# Commercial Deep Energy Retrofit: Castle Square Case Study

August 8, 2019

# Castle Square

# Castle Square Mid-Rise Retrofit

Project Overview:

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

# Castle Square Mid-Rise Retrofit

Project Objective:

- Leverage tax incentive financing, grants, incentives, technical support,  etc. to include Deep Energy Retrofit in rehabilitation scope
- Rehabilitation of otherwise limited scope

# Castle Square Mid-Rise Retrofit

## Project Overview:

- Owner: Castle Square Tenants Organization, Winn Development
- Location: Boston, MA
- Buildings: 4 Buildings, 7 stories (6 Residential over Ground Floor Commercial)
- Units: 192 Units, 48 Units/Building, 600-900 sq. ft./Unit

# Circumstances of the Project

- 51% Tenant Owned
  - ØCSTO in charge
  - ØInterests of tenant group protected
  - ØDriving factors for the “energy” measures: Comfort, IEQ concerns

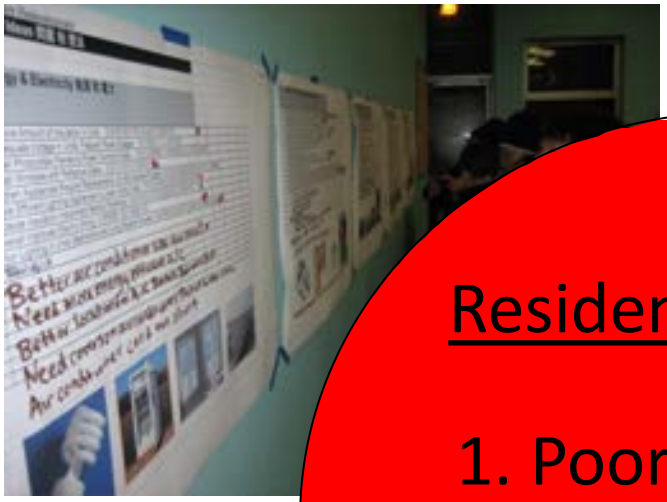
# Circumstances of the Project

- Originally built as subsidized housing
  - Small, compact apartments
  - Economy of layout
  - Structure affords no opportunity to run services in interstitial spaces,
  - Structure and aesthetic expression poses challenge to thermal performance

# Circumstances of the Project

- 100% occupied renovation (!)
  - Severe constraints on scope within apartments
    - Completed over 2-3 days
    - Tenants return to functioning kitchen first day
    - Belongings in bedrooms, living room not moved

# Resident Surveys & Charrettes



**Top Resident Concerns:**

1. Poor Ventilation
2. Comfort (Too Hot or Cold)

# Castle Square Mid-Rise Retrofit

Property Management Concerns:

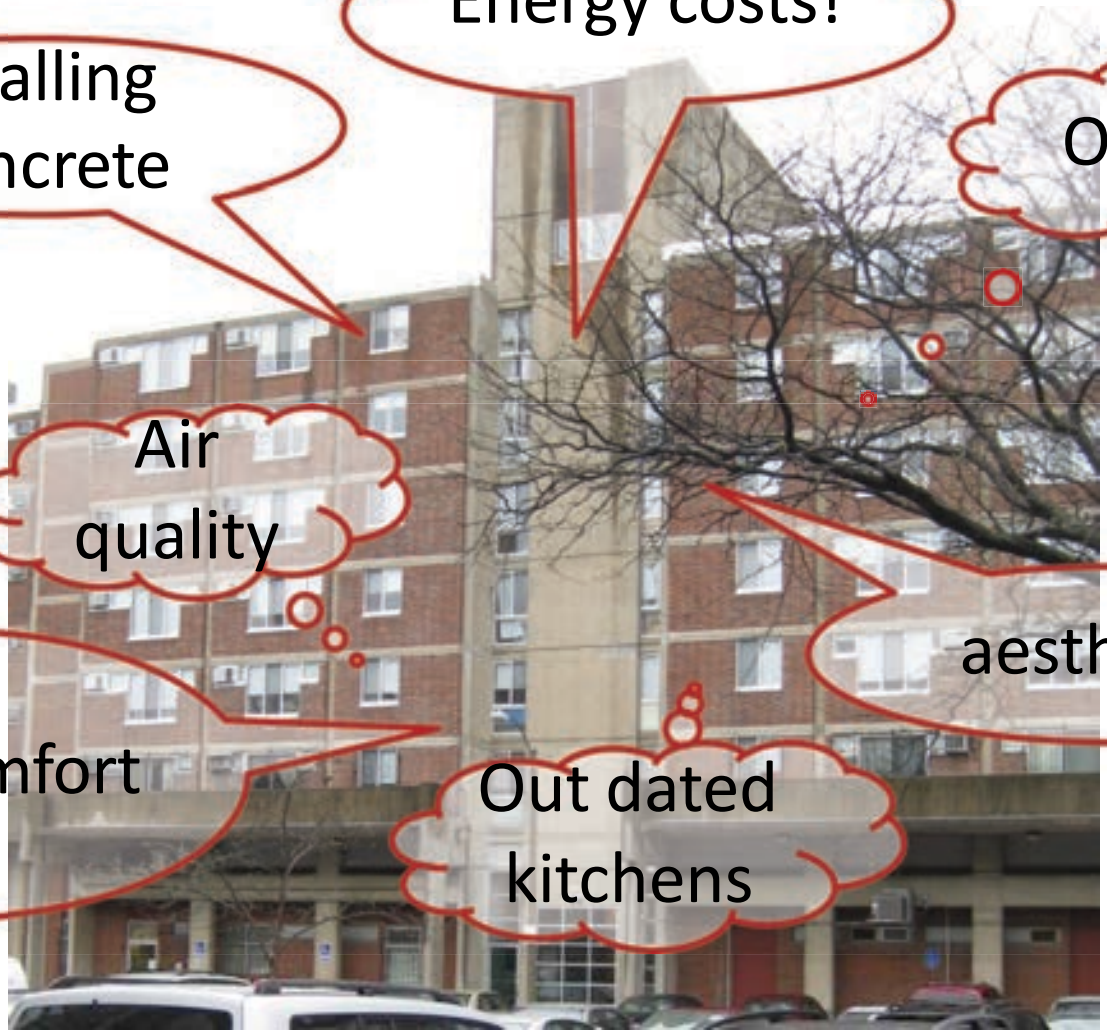
- IAQ
- Comfort
- Energy costs
- Water leakage
- Façade maintenance and repair issues

# Castle Square Mid-Rise Retrofit

Project Overview:

- Ambitious energy performance goals
  - Estimated Heating and Water Heating Energy Savings: >70%
  - Combined Gas & Elec. Savings: >50%
- Construction Start: October, 2010
- Construction Schedule: 18 Months

# Castle Square Mid-Rise Retrofit



# Castle Square Mid-Rise Retrofit

*What do we have to work with?*

Understanding the building through:

- Testing/measurement
- Investigation of construction
- Simple analysis

# Castle Square Mid-Rise: Testing

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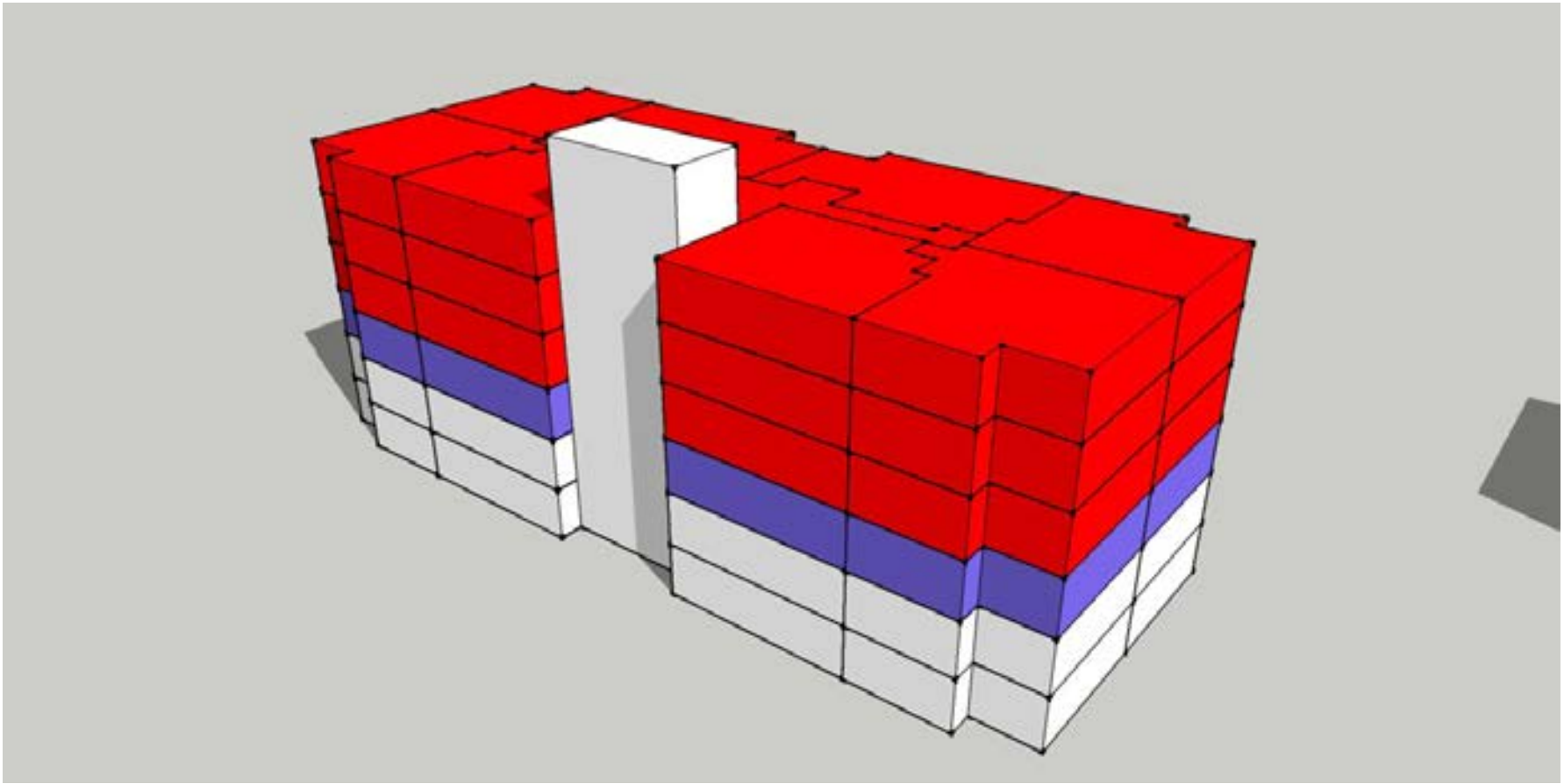
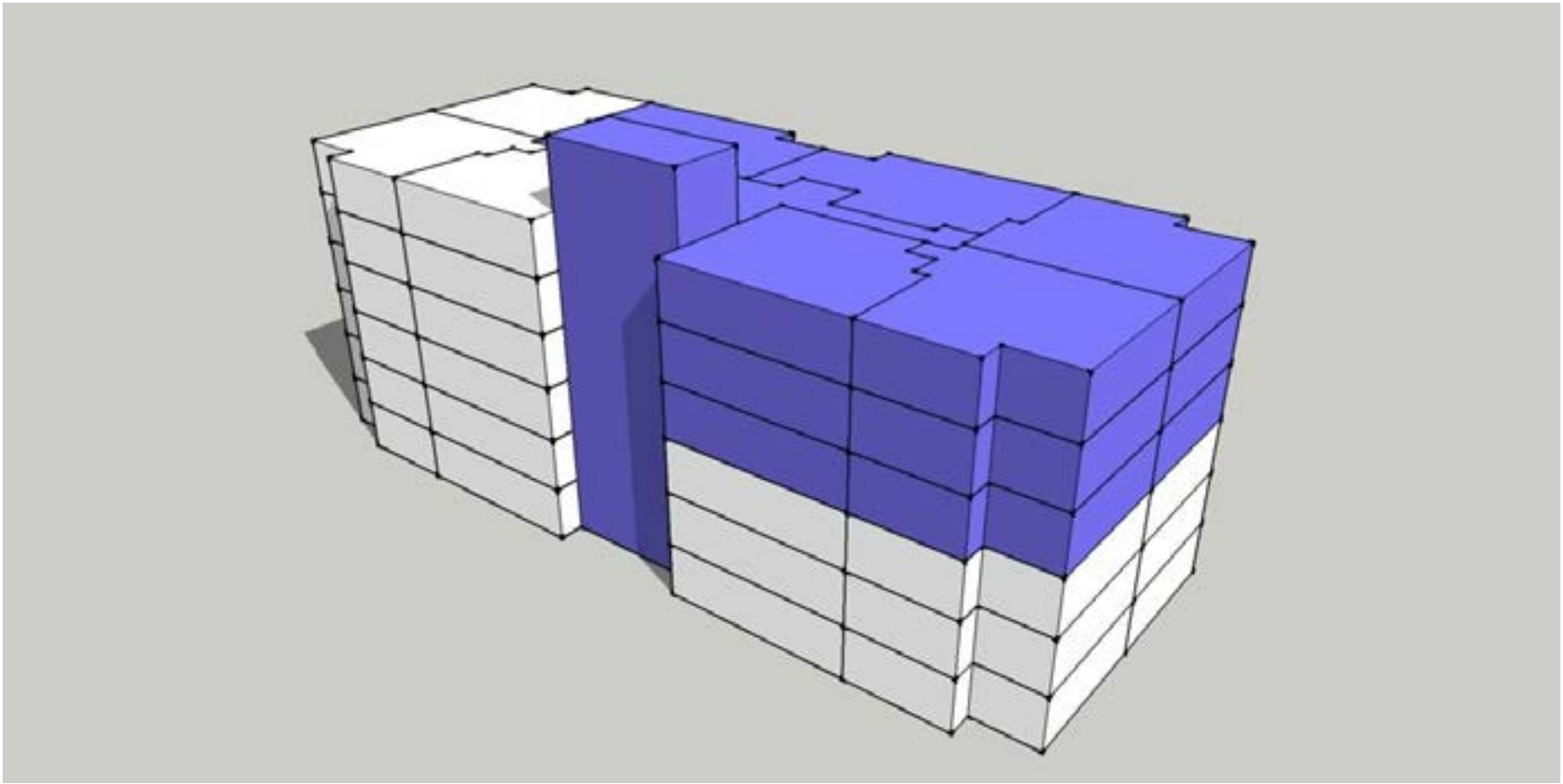


# Castle Square Mid-Rise: Testing



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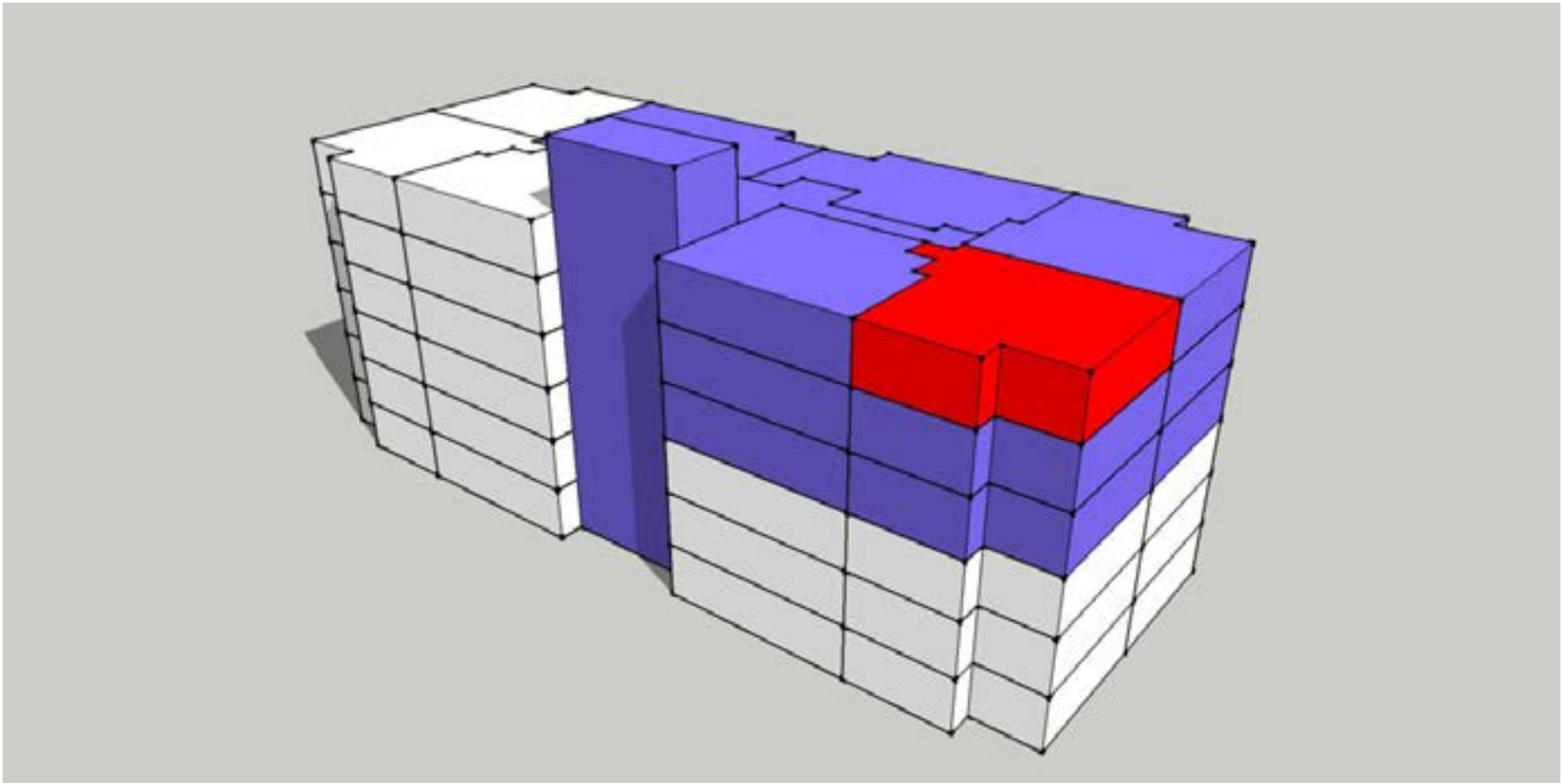

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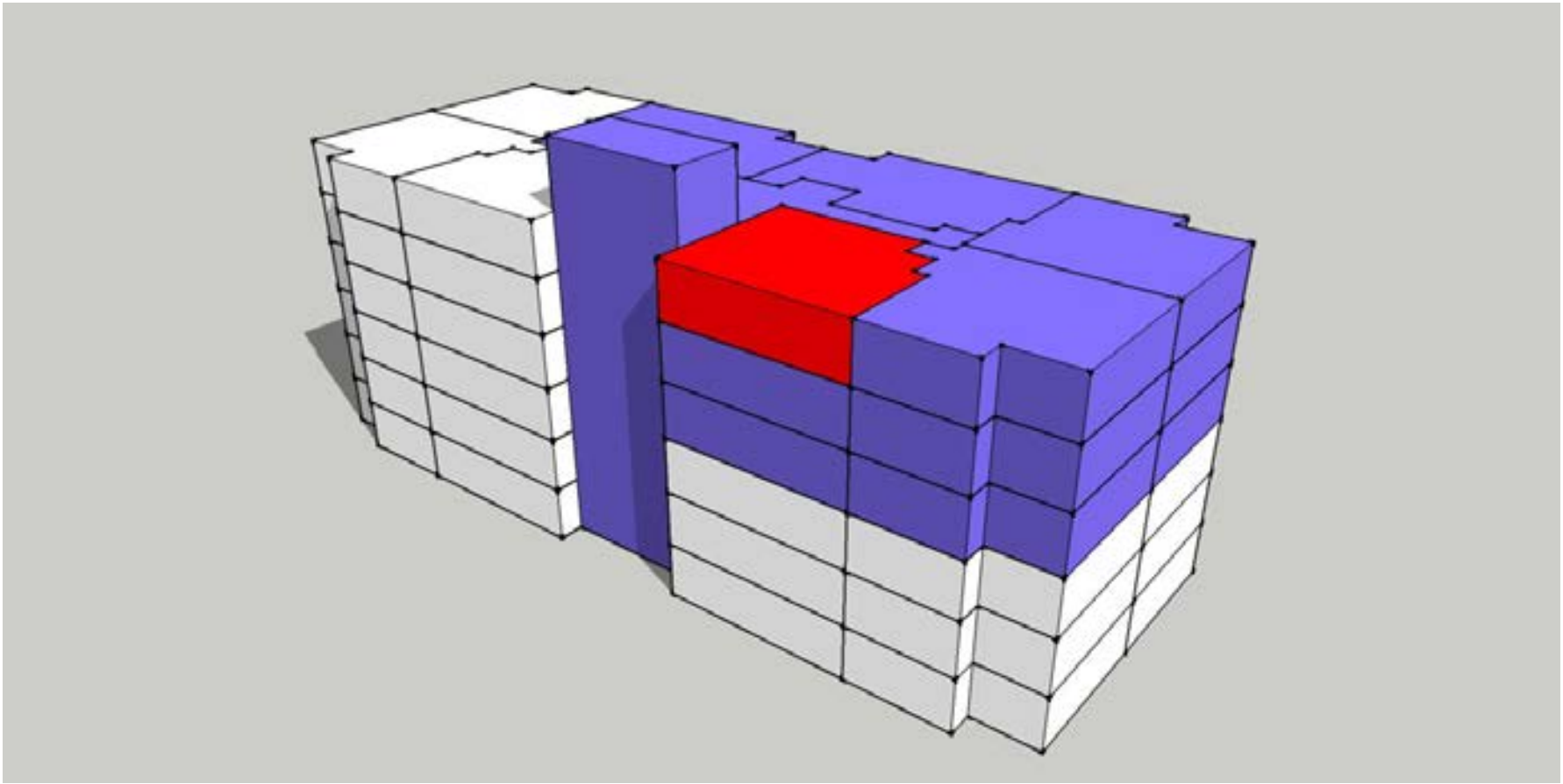

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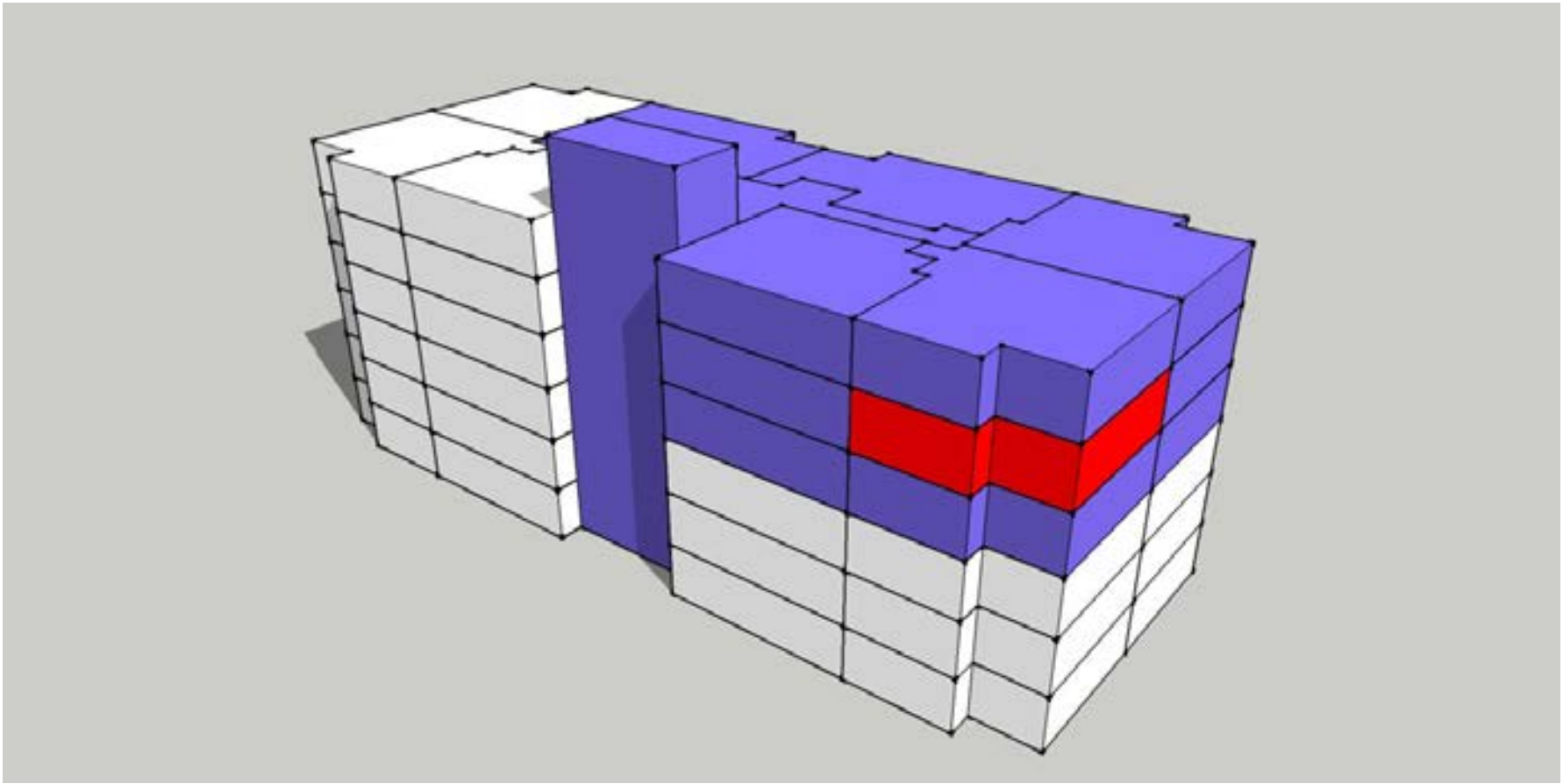

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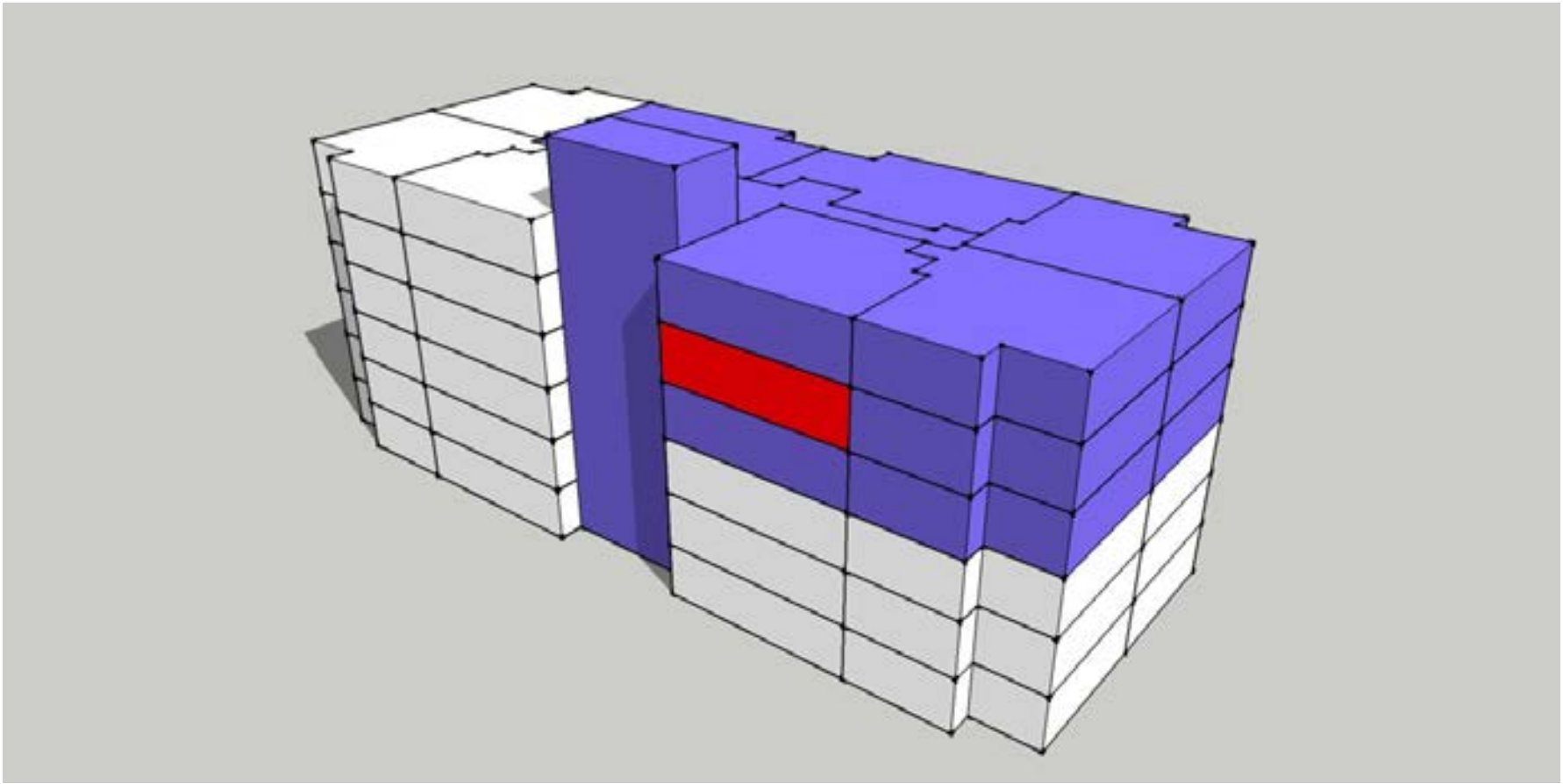


# Castle Square Mid-Rise: Testing

Testing and Measurement:

- Leakage to outside (guarded testing)
  - Ø~2.5 ACH50
  - Ø~0.7 cfm50 / sf exterior enclosure
- Total leakage for apartment units (unguarded)
  - Ø~10-17 ACH50
  - Ø~0.5-0.8 cfm50 / sf total enclosure

# Castle Square Mid-Rise: Investigation

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)

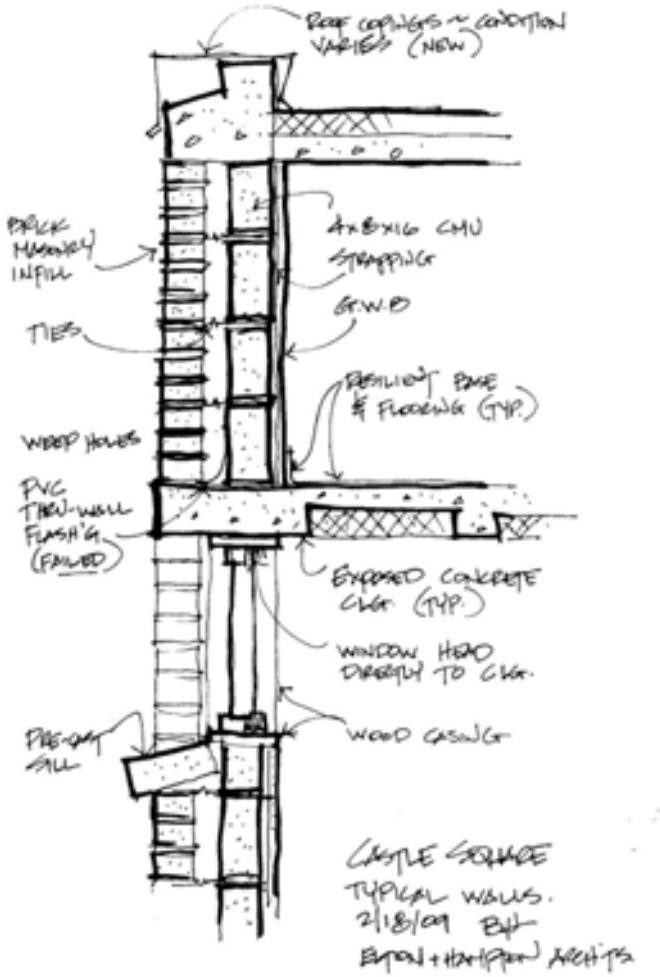
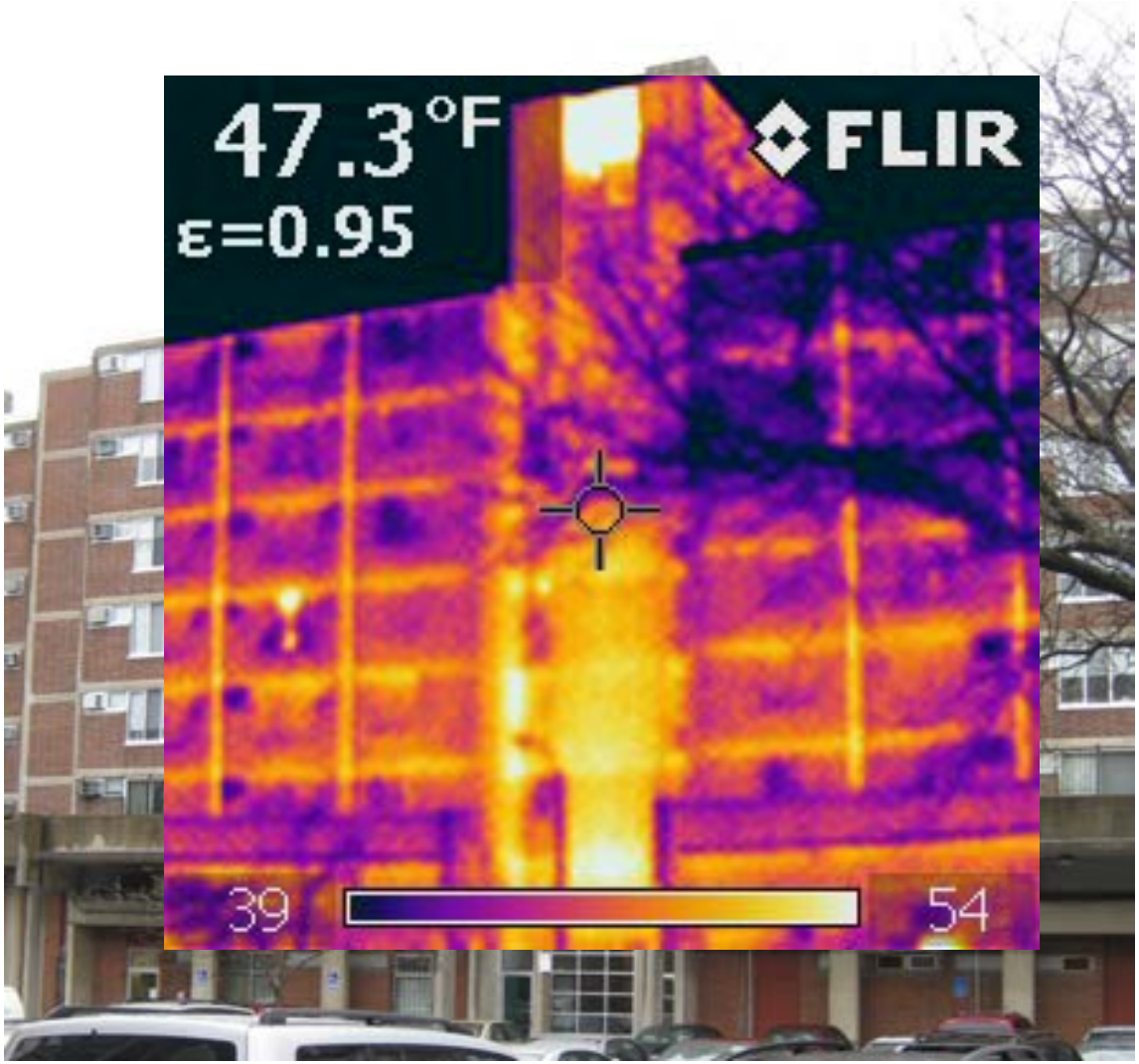



*Image courtesy of Elton + Hampton Architects*

# Castle Square Mid-Rise: Investigation



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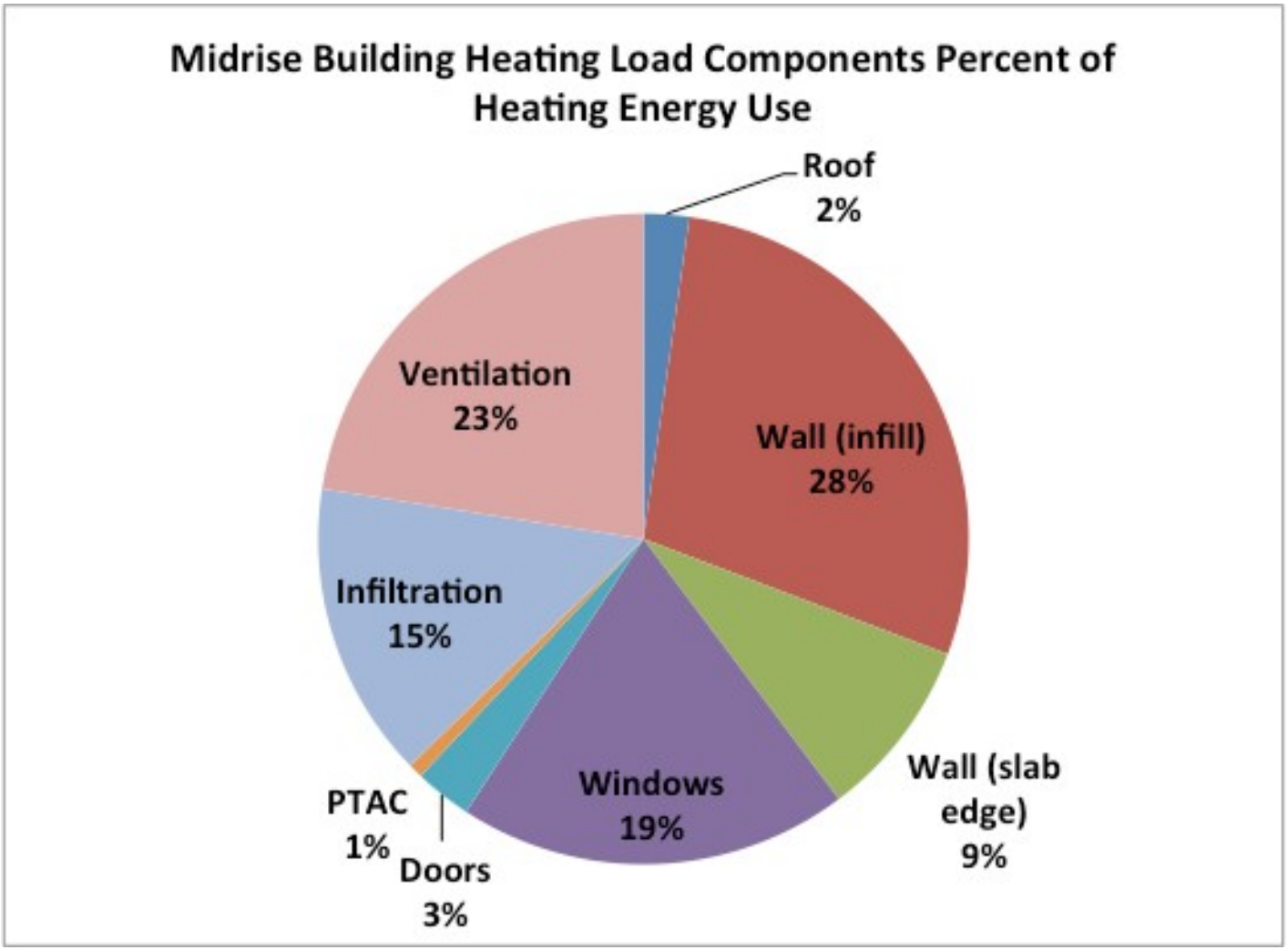
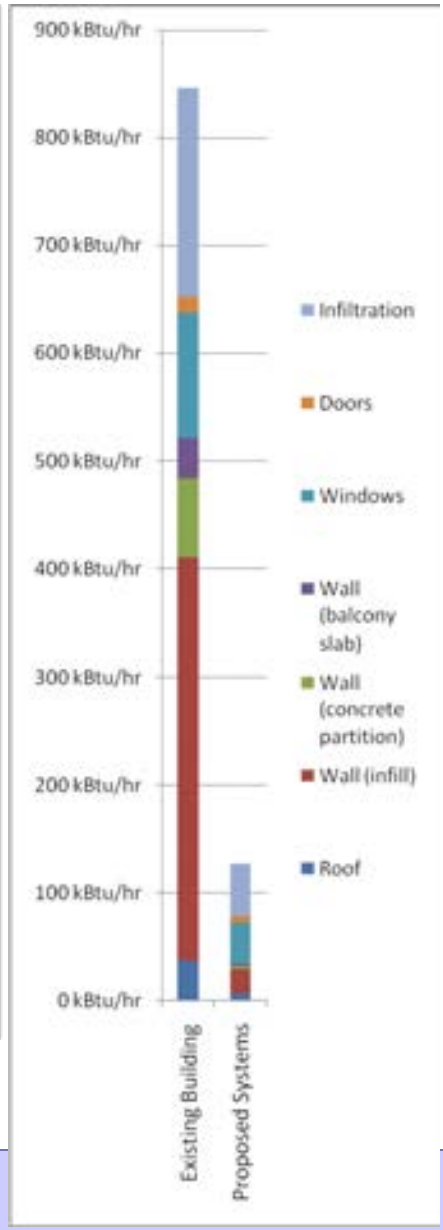
# Castle Square Mid-Rise: Analysis

Simple Analysis

- UA analysis
- Estimates of ventilation, infiltration

# Castle Square Mid-Rise: Analysis



# Castle Square Mid-Rise Retrofit

Testing, investigation, analysis:

- Building is moderately (but not abnormally) air leaky
- Apartment units are not well contained
- Any significant improvement to energy performance will require adding insulation to walls

# Castle Square Mid-Rise Retrofit

Testing, evaluation, analysis:

- High performance will require

1. adding insulation to walls,
2. controlling infiltration and ventilation,
3. improving windows

# Castle Square Mid-Rise Retrofit

Performance Targets:

- R-40 Walls
- R-5 Windows
- R-40 Roof
- Improve compartmenting as much as possible

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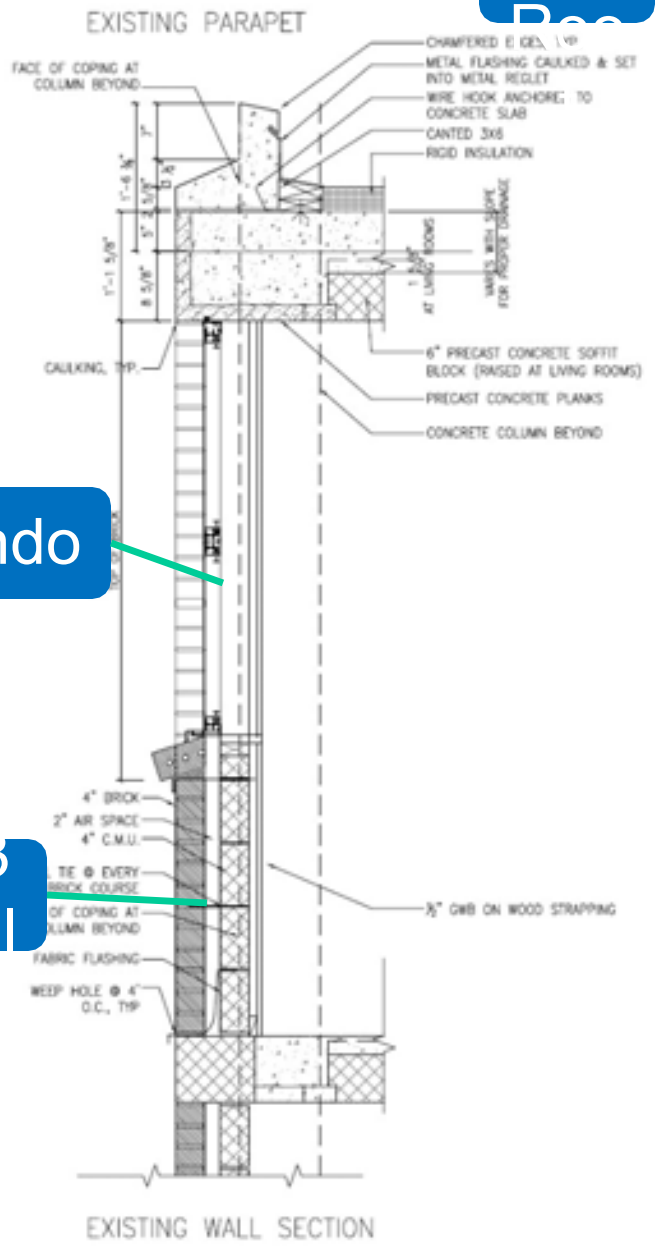
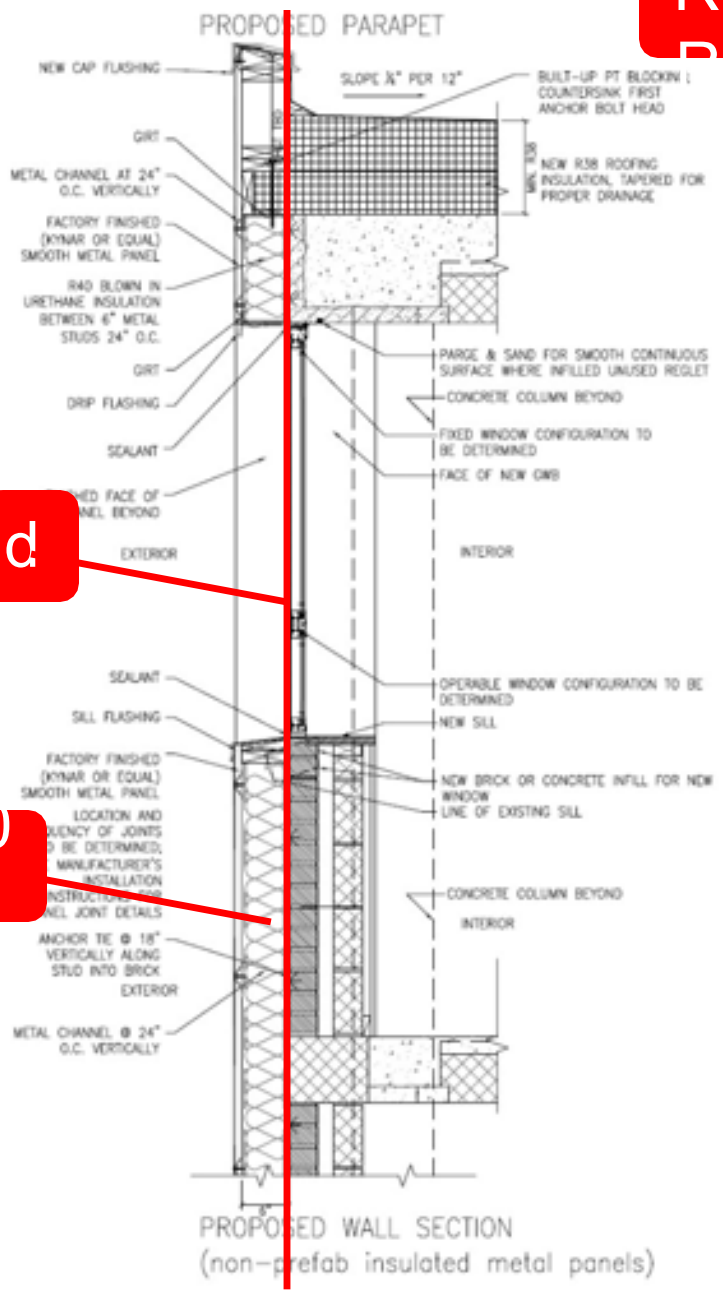



Windo

R-3 Wall

R-40




Wind

R-40 Wall

# Castle Square Mid-Rise Retrofit

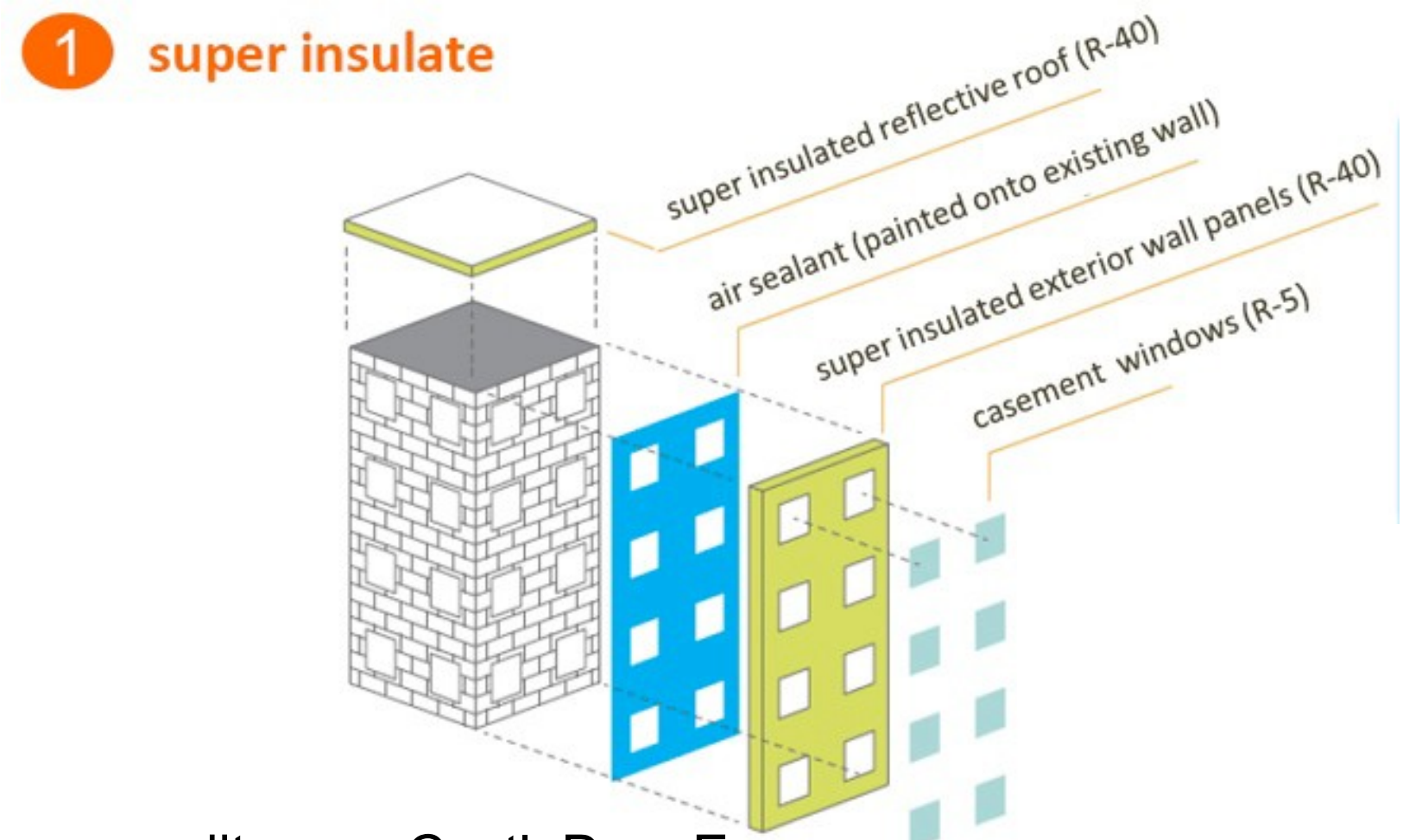



Image credit: www.CastleDeepEnergy.com

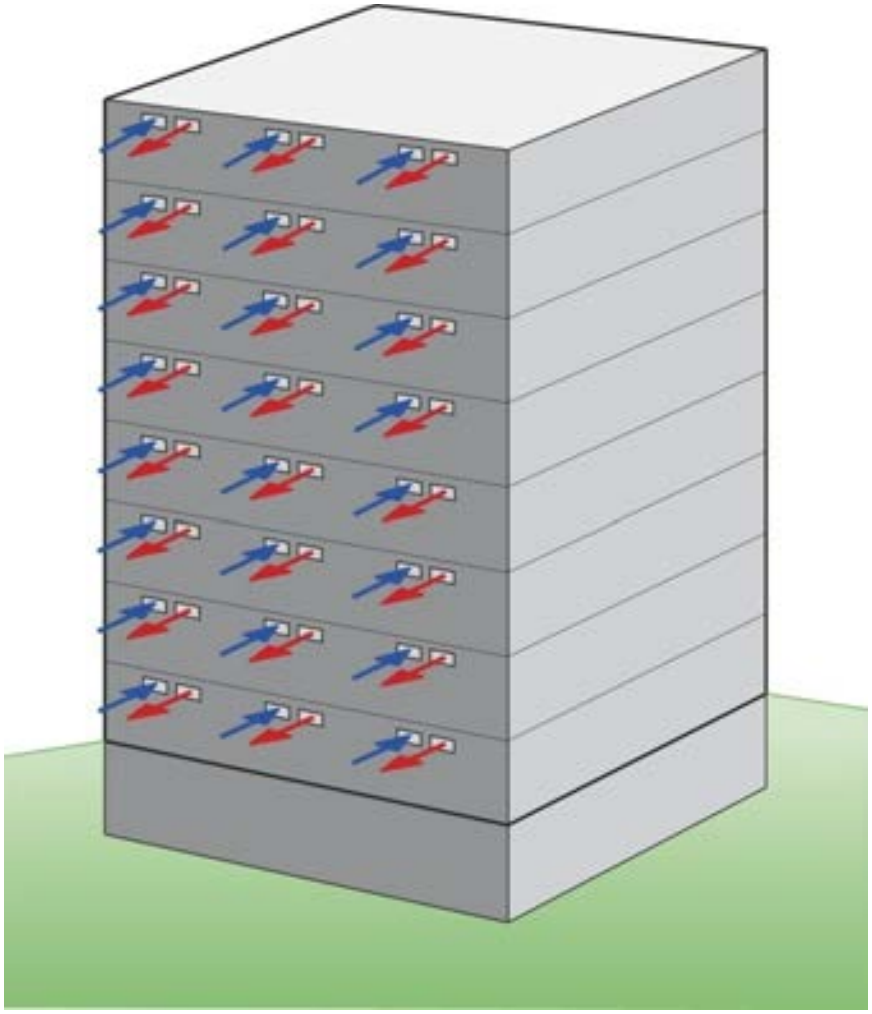
# Castle Square Mid-Rise Retrofit


Image credit: www.CastleDeepEnergy.com

# Castle Square Airflow Control/Ventilation

- Avoid cross-contamination
- Provide effective ventilation with minimal energy inputs
- Reduce drivers of infiltration
- *Compartmenting of apartments is critical to ventilation performance*

# Ventilation



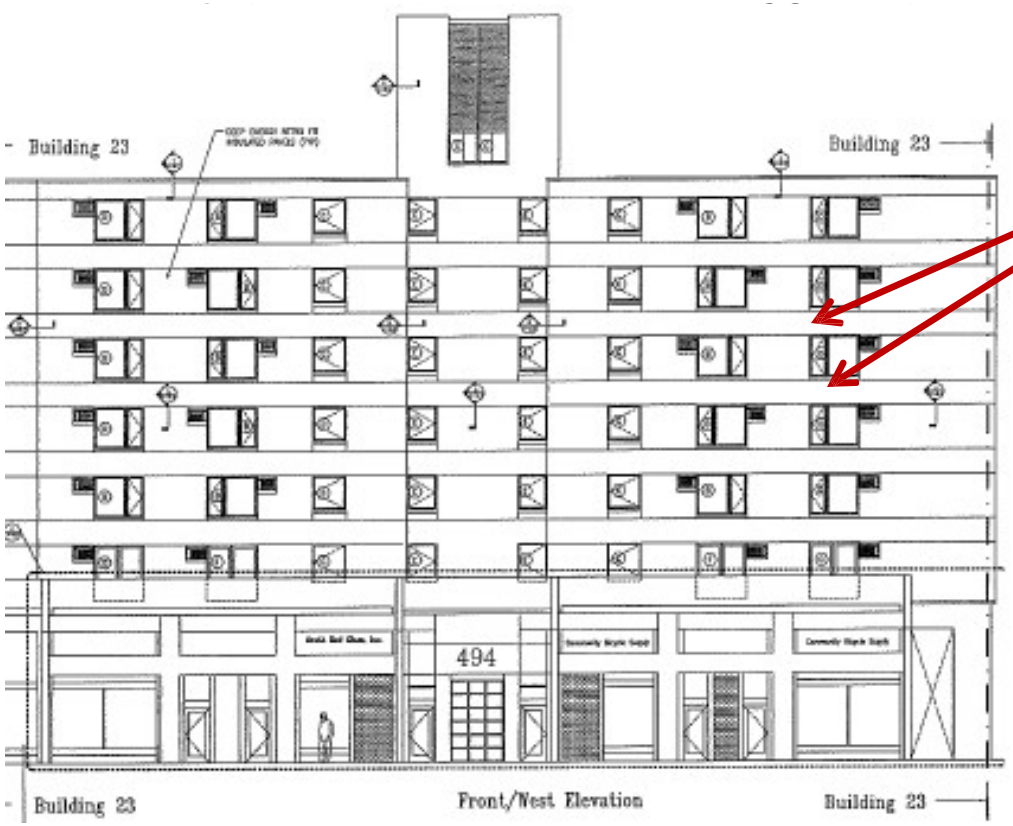
# Ventilation

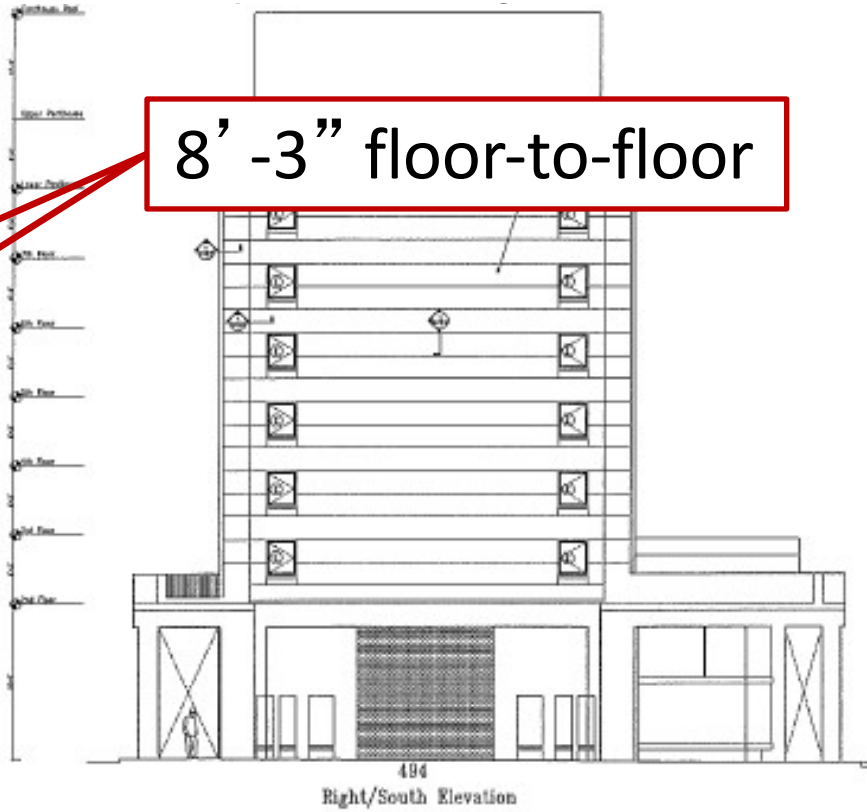
Context:

- Odor complaints a major motivation for residents
- Exhaust ventilation a part of existing infrastructure
- Project aspiring to LEED-NC recognition (ventilation distribution requirements)

# Ventilation

## Challenges:



# Ventilation

Options investigated:

- ØHRV per apartment
  - Ceiling too low for dropped soffit in circulation areas
  - Asbestos made penetration of partitions impractical
- ØCentral supply and Hx
  - Would need to refit or reconfigure riser
  - Distribution within apartment

# Ventilation

Selected approach:

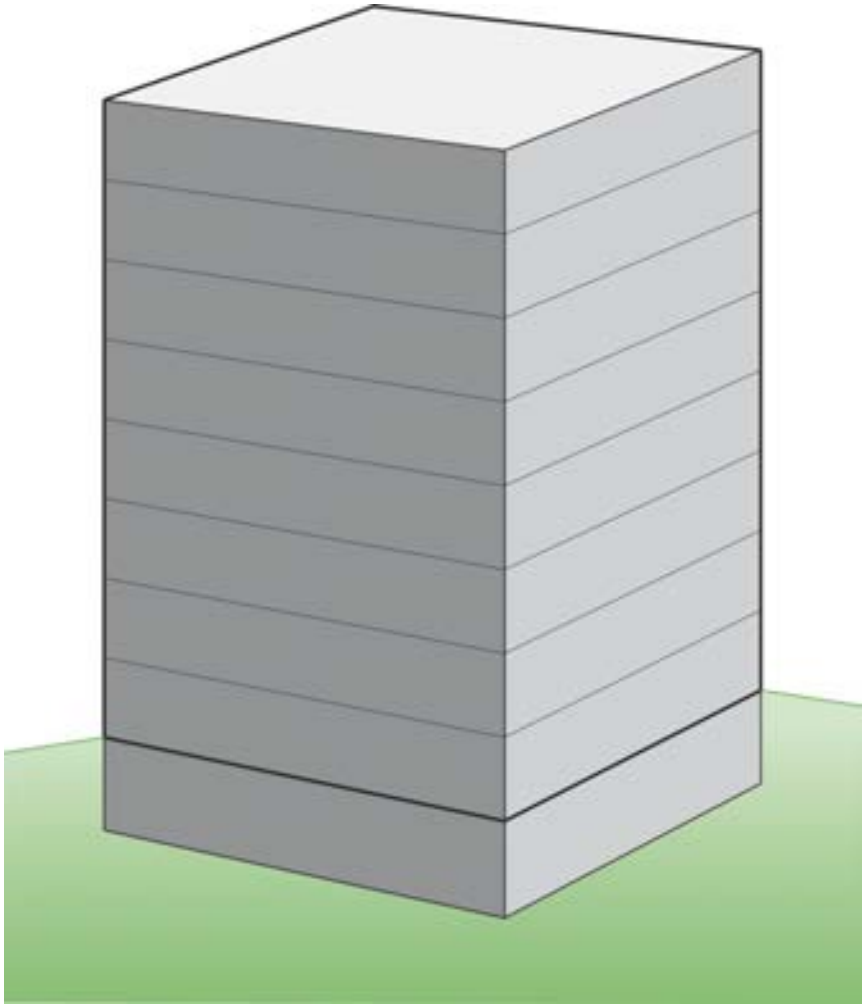
- Use existing ventilation shafts, exhaust
  - Controlled rate at unit – CAR
  - Seal exhaust riser from roof
  - Passive inlet vent (PIV)

# Ventilation

Whither the ventilation supply:

- Passive Inlet Vents (PIV)
  - Concern about effectiveness of passive vents
  - Act as intake only when apartment negative WRT exterior
  - Could exhaust ventilation act to depressurize enough – depends on how tight apartment is
  - Is source controlled?

# Compartmenting



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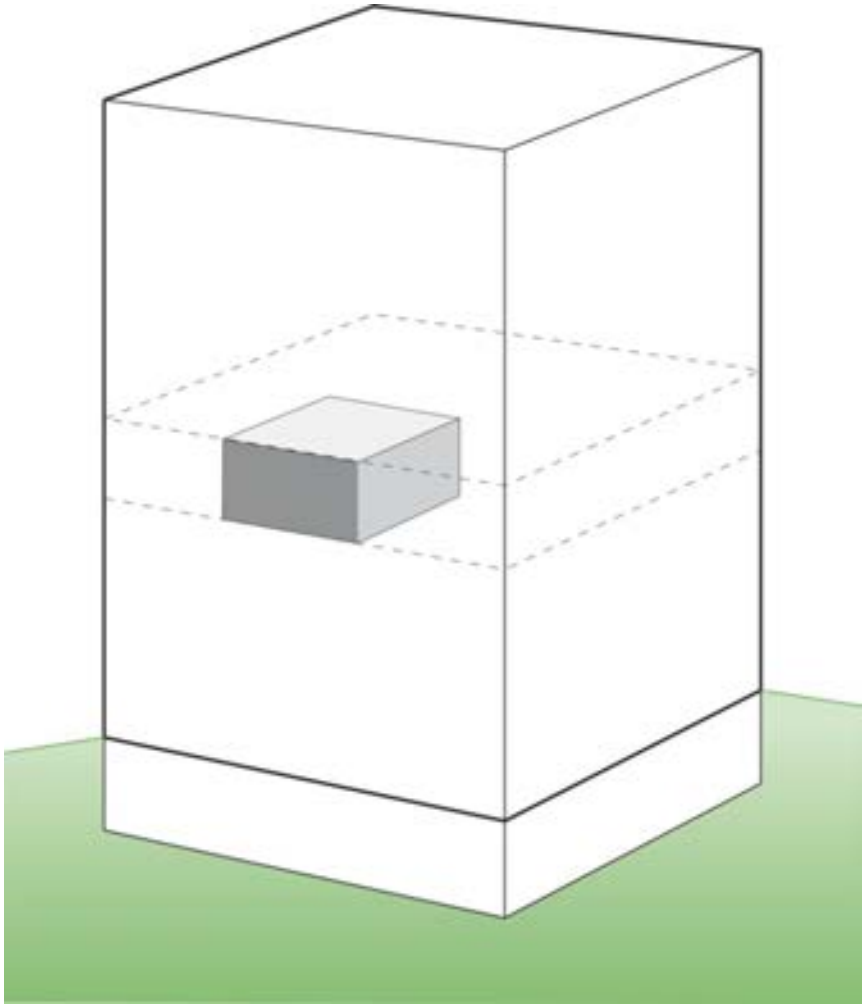

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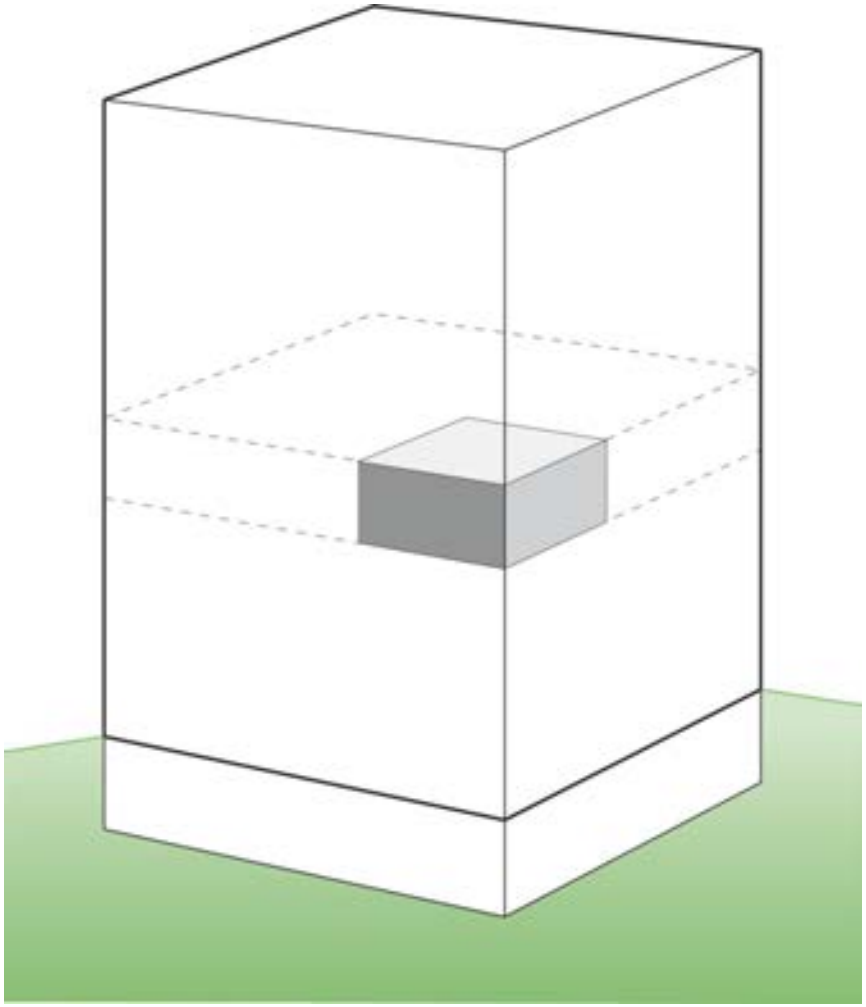


# Compartmenting

Context:

- Odor complaints a major motivation for residents
- Project aspiring to LEED-NC recognition (apartment air tightness requirement)

# Compartmenting

Challenges:

- ØOccupied renovation severely limits opportunities
  - 2 – 3 days total for interior work
  - Belongings not moved from living and bedrooms
- ØInterstitial interconnected
  - Openings into shafts
  - Hollow walls
- ØLimited disruption beyond kitchen and bath

# Compartmenting

How to identify effective and important measures?

- Have a look at building (may have to get destructive)
  - Understand/confirm construction
  - Assess significance of holes
  - Devise approaches to seal holes
  - Test implementation of measures.

# Compartmenting

# Compartmenting

# Compartmenting

# Castle Square Wall Insulation Strategy

Context

- Buildings are un-insulated
- Significant air leakage comfort complaints (papers blowing off of desks)
- Exterior rain infiltration issues
- Façade maintenance issues
- ***R-40 performance goal***

# Castle Square Wall Insulation Strategy

Challenges:

- Occupied Retrofit
- Significant Thermal Bridging of Concrete Structure
- Existing Building Construction Tolerances

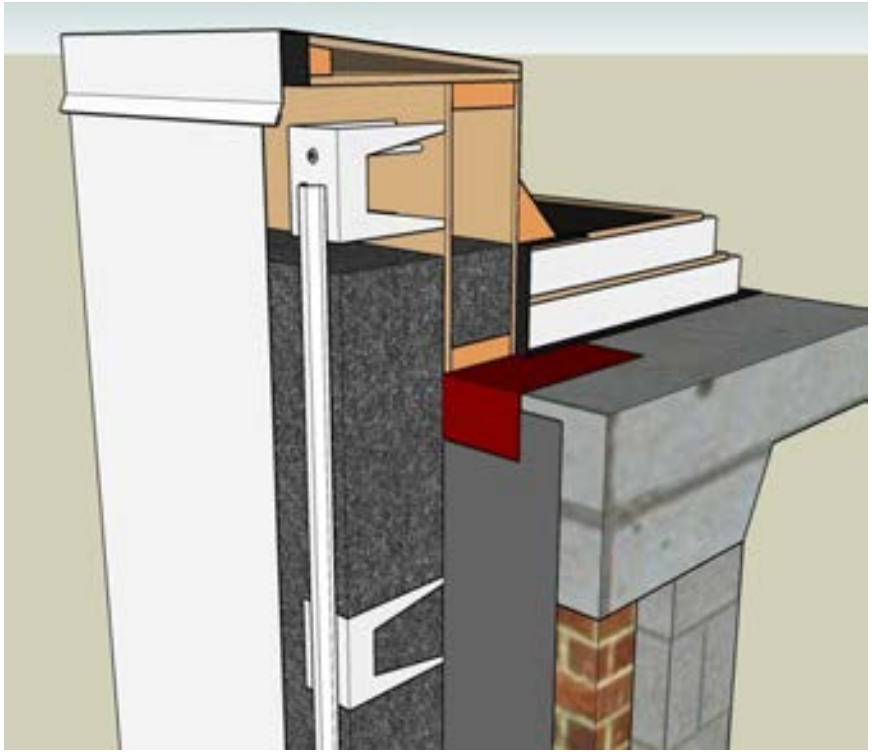
# Castle Square Wall Insulation Strategy

Options pursued:

- Exterior air barrier, insulation and cladding
- Exterior insulation and finish system (EIFS)
- Insulated metal panels (IMP)

# Castle Square Wall Insulation Strategy

- Exterior air barrier, insulation, and cladding



# Castle Square Wall Insulation Strategy

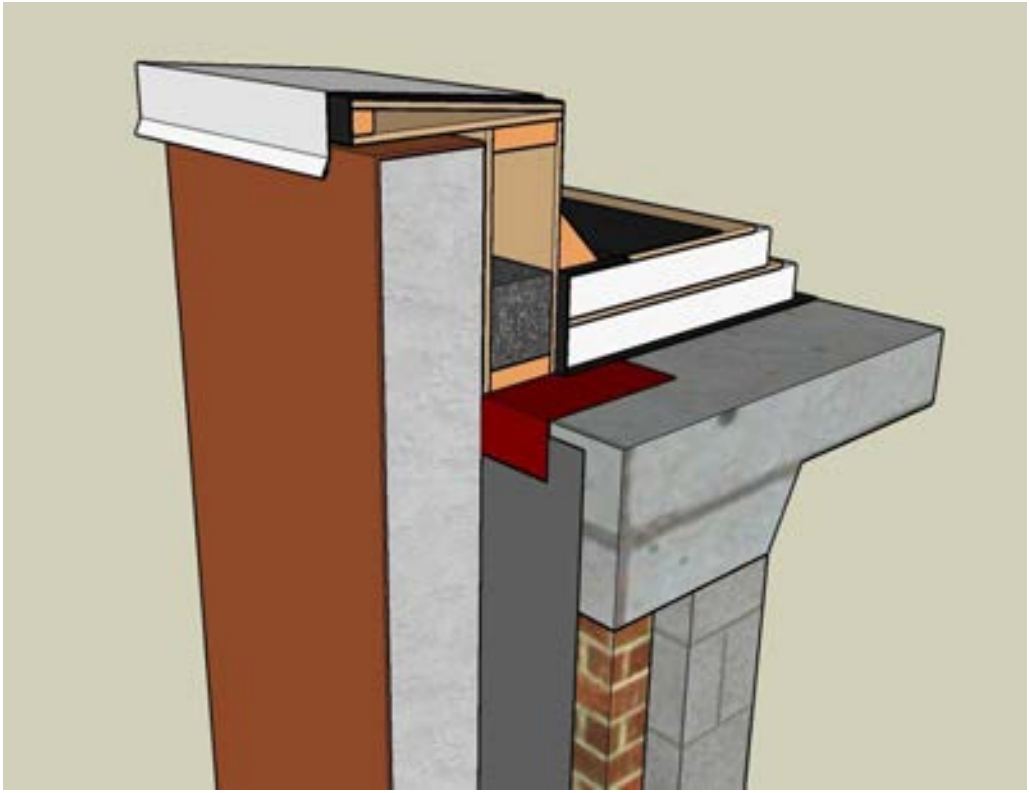
- Exterior air barrier, insulation, and cladding:
  - Large range of options
    - Insulation types
    - Air barrier materials
    - Cladding options

# Castle Square Wall Insulation Strategy

- 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 Insulation Strategy

- Exterior insulation and finish system (EIFS)



# Castle Square Wall Insulation Strategy

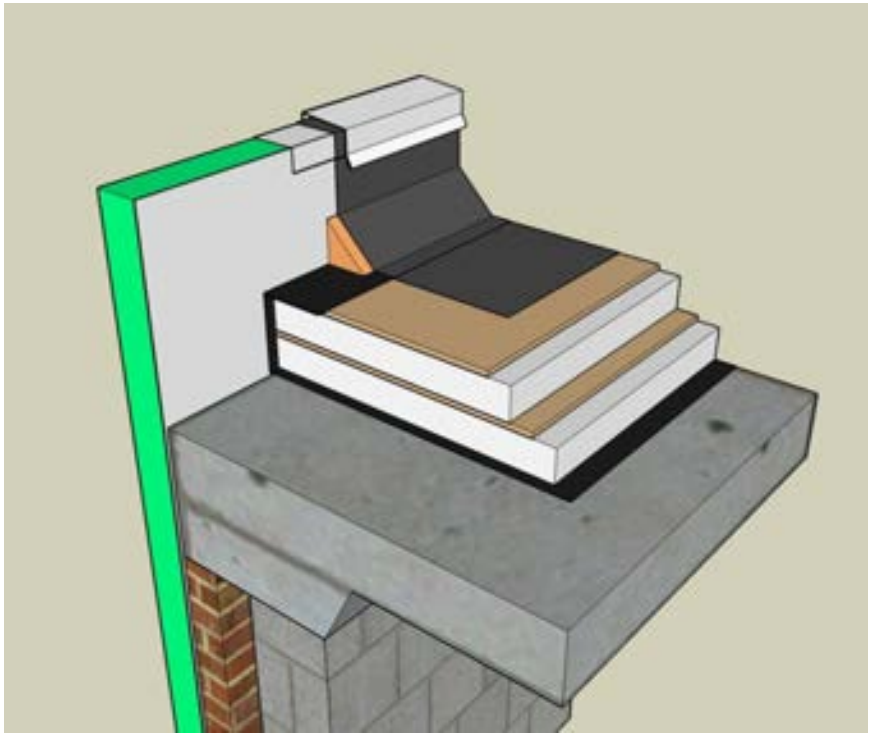
- Exterior insulation and finish system (EIFS)
  - Lower cost option
  - No need for design of cladding attachment system

# Castle Square Wall Insulation Strategy

- Exterior insulation and finish system (EIFS)
  - Thick layers of insulation needed to achieve design goals
  - Insurance concerns (Fire, water, durability)

# Castle Square Wall Insulation Strategy

- Insulated metal panels (IMP)



# Castle Square Wall Insulation Strategy

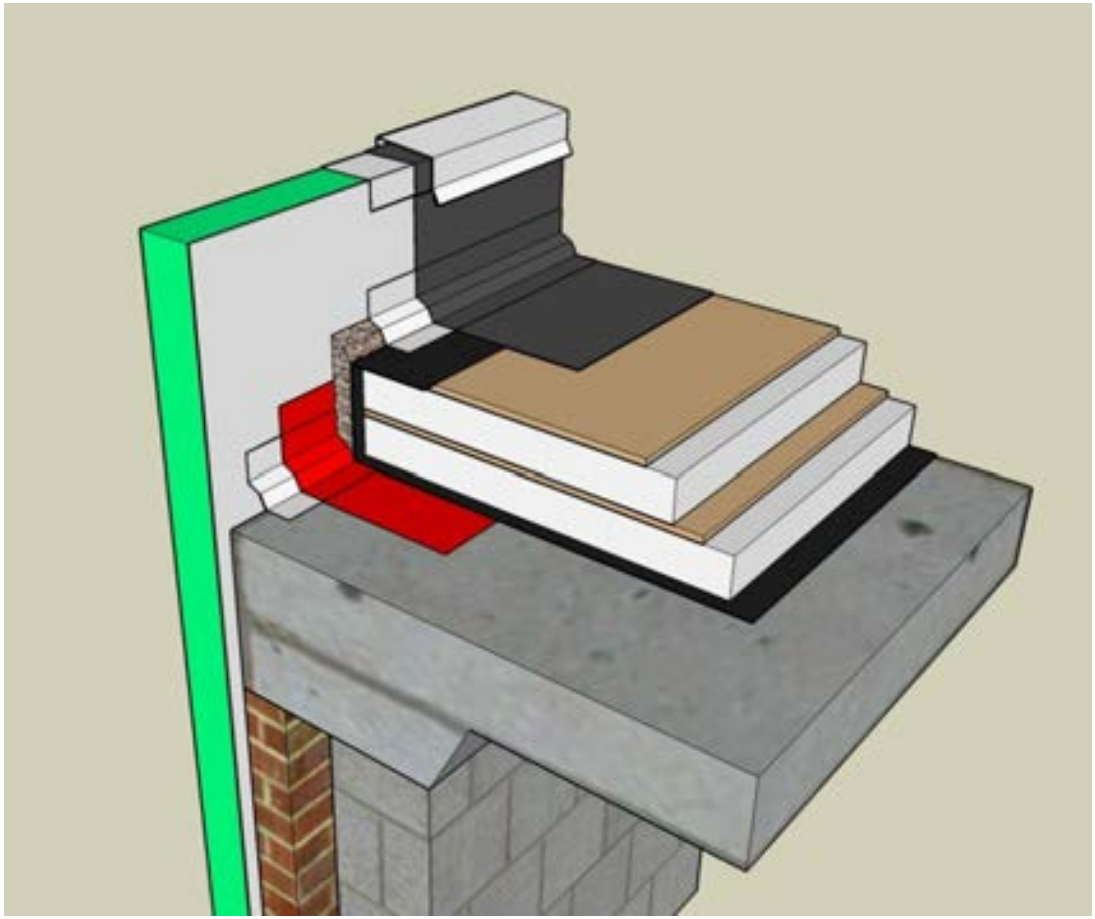
- Insulated metal panels (IMP)
  - High R-Value – thinner overall thickness
  - Fire rated
  - Durable

# Castle Square Wall Insulation Strategy

- Insulated metal panels (IMP)
  - Attachment due to building variances
  - Water and Air control approach:
    - Use panels as the complete enclosure? (air barrier, insulation, water management)
    - Use the panels as an insulated cladding with another air barrier and water management layer behind?

# Castle Square Wall Insulation Strategy

Insulated metal panels (IMP) as complete enclosure:



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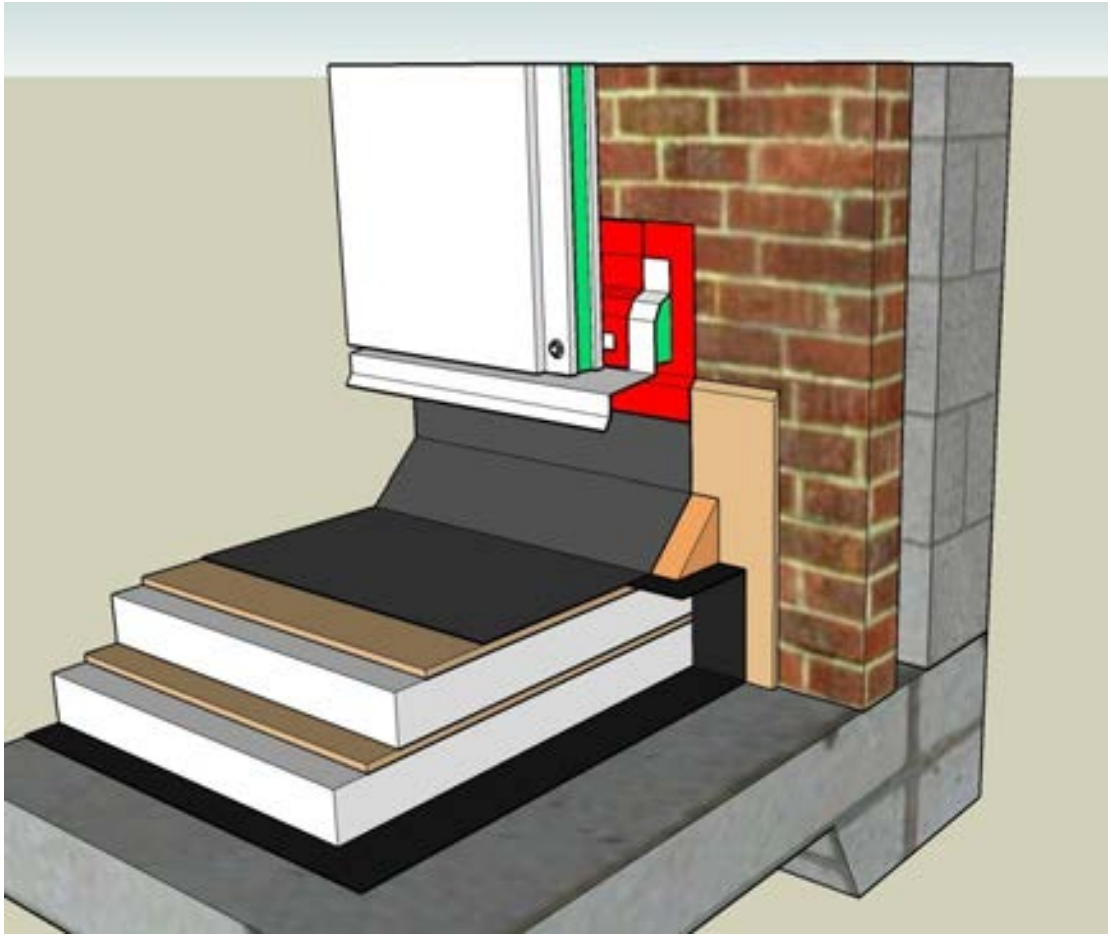
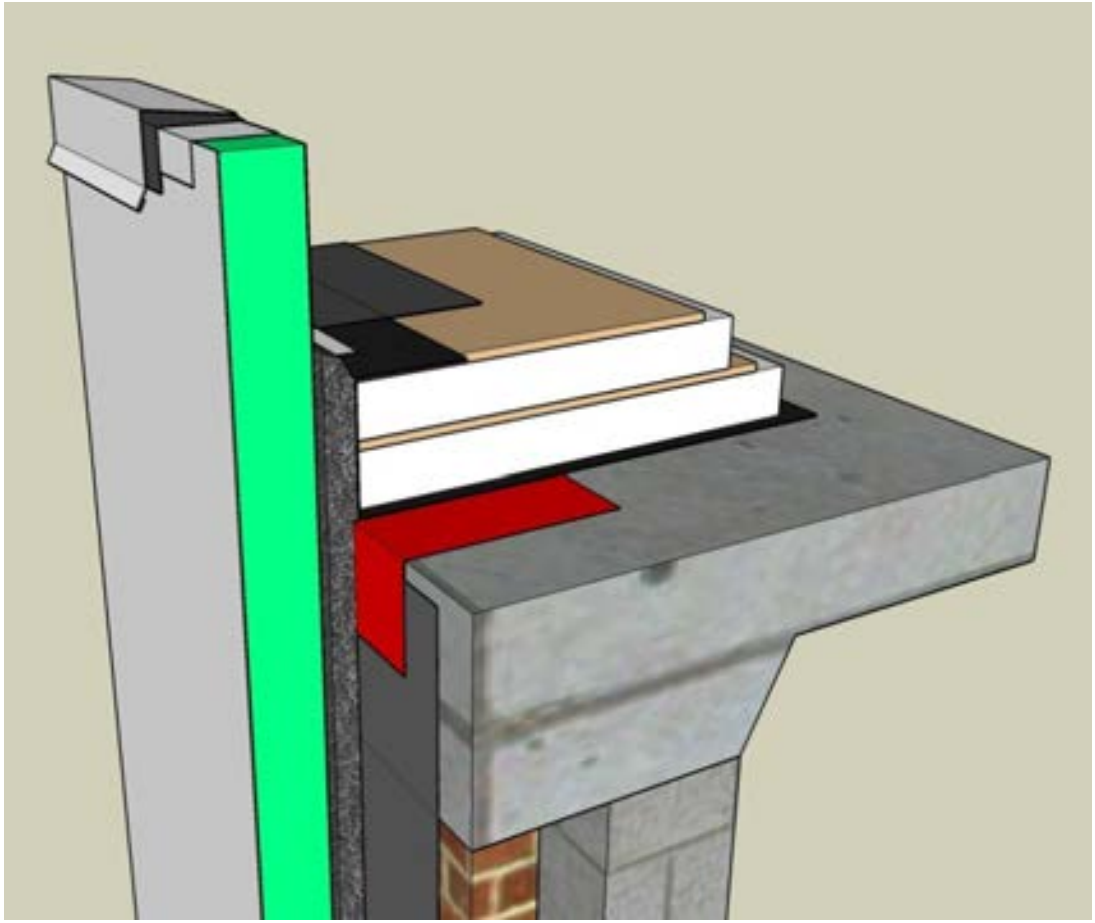


# Castle Square Wall Insulation Strategy

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



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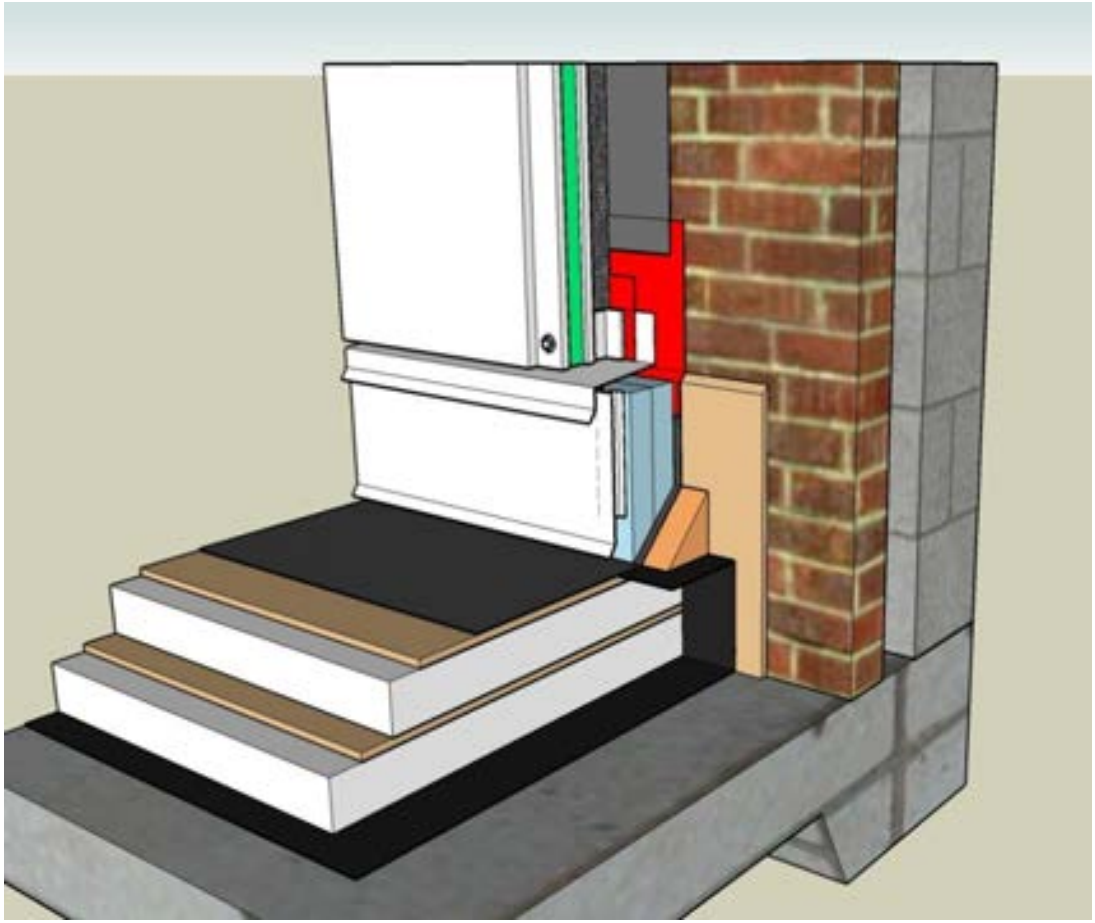


# Castle Square Wall Insulation Strategy

- Wall System Approaches for Super Insulation (R40) Retrofit

2. Field-constructed system
separate components: applied air barrier and drainage plane, cladding attachment, exterior insulation, and cladding;
judged to costly and complicated

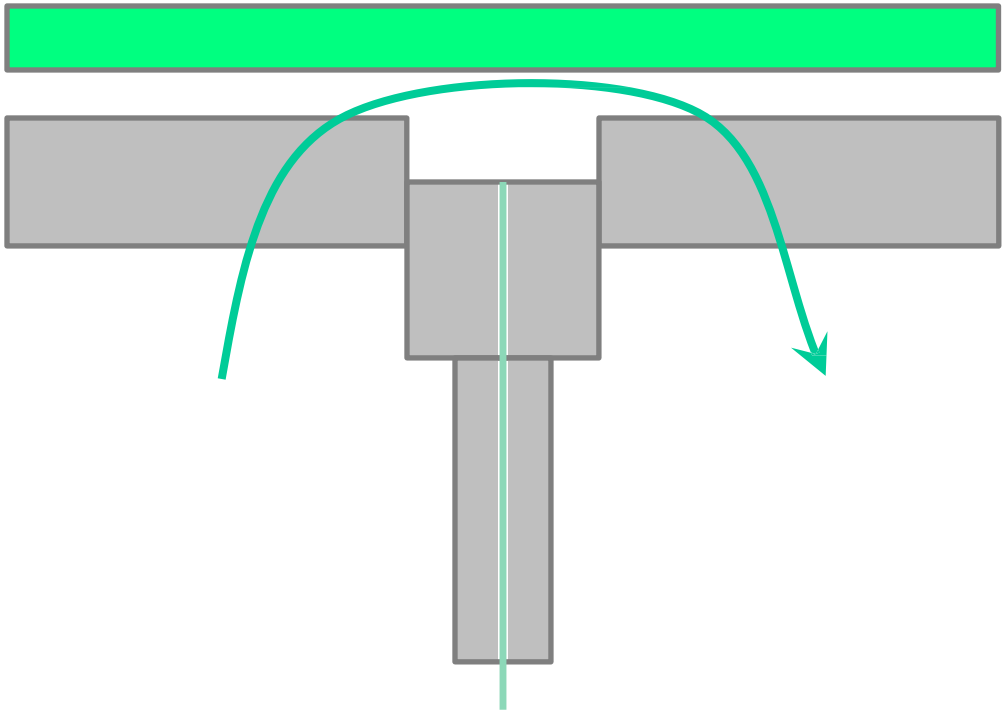
2. EIFS (Exterior Insulation and Finish System)
required thickness not approved by insurance

3. Insulated metal panel system

# Castle Square Wall Insulation Strategy

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

# Building Enclosure



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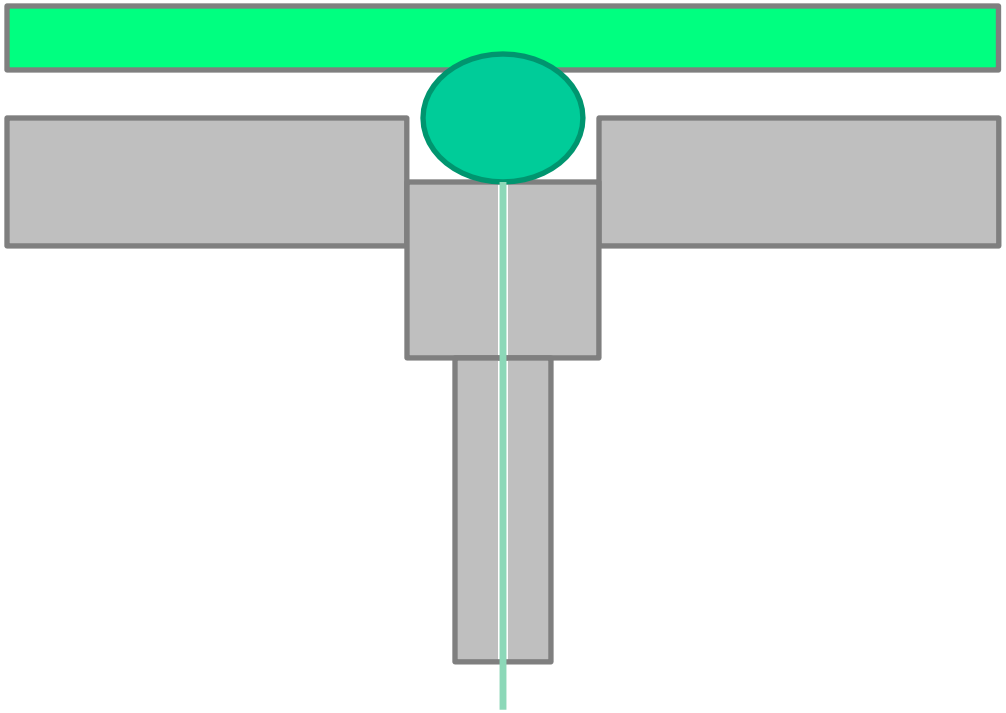

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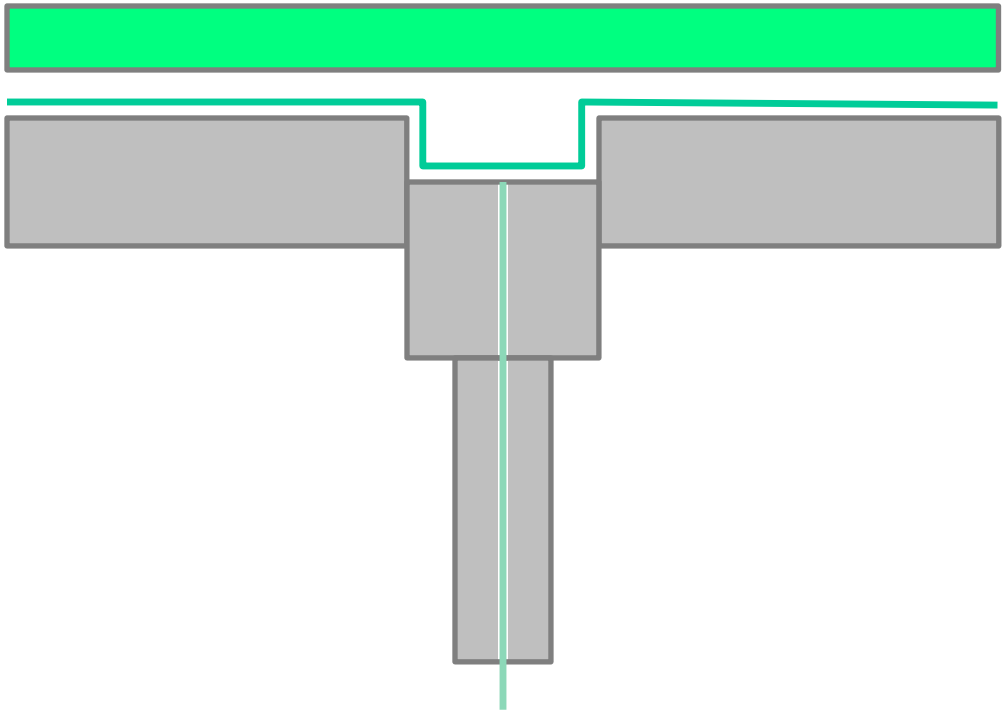
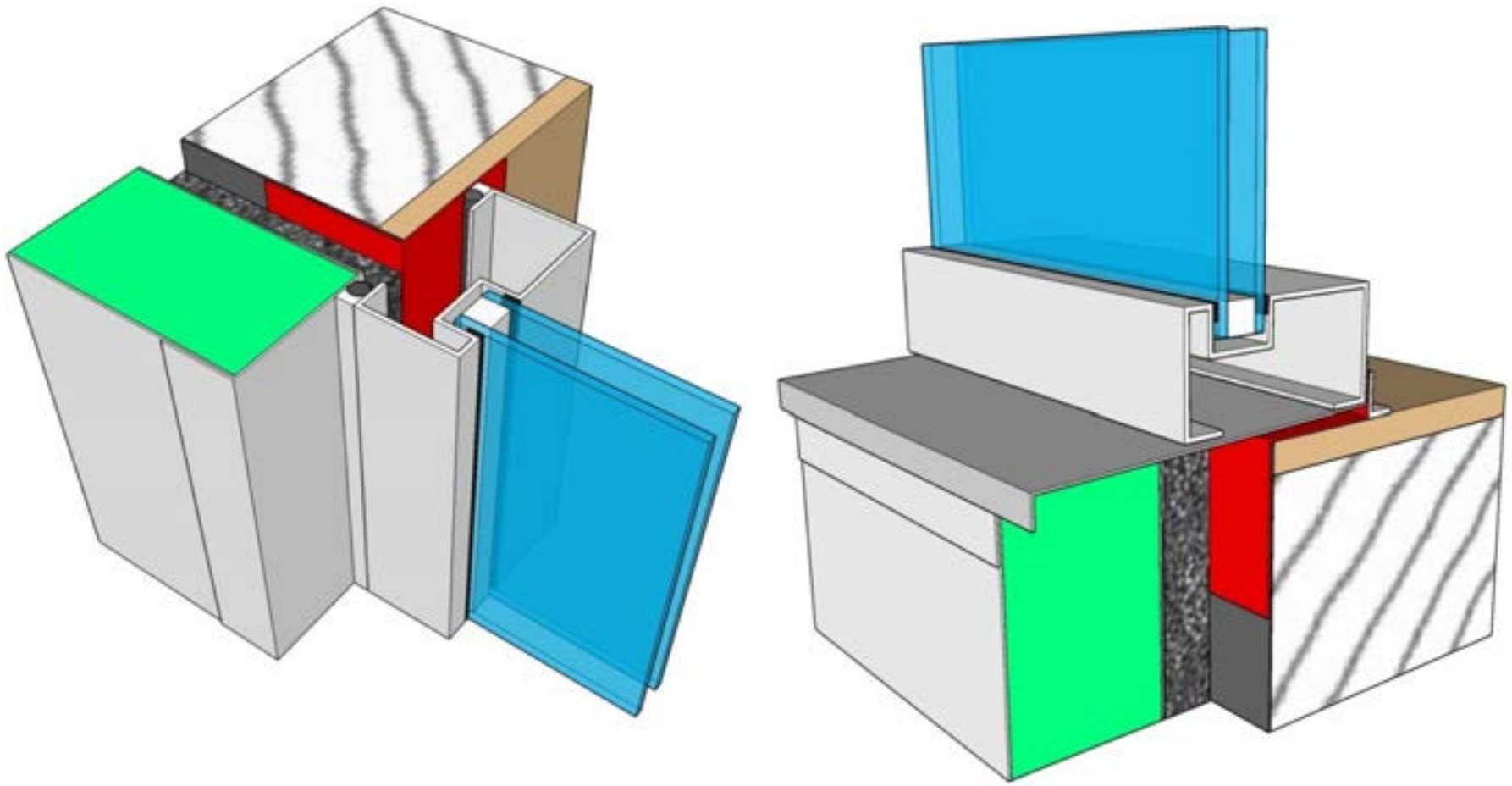


# Building Enclosure

- Insulated metal panels (IMP)
  - Integration of windows and other enclosure elements made at the air barrier/water resistive barrier location

# Building Enclosure

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Rome Pizza


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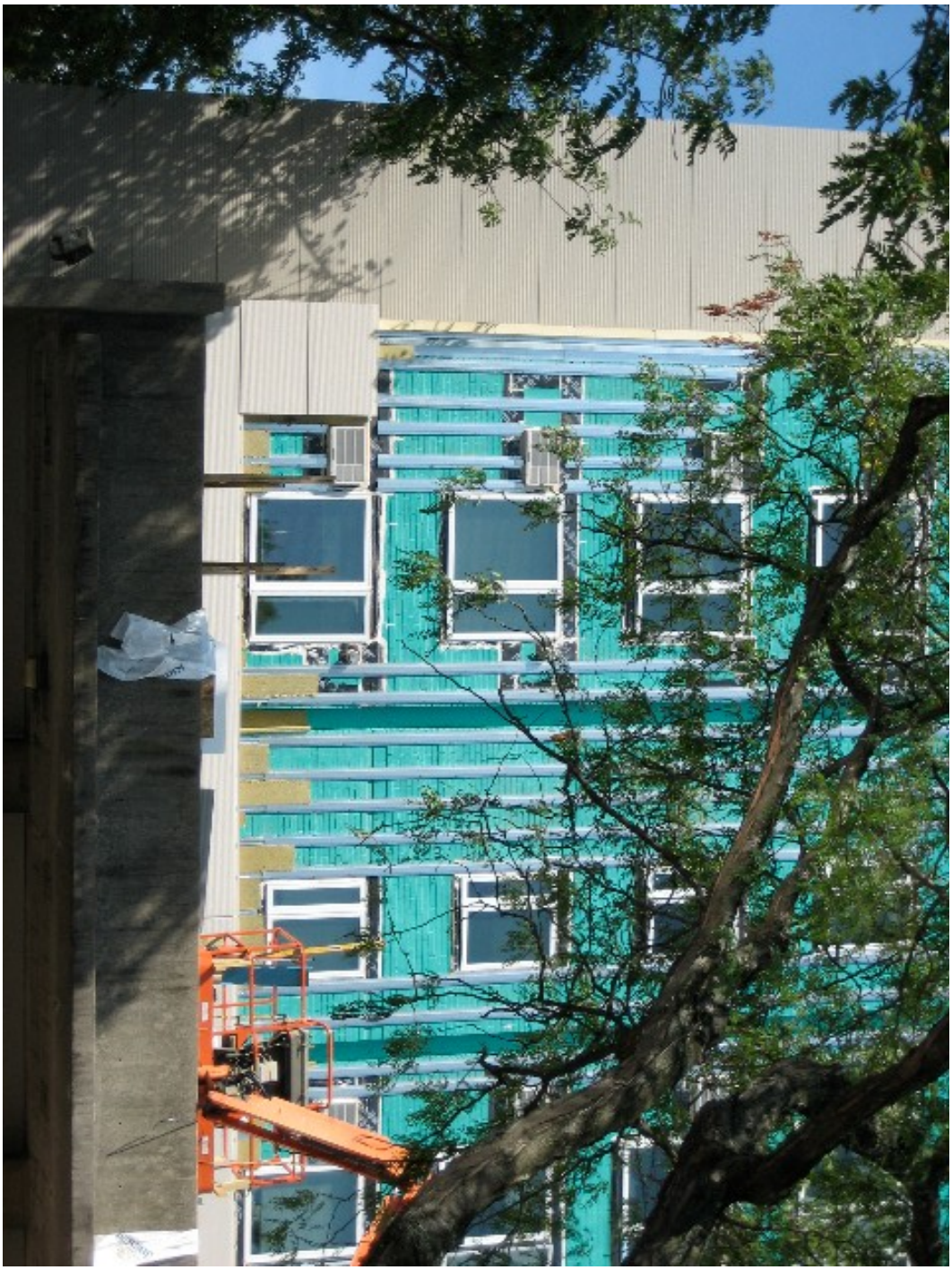
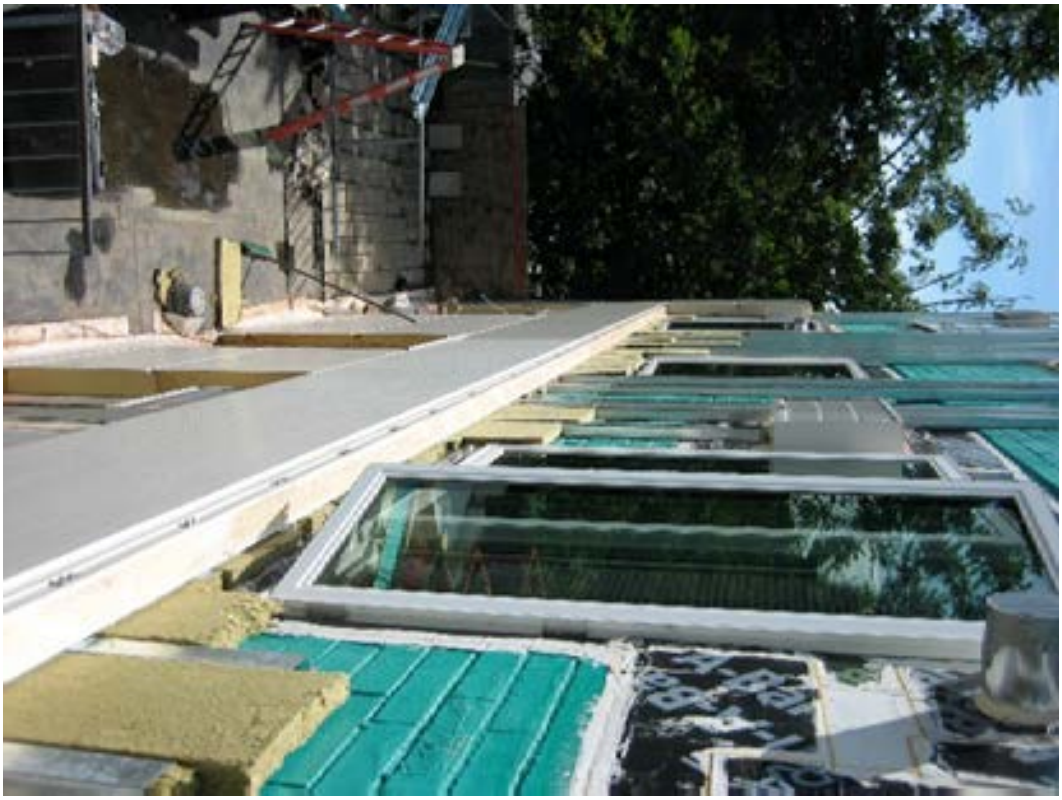


Photo credit: Elton + Hampton Architects



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