

Ken Neuhauser

October 17, 2013

# High Performance Exterior Retrofit Options for Masonry Walls in a Cold Climate

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8th Annual North American Passive  
House Conference



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# Who am I and why am I here?

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- Building America Research Partner
- Building science consulting

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# What is this all about?

*High performance* retrofit strategy for

- Masonry wall enclosure
- Cold climate
- Occupied

# Building 1, Pre-Retrofit



Image credit: Biome Studio / [www.castledeeenergy.com](http://www.castledeeenergy.com)



# Building 2, Pre-Retrofit

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# Building 3, Pre-Retrofit





# Building 3, Pre-Retrofit



# Building 1, Insulated Metal Panel





# Building 2 & 3, Fiber-Cement over Rigid

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# High Performance Masonry Wall Retrofit

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- Why Outside?
  - Occupied building
  - Outside is ugly
  - Preserve building
  - Performance

# Why Outside – Outside is Ugly?

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# Why Outside – Outside is Ugly?





# Why Outside – Outside is Not Pretty

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# High Performance Masonry Wall Retrofit

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- Why Outside?
  - Occupied building
  - Outside is ugly
  - Preserve building
  - Performance
- Refer to previous presentation re:
  - Water vapor
  - Bulk water

# High Performance Masonry Wall Retrofit

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- Why Outside?
  - Occupied building
  - Outside is ugly
  - Preserve building
  - Performance

Simplified geometry = better continuity

# High Performance Masonry Wall Retrofit

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- Why not EIFS?
  - Plastic
  - Combustible
  - Not abuse resistant
  - High thermal resistance is really thick!



# Building 1, Castle Square Mid-Rise



Image credit: Biome Studio / [www.castledeeenergy.com](http://www.castledeeenergy.com)

# Castle Square Mid-Rise





# Castle Square Mid-Rise

## Existing Enclosure:

- ~R-20 Roof Insulation
- Exposed concrete frame with **uninsulated** brick cavity wall infill
- Aluminum Frame Windows (assumed no thermal break in frame, no Low-E)

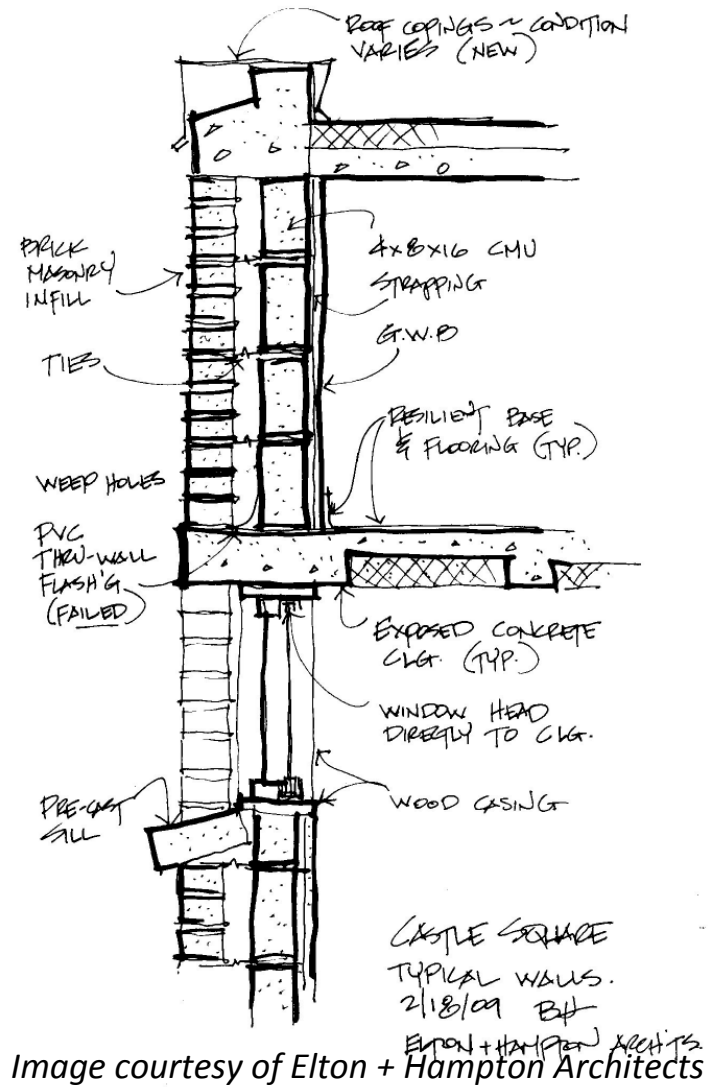
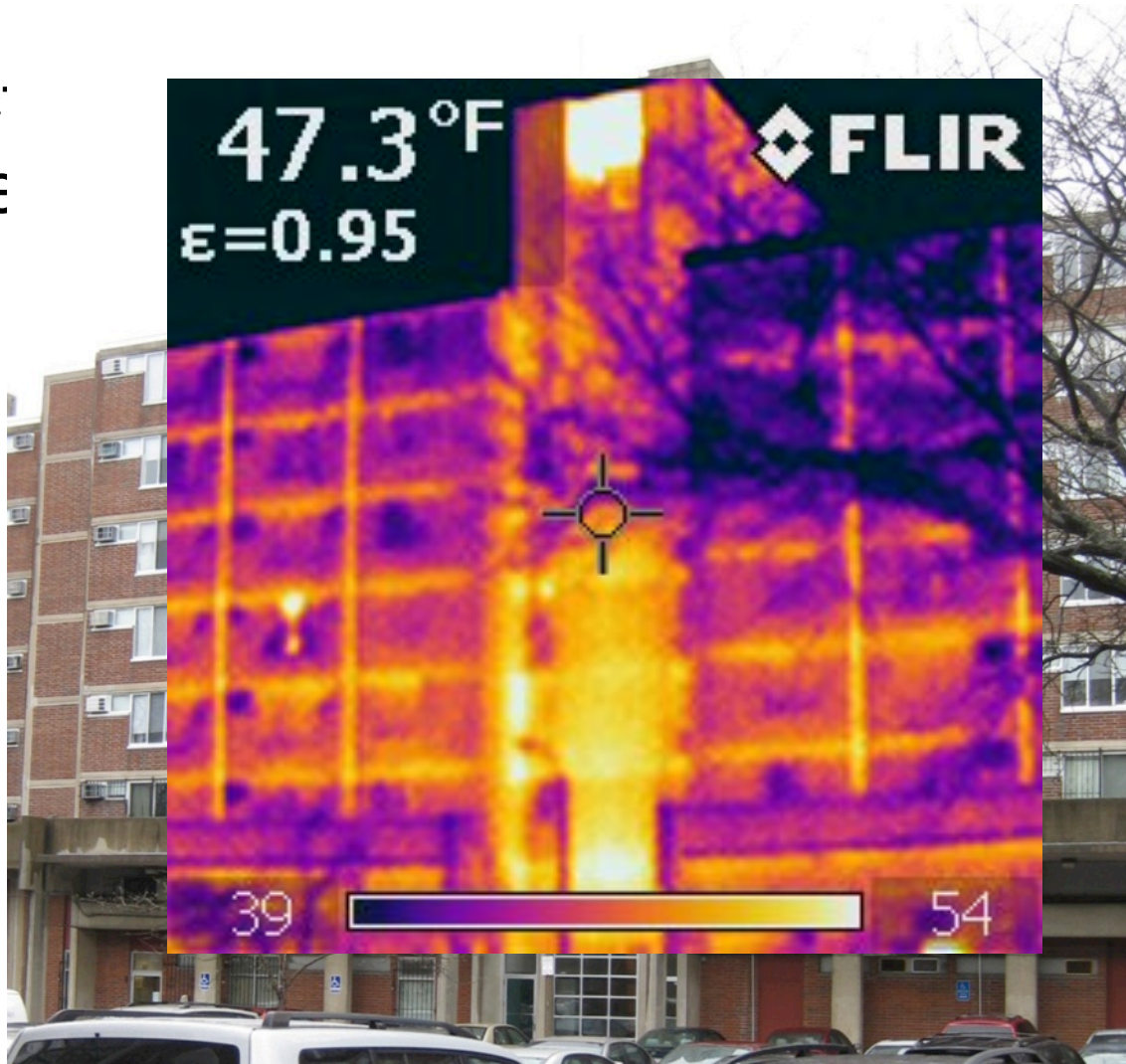


Image courtesy of Elton + Hampton Architects

# Castle Square Mid-Rise

- Structural challenge



# Castle Square Mid-Rise Retrofit

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Testing, evaluation, analysis concludes:

High performance will require

- adding insulation to walls,
- controlling infiltration and ventilation,
- improving windows

# Castle Square Wall Retrofit Strategy

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## Performance Targets for Wall:

- R-40
- Improve compartmenting as much as possible

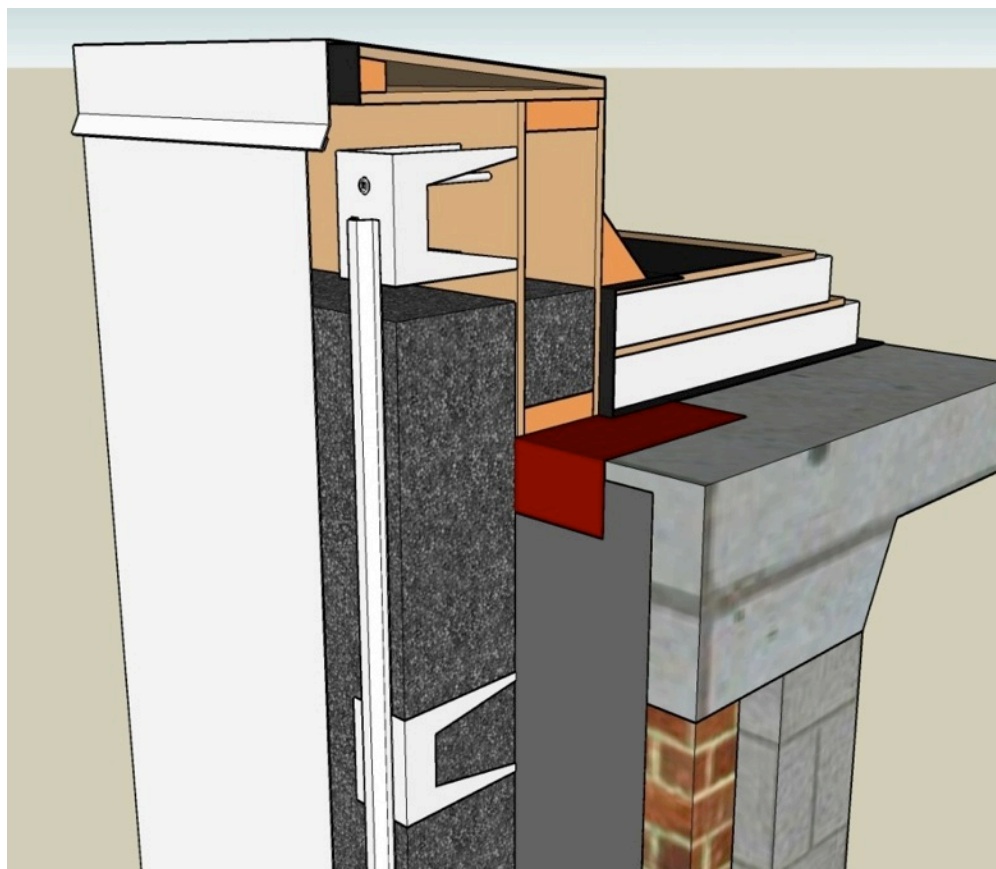
## Options pursued:

1. Exterior air barrier, insulation and cladding
2. Exterior insulation and finish system (EIFS)
3. Insulated metal panels (IMP)

# Castle Square Wall Retrofit Strategy

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## 1. Exterior air barrier, insulation, and cladding



# Castle Square Wall Retrofit Strategy

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## 1. Exterior air barrier, insulation, and cladding

Large range of options with respect to

- Insulation types
- Air barrier materials
- Cladding options

# Castle Square Wall Retrofit Strategy

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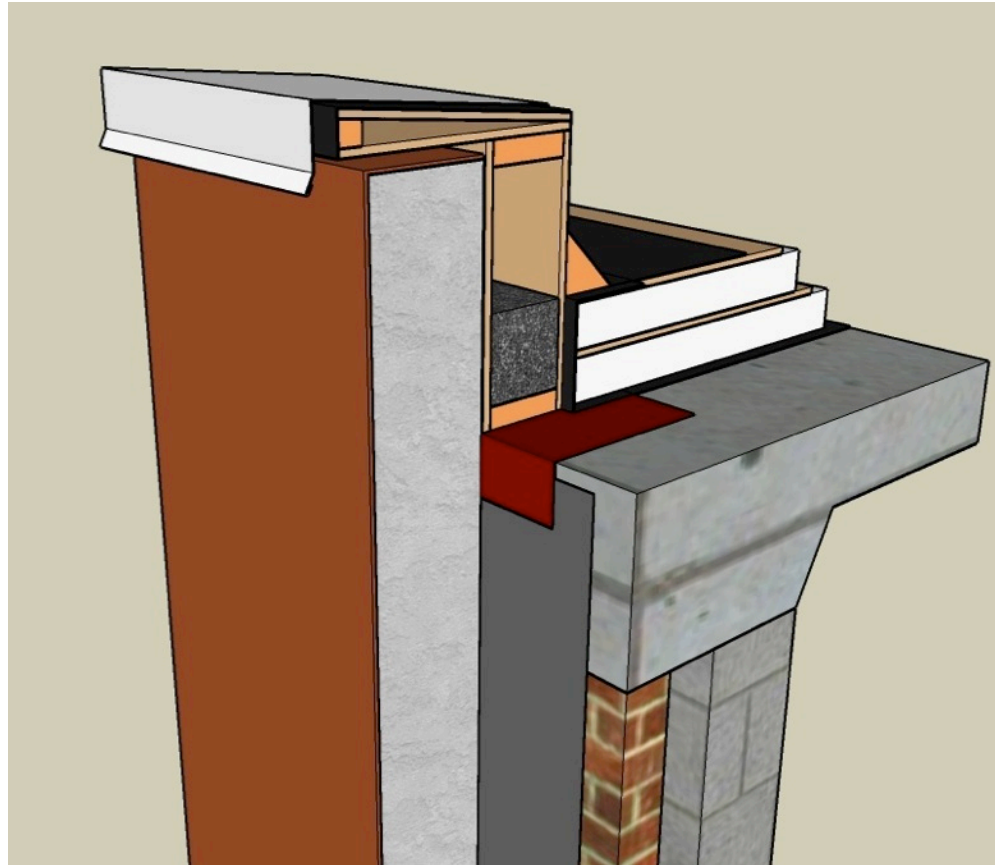
1. Exterior air barrier, insulation, and cladding
  - Fire concerns
    - Lack of UL rated assemblies
  - Insulation thickness needed to achieve desired R-Value could be significant



# Castle Square Wall Retrofit Strategy

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## 2. Exterior insulation and finish system (EIFS)



# Castle Square Wall Retrofit Strategy

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## 2. Exterior insulation and finish system (EIFS)

- Lower cost option
- No need for design of cladding attachment system

# Castle Square Wall Retrofit Strategy

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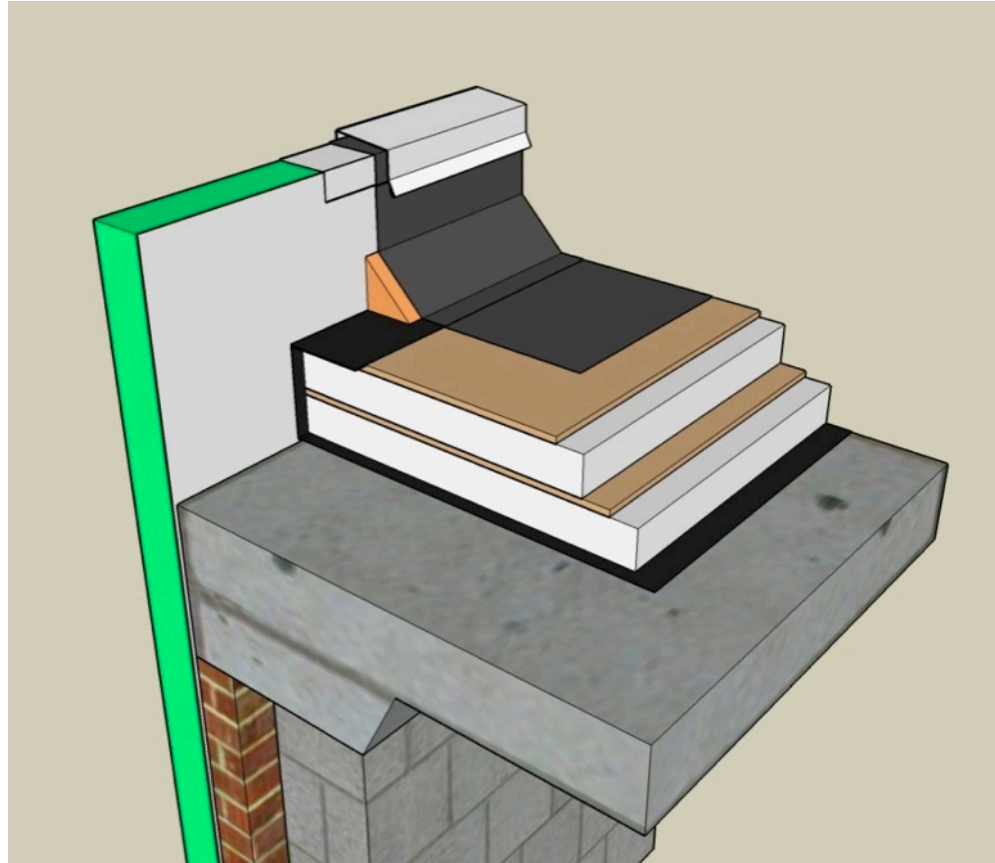
## 2. Exterior insulation and finish system (EIFS)

- Thick layers of insulation needed to achieve design goals
- Insurance concerns (Fire, water, durability)

# Castle Square Wall Retrofit Strategy

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## 3. Insulated metal panels (IMP)



# Castle Square Wall Retrofit Strategy

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## 3. Insulated metal panels (IMP)

- High R-Value – thinner retrofit profile
- Fire rated
- Durable

# Castle Square Wall Retrofit Strategy

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## 3. Insulated metal panels (IMP)

- Attachment over non-plumb/plane surfaces
- Cost
- Question of Water and Air control approach

# Castle Square Wall Retrofit Strategy

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- Wall System Approaches for Super Insulation (R40) Retrofit
  1. Field-constructed system
    - separate components: applied air barrier and drainage plane, cladding attachment, exterior insulation, and cladding;
    - judged to costly and complicated
  2. EIFS (Exterior Insulation and Finish System)
    - required thickness not approved by insurance
  3. Insulated metal panel system



# Castle Square Wall Retrofit Strategy

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## Insulated metal panel (IMP) challenges

Attachment over non-plumb/plane surfaces

- Requires panels spaced off wall <!>

Question of Water and Air control approach:

1. Panels as the complete enclosure?

- Panels provide air barrier, insulation, water management

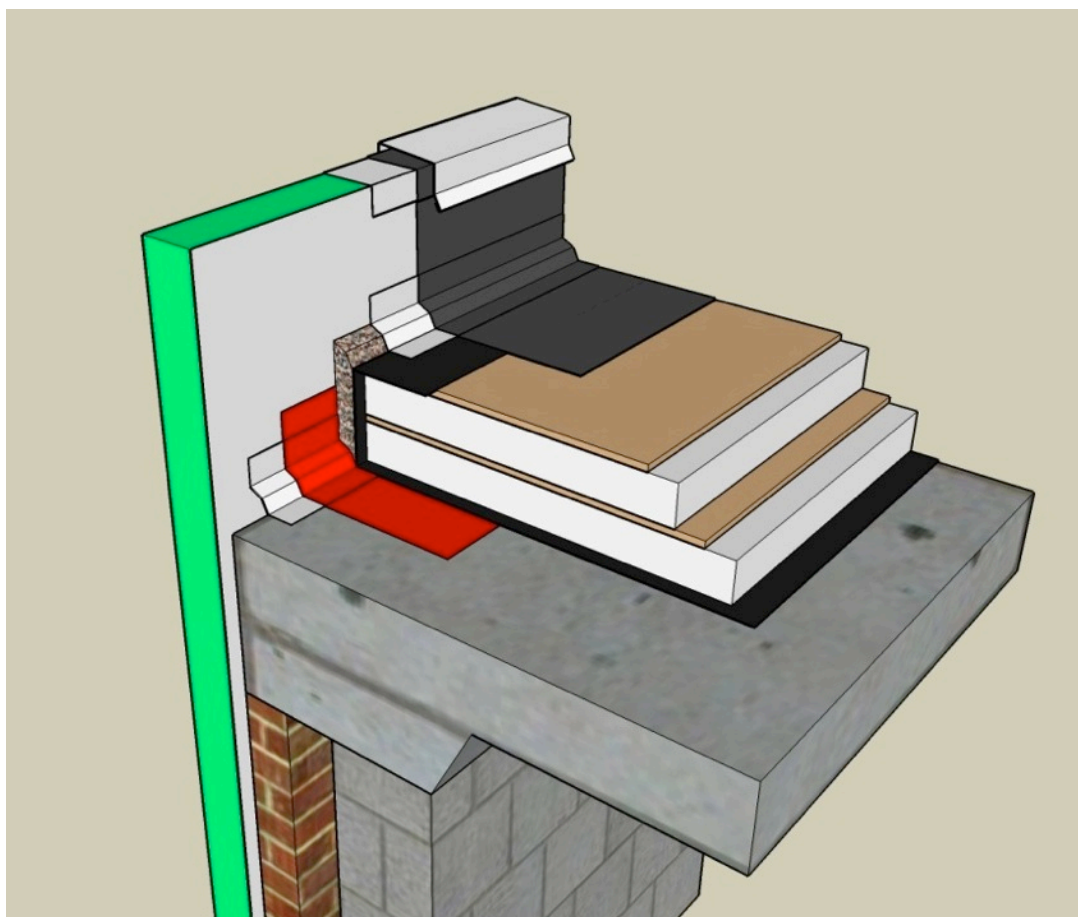
2. Panels as an insulated cladding?

- Separate water and air control behind

# Castle Square Wall Retrofit Strategy

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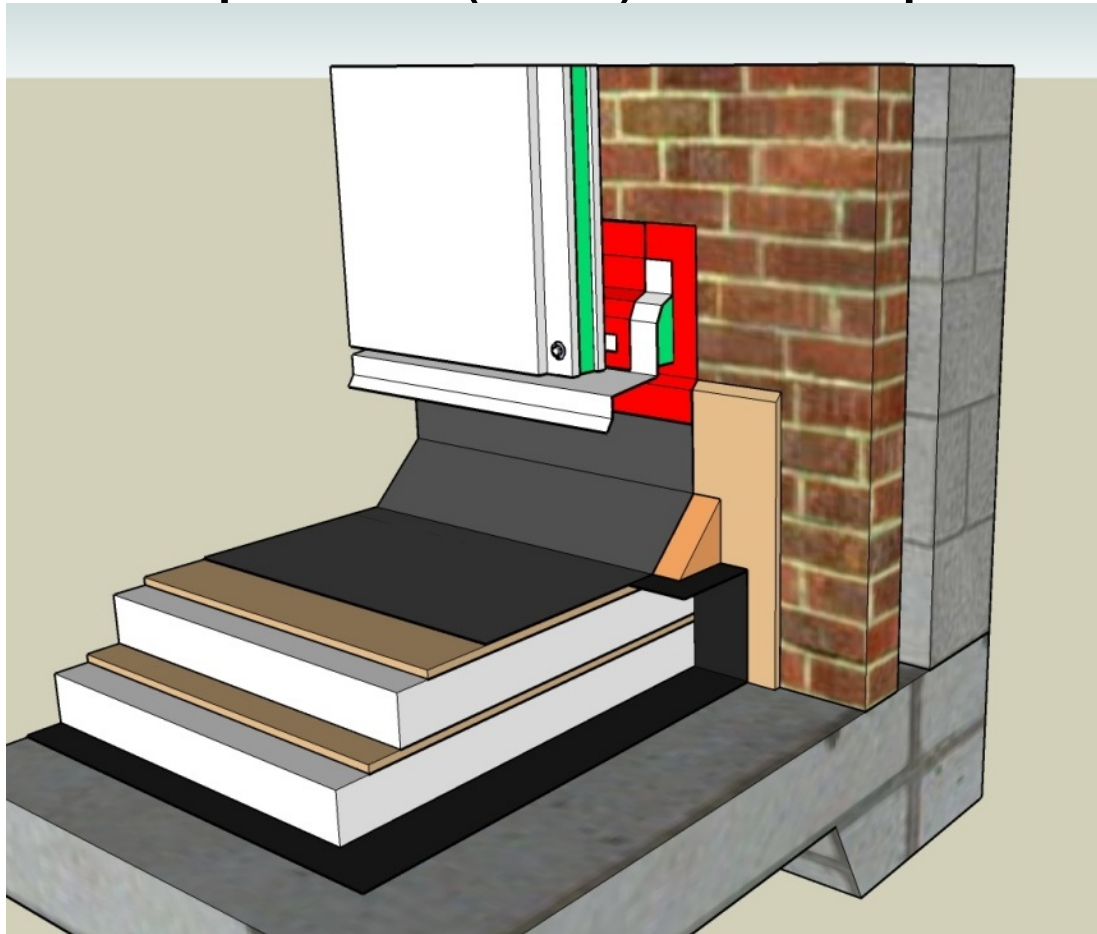
Insulated metal panels (IMP) as complete enclosure:



# Castle Square Wall Retrofit Strategy

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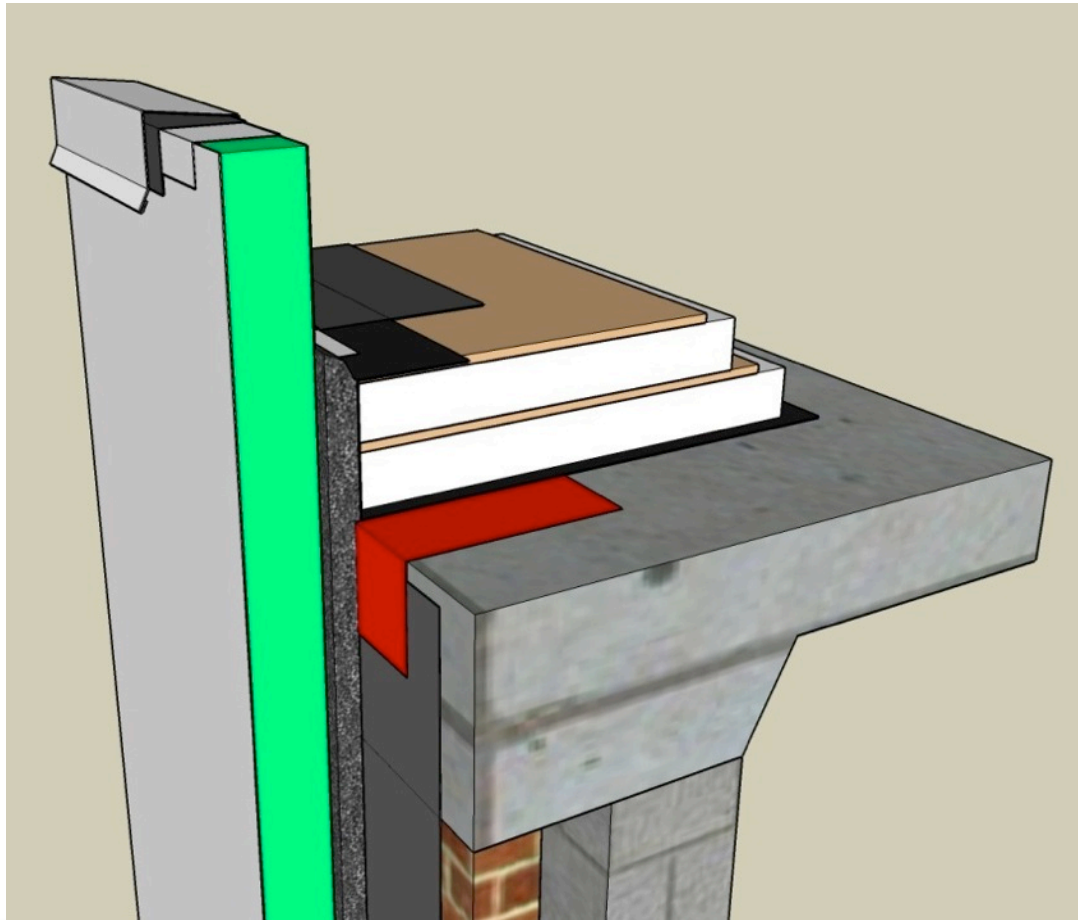
Insulated metal panels (IMP) as complete enclosure:



# Castle Square Wall Insulation Strategy

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Insulated metal panels (IMP) with separate water/air control:

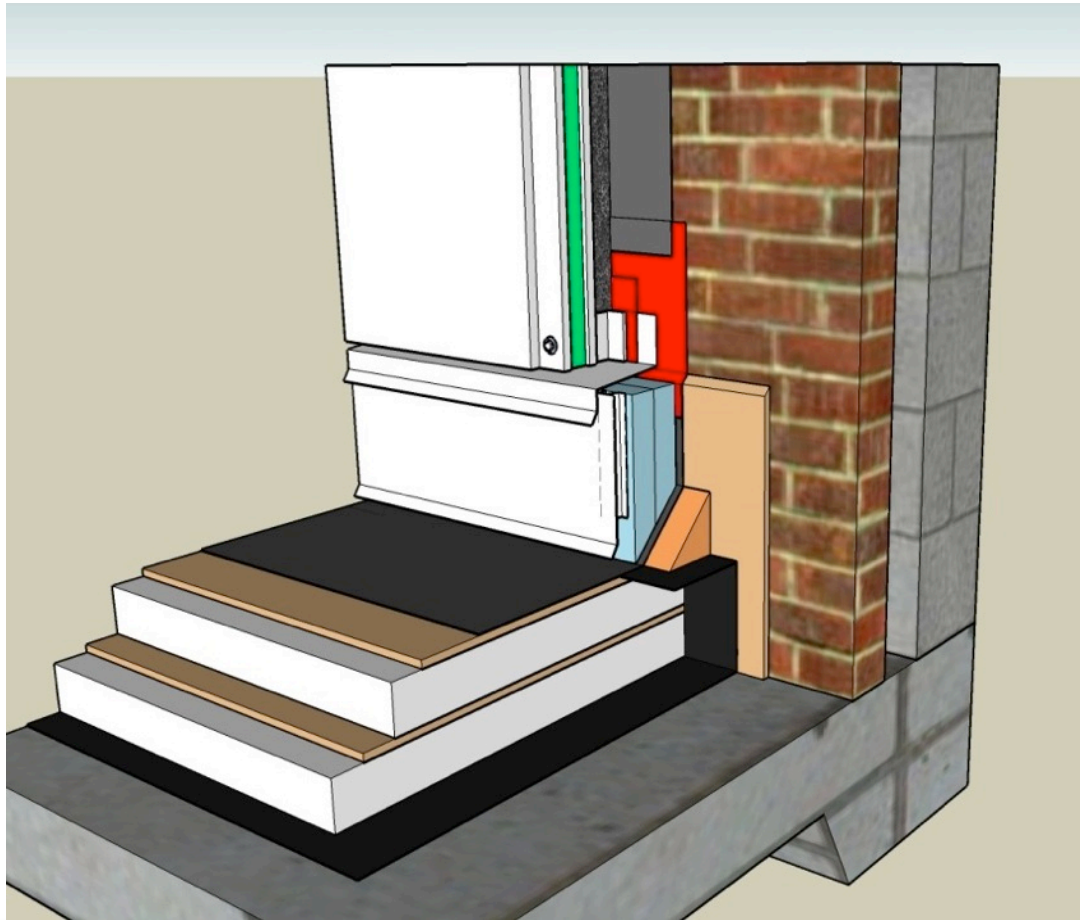




# Castle Square Wall Retrofit Strategy

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Insulated metal panels (IMP) with separate water/air control:



# Castle Square Wall Retrofit Strategy

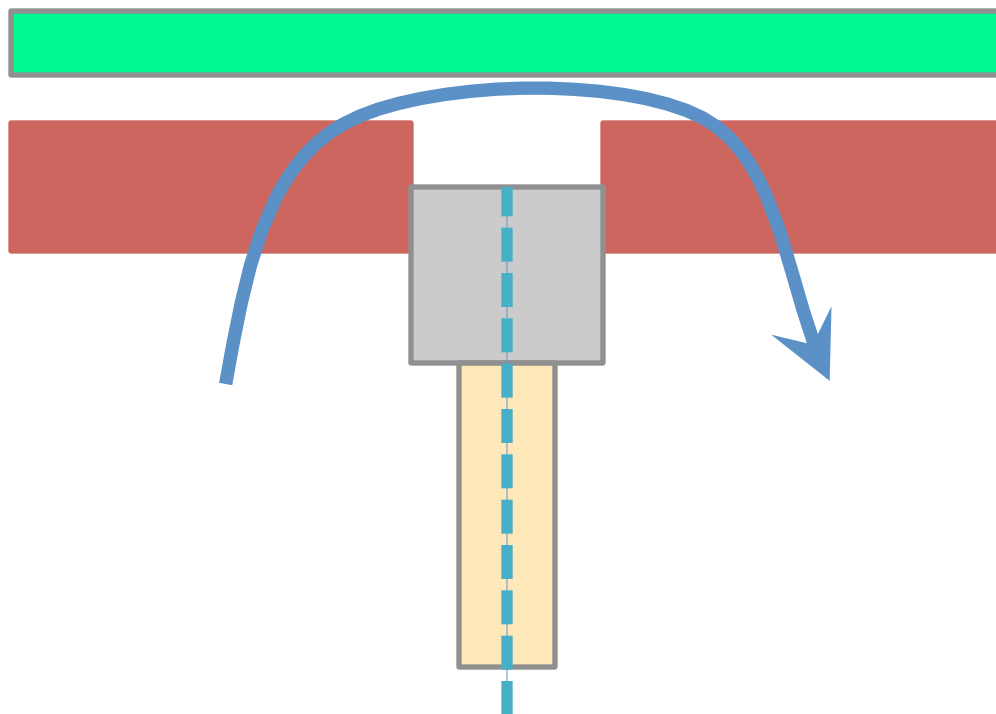
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- Insulated metal panels (IMP)
  - Compartmentalization of the living units

# Castle Square Wall Retrofit Strategy

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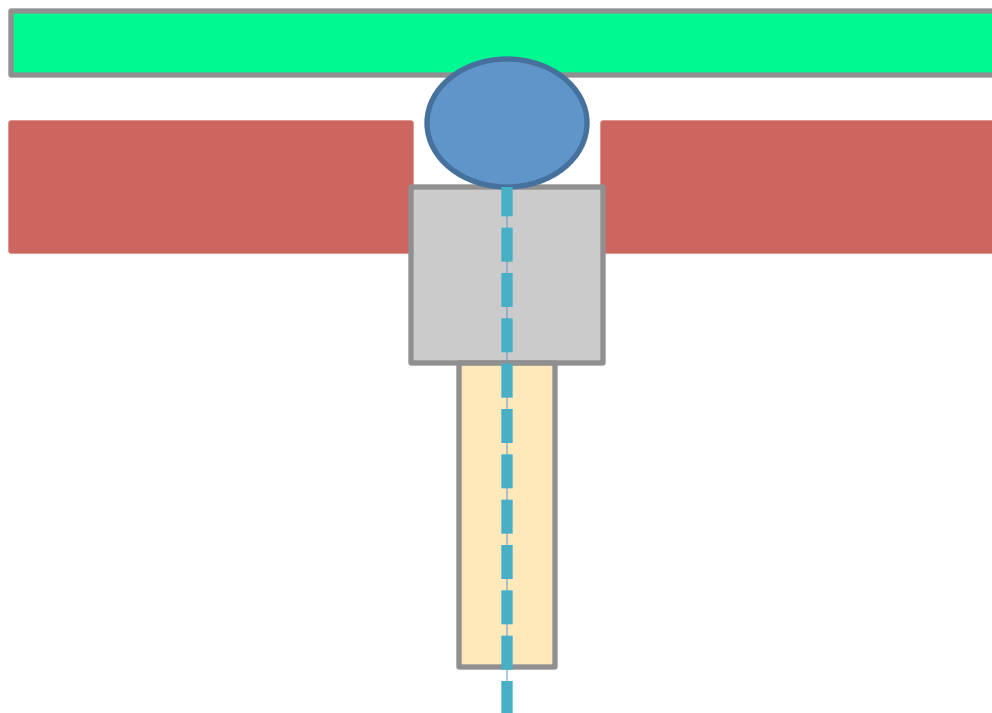
- Compartmentalization?



# Castle Square Wall Retrofit Strategy

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- Compartmentalization?

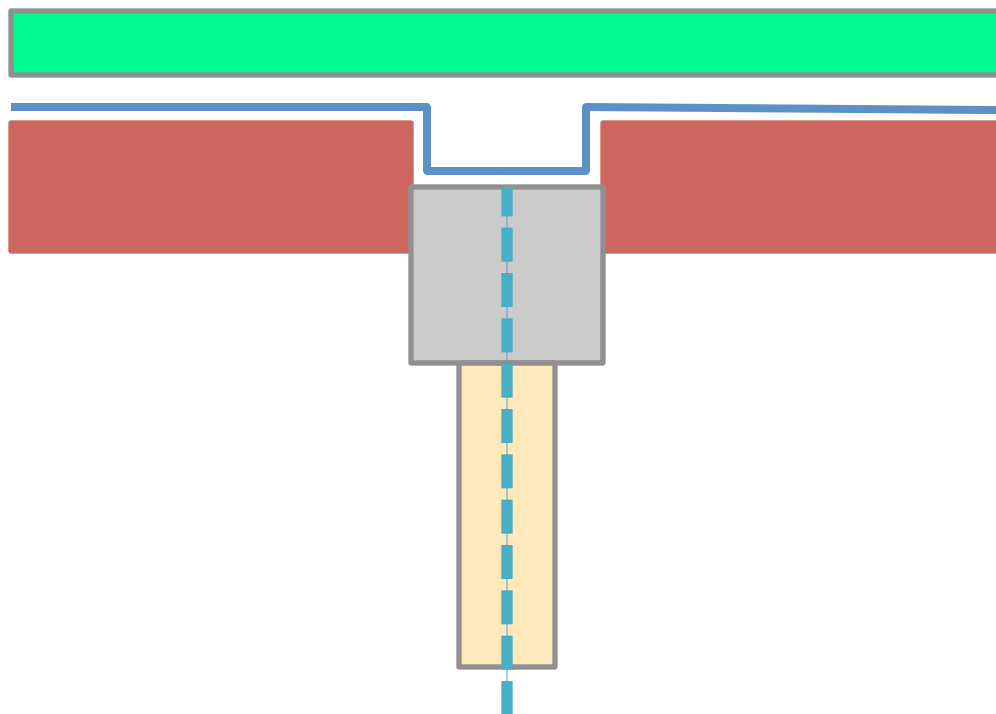




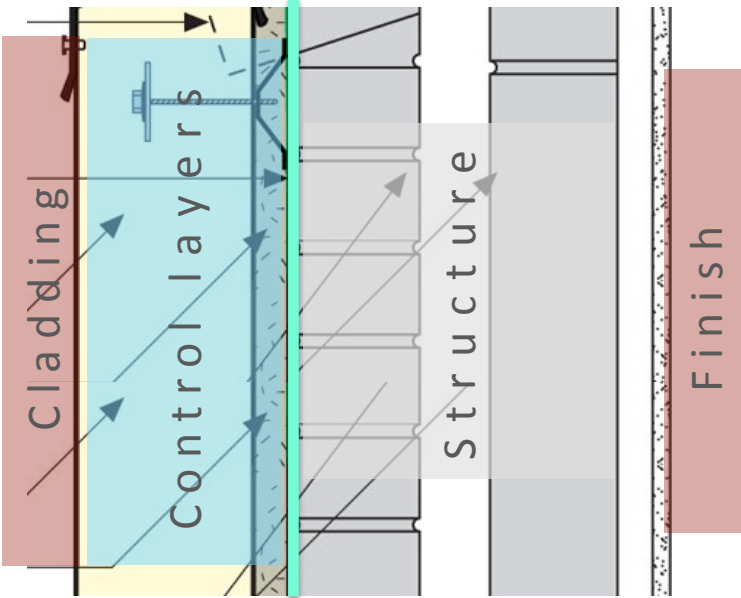
# Castle Square Wall Retrofit Strategy

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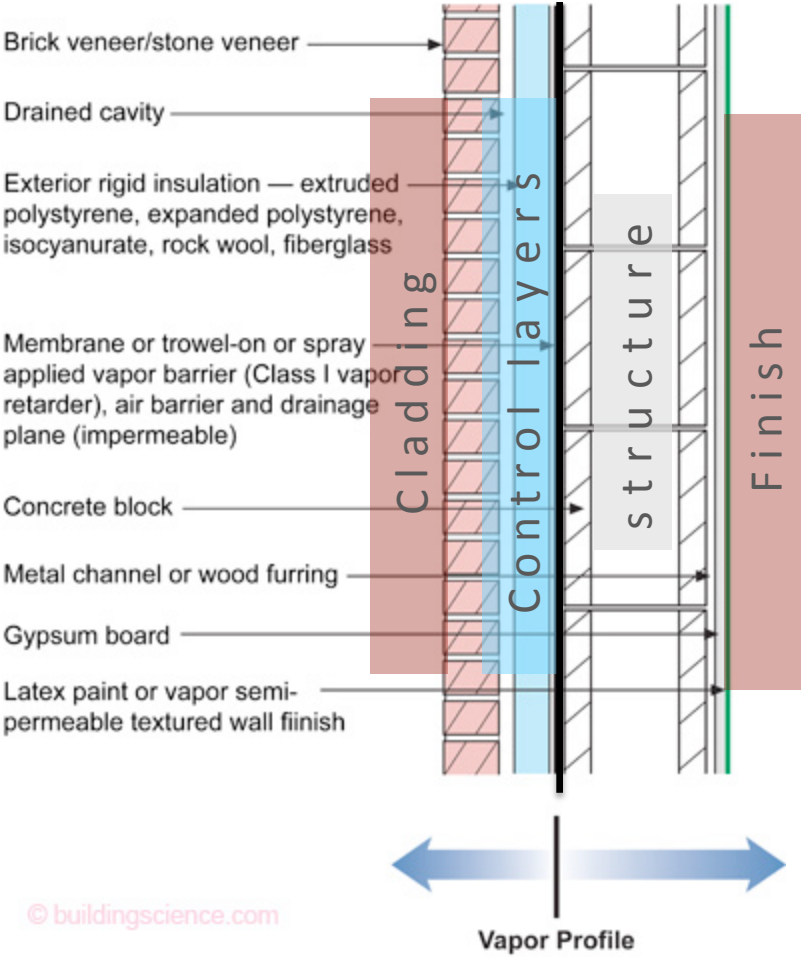
- Compartmentalization!



# Castle Square Wall Retrofit Strategy



Designed wall



The “perfect wall”

# Castle Square Mid-Rise Retrofit

## 1 super insulate

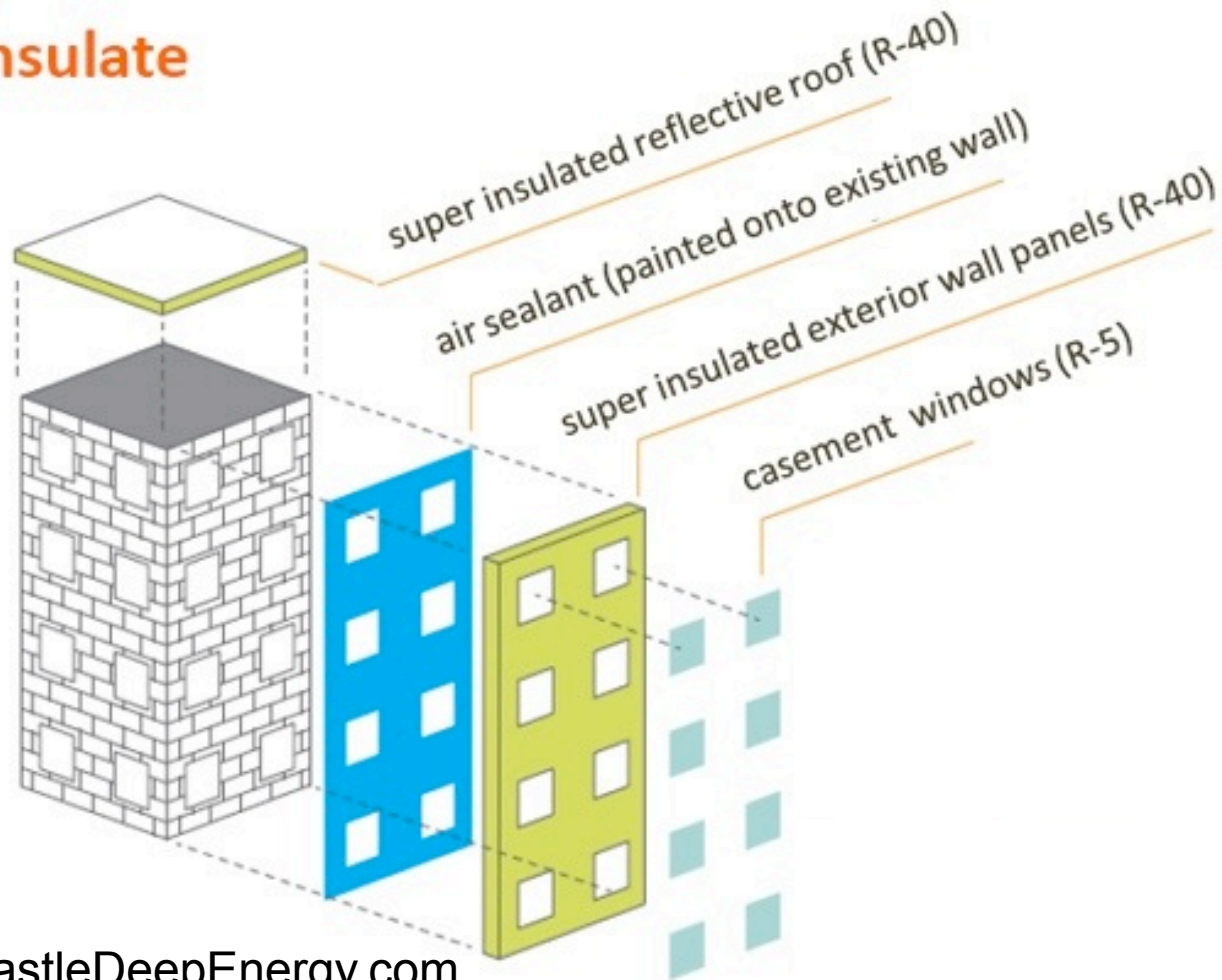


Image credit: [www.CastleDeepEnergy.com](http://www.CastleDeepEnergy.com)

# Castle Square Mid-Rise Retrofit

## 2 air seal

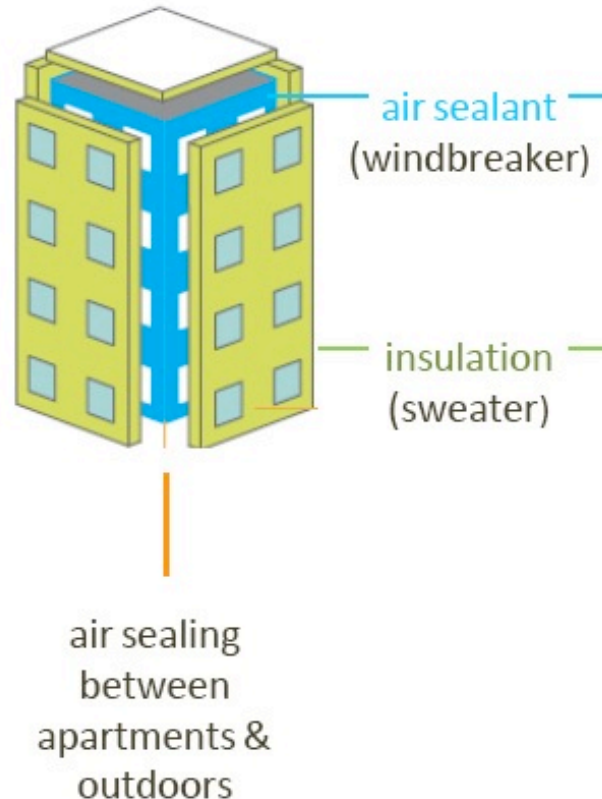


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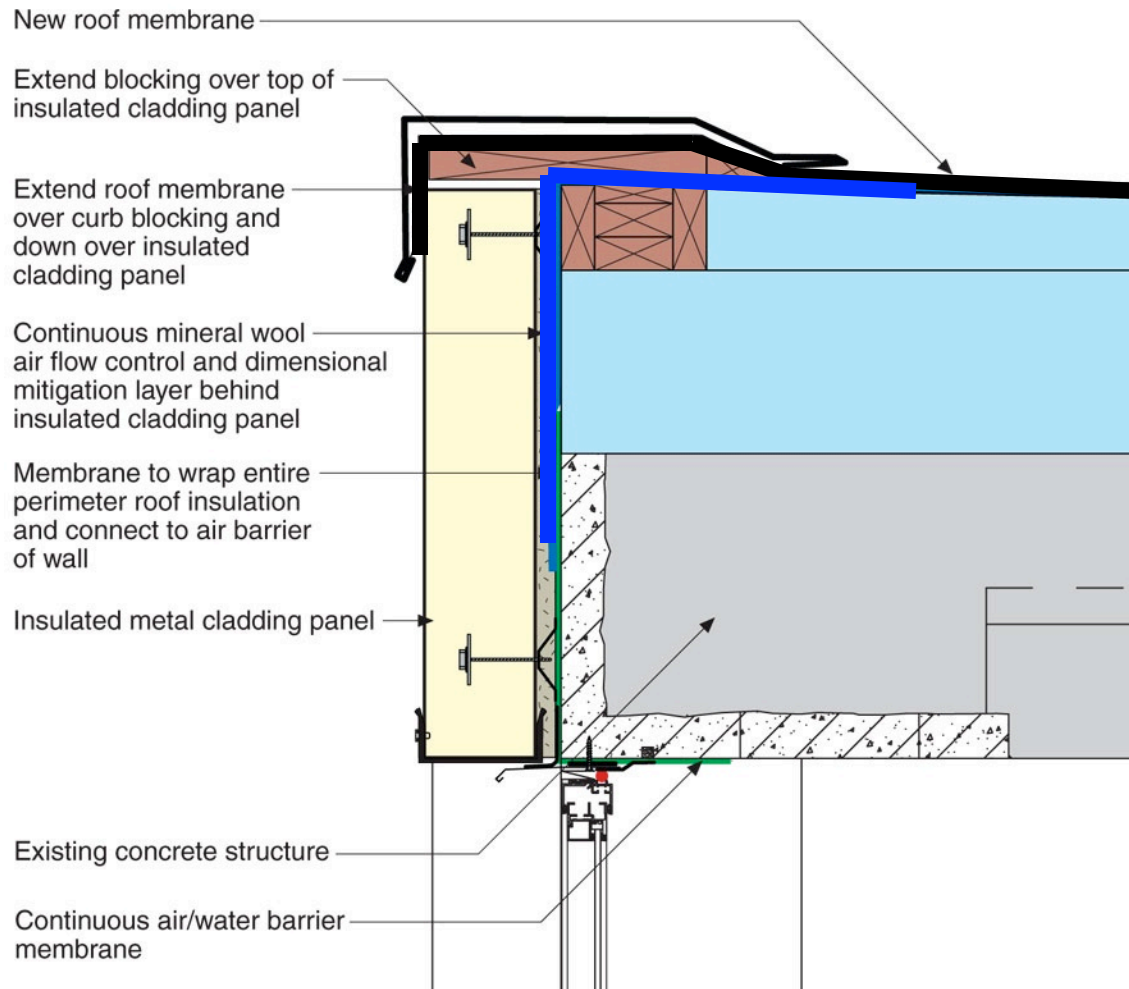
# Castle Square Wall Retrofit Strategy

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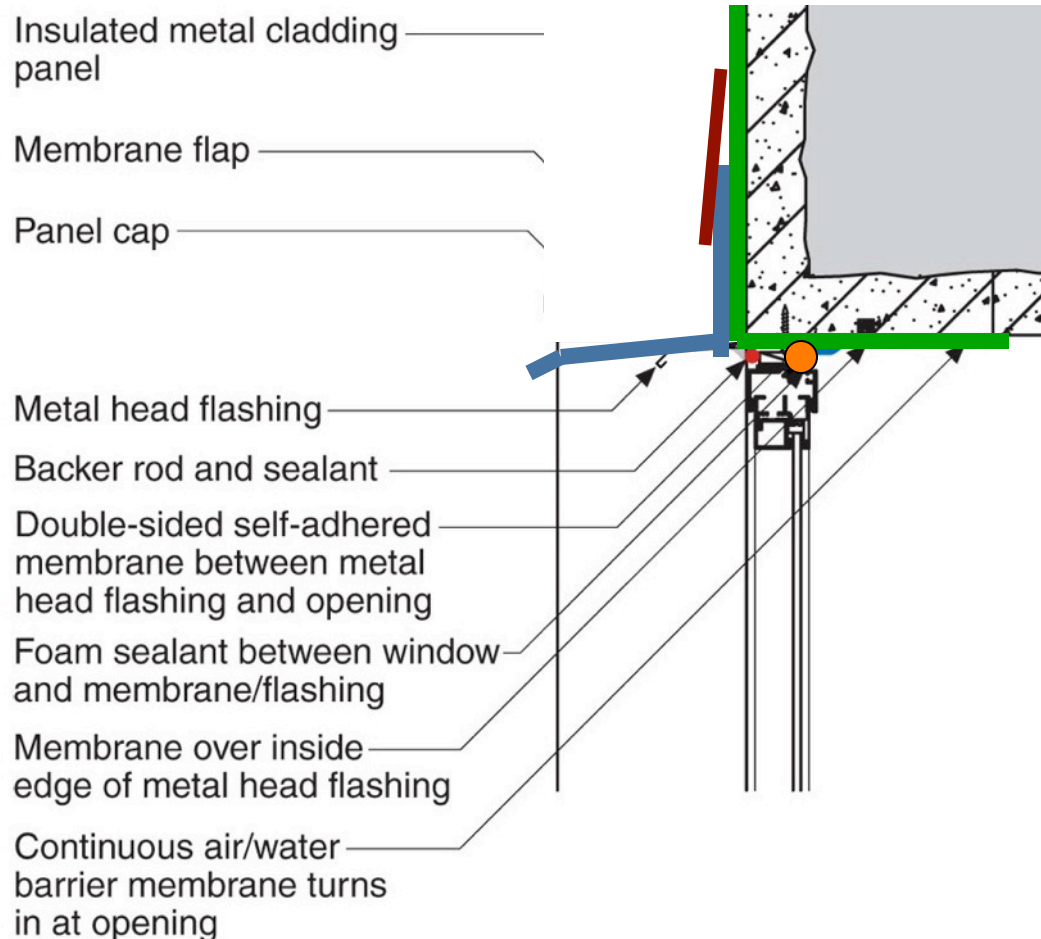
- Integration of windows, roofs, etc. with water / air control layer



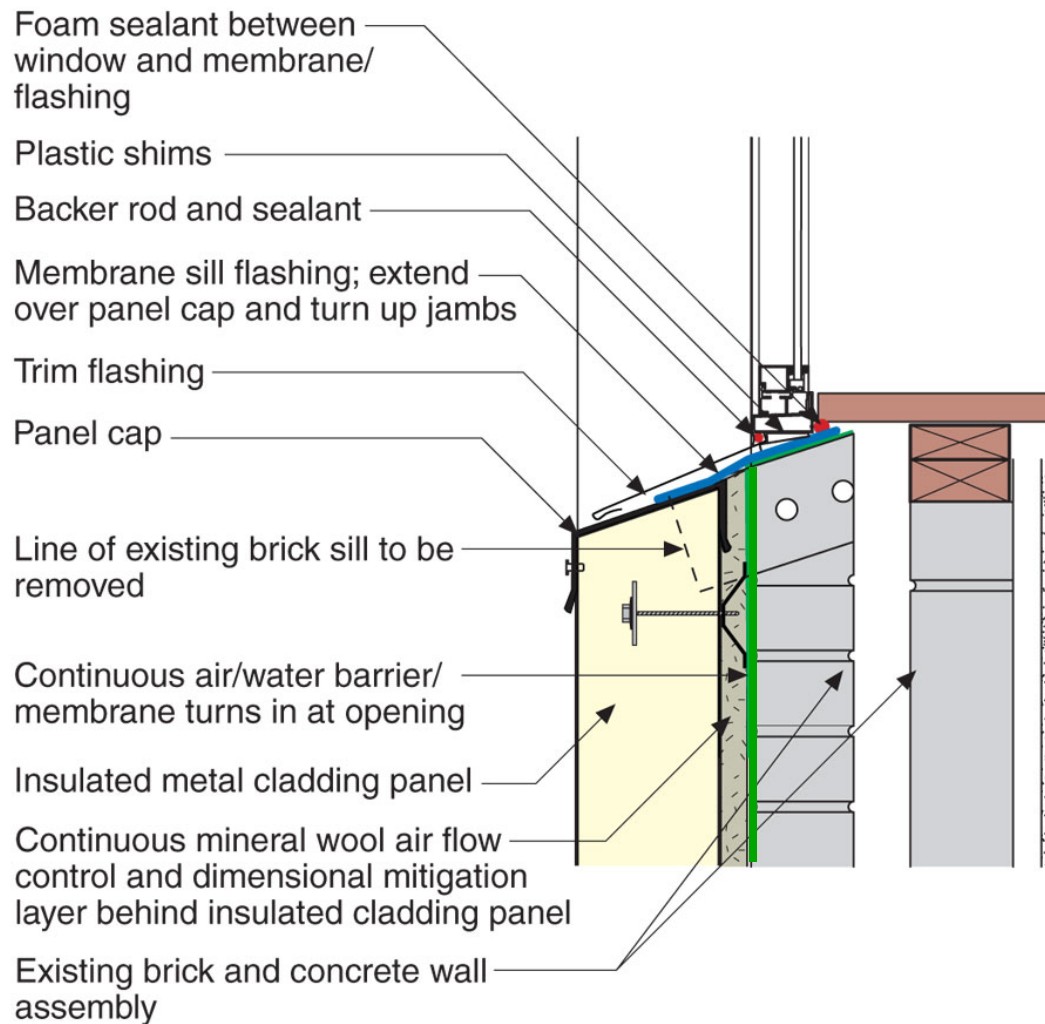
# Castle Square Wall Retrofit



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# Castle Square Wall Retrofit



Photo credit: Elton + Hampton Architects

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Photo credit: Elton + Hampton Architects



# Castle Square Wall Retrofit

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# Castle Square Wall Retrofit

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# Castle Square Retrofit

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- Results from overall project:
  - > 50% gas savings
  - EUI: 58.5 kBtu/sf-yr
  - Gas for heating and hot water: 4.5 kBtu/sf-yr



# Brick Masonry Bearing Walls - Chicago





# Brick Masonry Retrofit - Chicago

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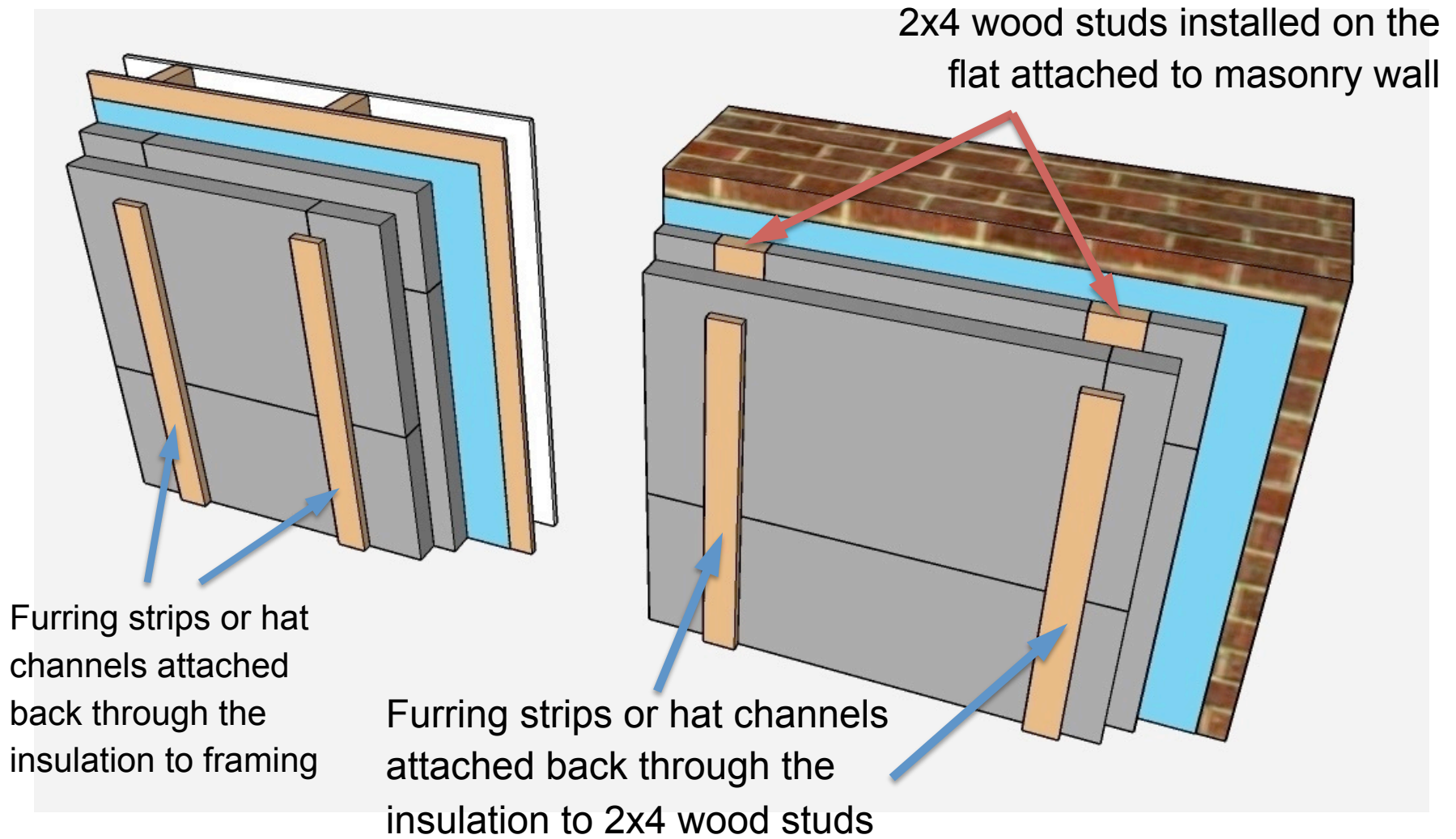
Implementation through weatherization channels:

- Low cost solutions
- Implementation by Wx program contractors
- Employ readily available building materials

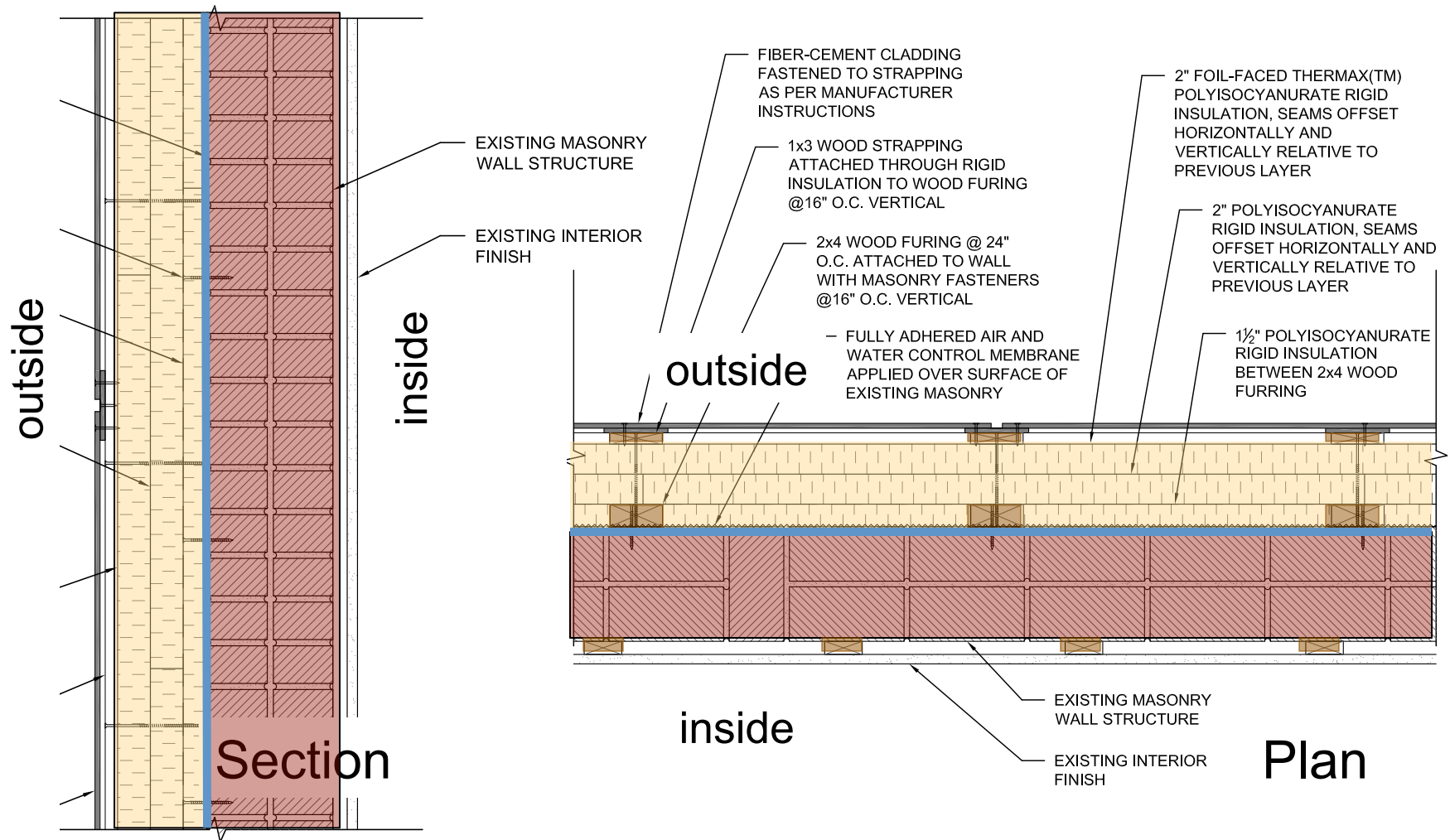
Location:

- Combustibility a major concern
- Abuse resistance

# Brick Masonry Retrofit Strategy



# Brick Masonry Retrofit Strategy



# Brick Masonry Retrofit - Chicago





# Brick Masonry Retrofit - Chicago

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# Brick Masonry Retrofit - Chicago

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# Brick Masonry Retrofit - Chicago

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# Brick Masonry Retrofit - Chicago





# Brick Masonry Retrofit - Chicago





# Brick Masonry Retrofit - Chicago



# Brick Masonry Retrofit - Chicago





# Brick Masonry Retrofit - Chicago





# Brick Masonry Retrofit - Chicago



# Brick Masonry Retrofit – Existing Windows

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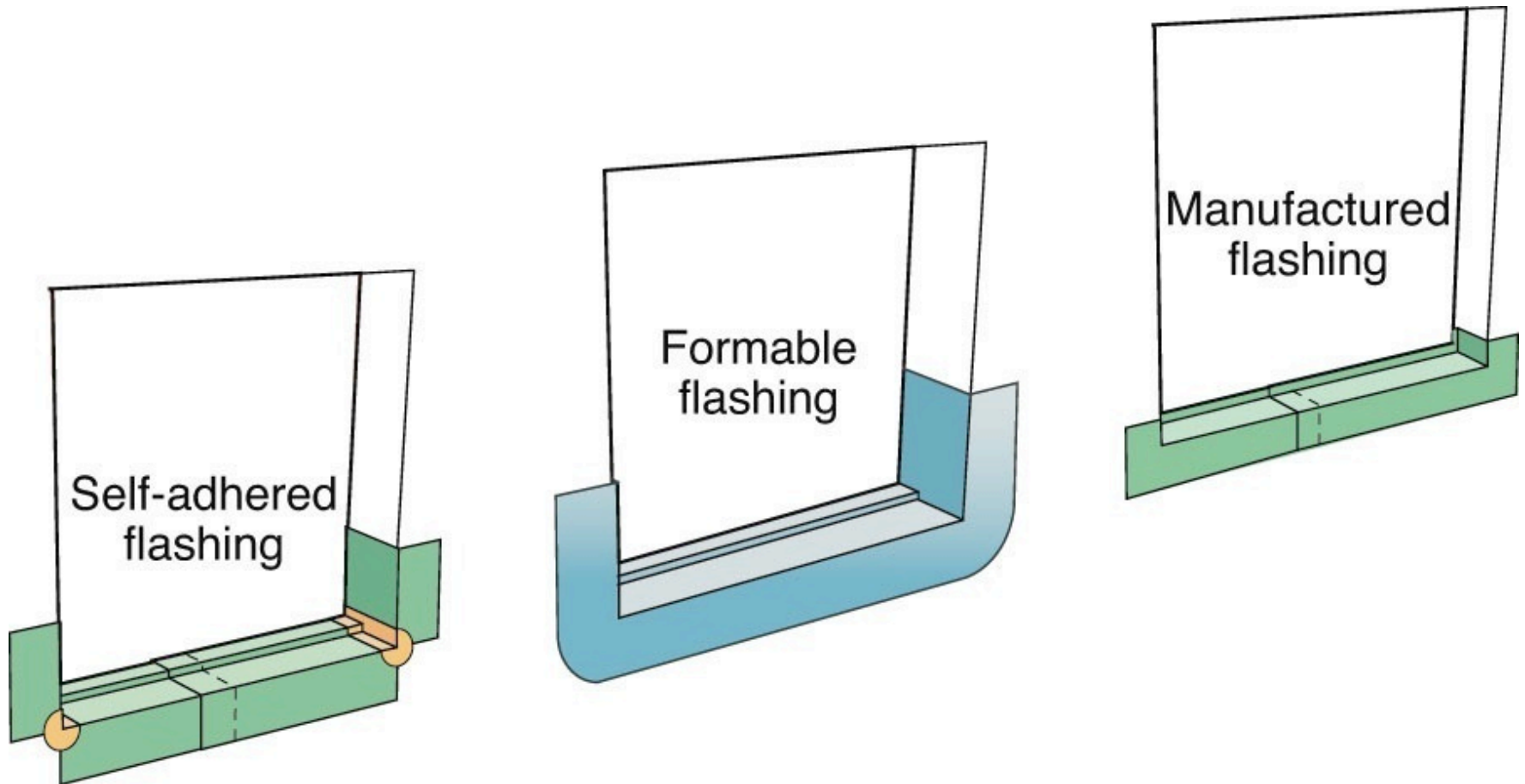
## Window openings:

- Flashing
- Flanking losses (thermal bridges)
- Replacement



# Brick Masonry Retrofit – Windows

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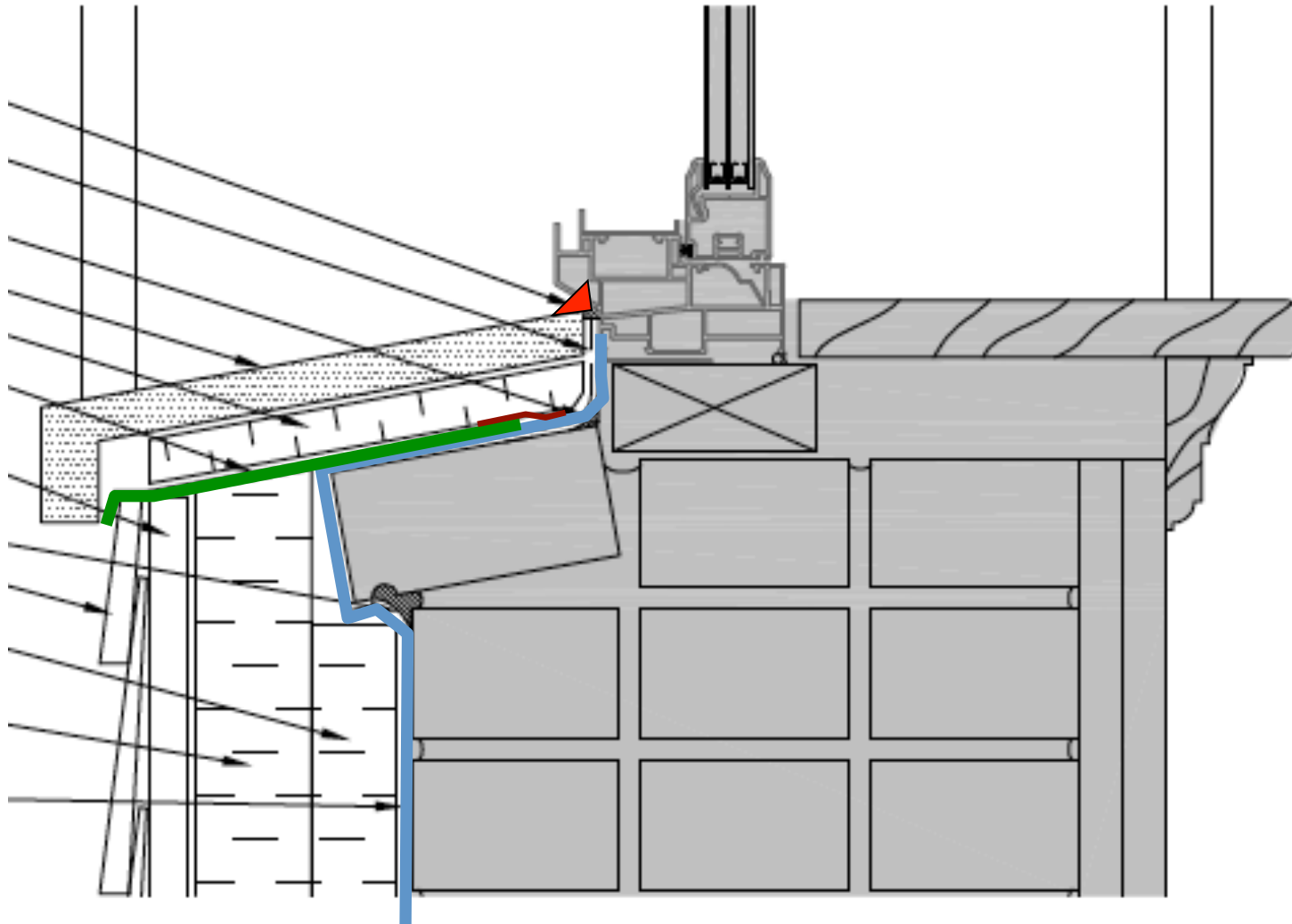


# Brick Masonry Retrofit – Existing Windows

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# Brick Masonry Retrofit – Existing Windows

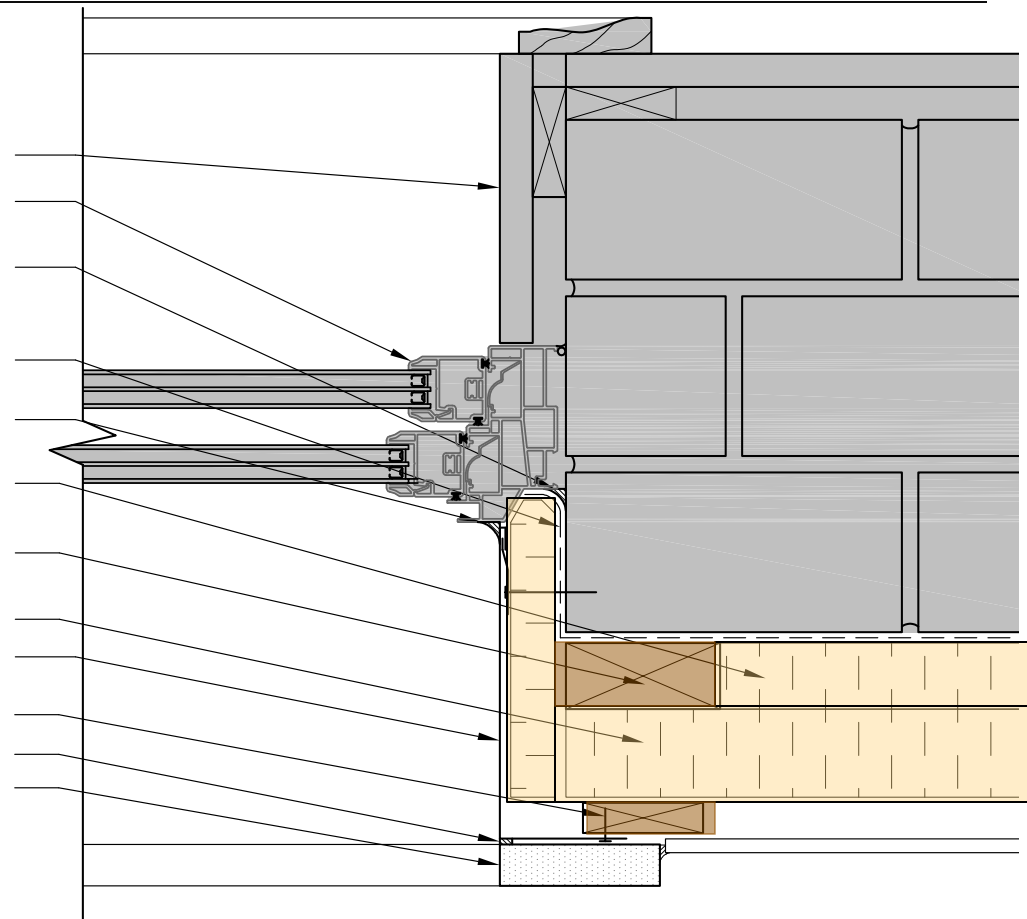




# Brick Masonry Retrofit – Existing Windows

## Windows

- Flashing
- Flanking losses (thermal bridges)
- Replacement

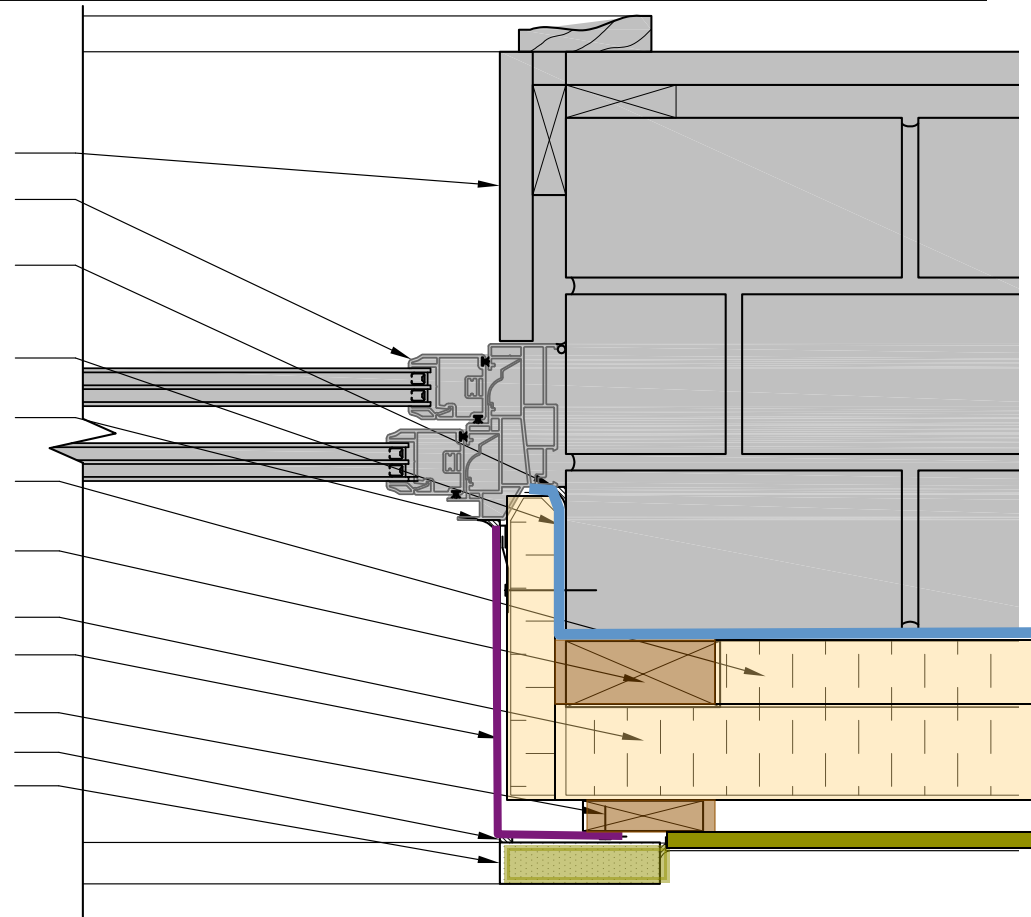


REPLACEMENT WINDOW JAMB DETAIL

# Brick Masonry Retrofit – Existing Windows

## Windows

- Flashing
- Flanking losses (thermal bridges)
- Replacement



REPLACEMENT WINDOW JAMB DETAIL

# Brick Masonry Retrofit – Existing Windows

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# Brick Masonry Retrofit - Chicago

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# Brick Masonry Retrofit - Chicago

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# Brick Masonry Retrofit - Chicago

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# Brick Masonry Retrofit - Chicago

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# CEDA Wx Implementation – cost data

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- 2 Story (Average of 3 lowest bids):
  - \$14.43 / s.f. gross wall area
- Post implementation contractor estimate:
  - \$12.60 / s.f. gross wall area
- Above 2 stories (Average of 3 lowest bids):
  - \$25.31 / s.f. gross wall area
- Post implementation contractor estimate:
  - \$20.10 – 21.30 / s.f. gross wall area

# Evaluation of Two CEDA Weatherization Pilot Implementations of an Exterior Insulation and Over-Clad Retrofit Strategy for Residential Masonry Buildings in Chicago