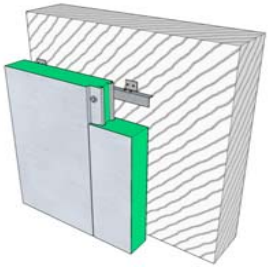
Insulated Metal Panels

- Insulated Metal Panels (IMP)
  - Lightweight
  - Moderate cost
  - Water managed
- Minimal Thermal Bridging
- R-7.5+ per inch
- Can be an excellent enclosure system
- Requires some consideration for retrofit applications



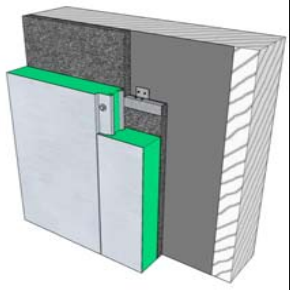
Insulated Metal Panels

- Can be used as both a complete enclosure system



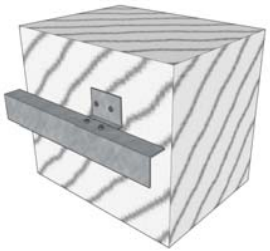
Insulated Metal Panels

- Can be used as both a complete enclosure system
- Can also be used as an insulated cladding system



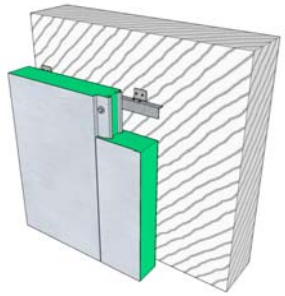
Insulated Metal Panels

- Attachment often to metal hat channel or z-furring
  - In retrofit applications out of plane walls can require special adjustable systems or shims



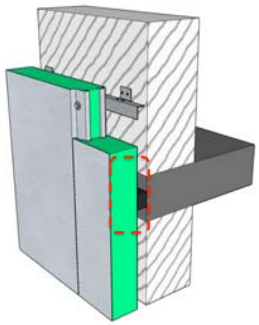
Insulated Metal Panels

- IMP as a complete enclosure system
  - Provides all enclosure functions into a single system
  - System design as intended by panel manufactures



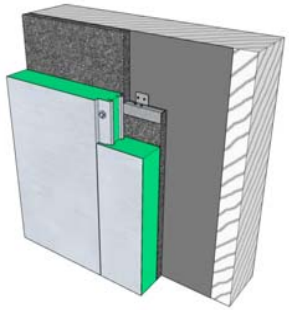
Insulated Metal Panels

- IMP as a complete enclosure system
  - May require special detailing for compartmentalization at floors or partition walls, particularly in retrofit applications



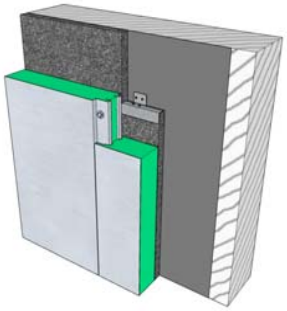
Insulated Metal Panels

- IMP as an insulated cladding system
  - Provides thermal insulation and cladding
  - Rain water management and air tightness are provided by other elements
  - Modification to manufacturers intended design



Insulated Metal Panels (Retrofits)

- IMP as an insulated cladding system
  - Need to fill space between the panel and back up wall to prevent air by-pass of the insulation
  - Can simplify certain details such as interfaces at balconies, lower roofs, and compartmentalization
  - More in line with common construction detailing



Castle Square Deep Energy Retrofit

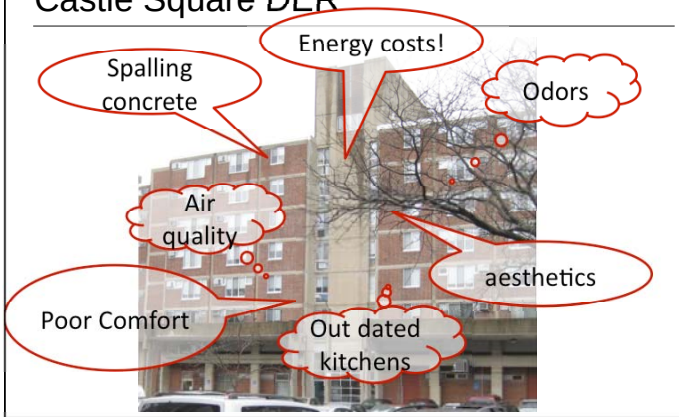
Castle Square DER

Castle Square DER

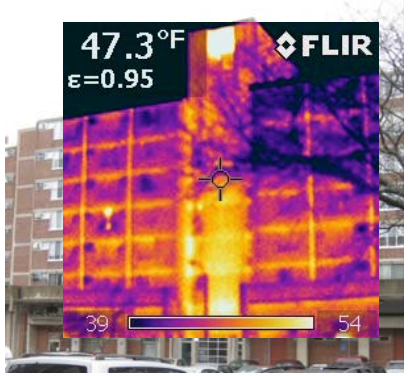
Project Overview:

- Occupied rehabilitation
- 1960's era, brick and concrete public housing structure
- Majority owned by residents association

Castle Square DER



Castle Square DER



Castle Square DER

- Enclosure System Challenges
  - Occupied rehab
  - Small existing floor areas
  - Cavity space between interior wall and brick
- Early decision to pursue exterior insulation retrofit option
- All systems were considered
  - Insulation and cladding
  - EIFS
  - IMP
    - Both as a complete enclosure and as an insulated cladding

Castle Square DER

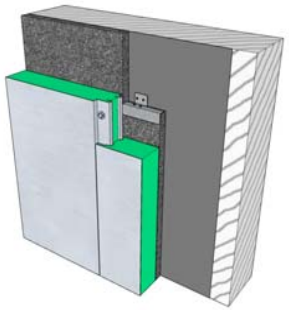
- Enclosure Option Selection
  - Insulation and Cladding
    - Lack of UL rated assemblies
    - High cost of fire tests (NFPA 285)
  - EIFS
    - Lowest Cost
    - Highest Insurance
  - IMP (as a complete enclosure)
    - Transition detailing and compartmentalization concerns

Castle Square DER

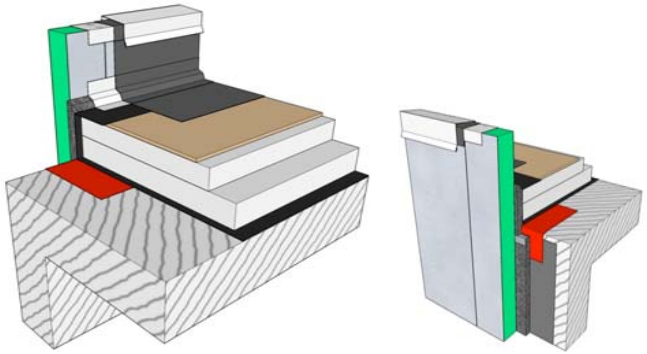
- Enclosure Option Selection
  - IMP (as an insulated cladding)
    - Moderate cost
    - Able to address compartmentalization and transitions
    - Had to convince manufacturer that it was OK to do this

Castle Square DER

- Enclosure Option Selection
  - IMP (as an insulated cladding)

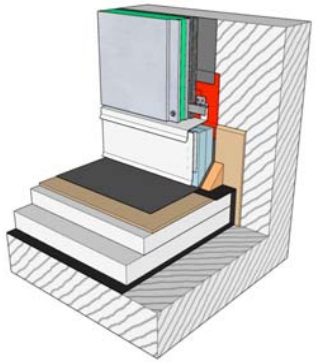


Castle Square DER



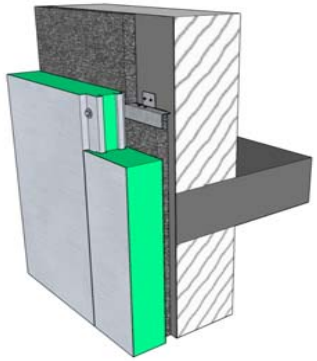
Castle Square DER

Castle Square DER



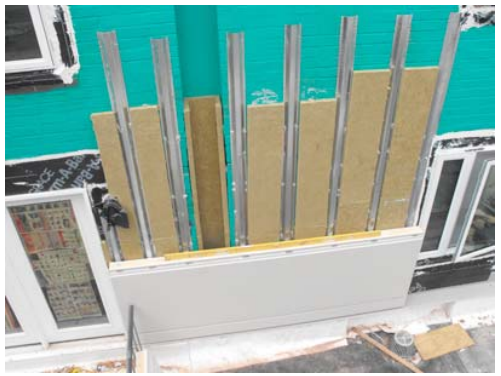
Castle Square DER

Castle Square DER

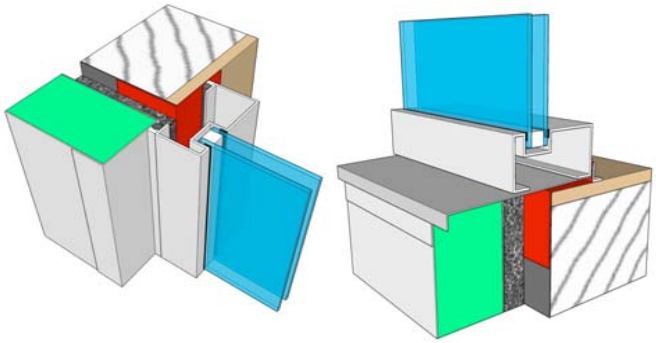


- Compartmentalization was achieved by an exterior liquid applied air barrier membrane

Castle Square DER



Castle Square DER



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Thank you for your time!
Any Questions?

This concludes The American Institute of Architects Continuing Education Systems Program