

Peter Baker

Commercial Deep Energy Retrofit: Castle Square Case Study

November 16, 2017



Castle Square



Castle Square DER

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 DER

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 DER

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



Castle Square DER

Circumstances of the Project

- 51% Tenant Owned
 - CSTO in charge
 - Interests of tenant group protected
 - Driving factors for the “energy” measures: Comfort, IEQ concerns



Castle Square DER

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



Castle Square DER

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



Castle Square DER


Resident Surveys & Charrettes




Castle Square DER



Resident Surveys & Charrettes



Castle Square DER



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 DER




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 DER



Castle Square Mid-Rise Retrofit

Spalling concrete

Energy costs!

Odors

Air quality

Poor Comfort

Out dated kitchens

aesthetics

bsc Building Science Corporation

Castle Square DER

Castle Square Mid-Rise Retrofit

What do we have to work with?

Understanding the building through:

- Testing/measurement
- Investigation of construction
- Simple analysis

bsc Building Science Corporation

Castle Square DER

Castle Square Mid-Rise: Testing

bsc Building Science Corporation

Castle Square DER

Castle Square Mid-Rise: Testing

bsc Building Science Corporation

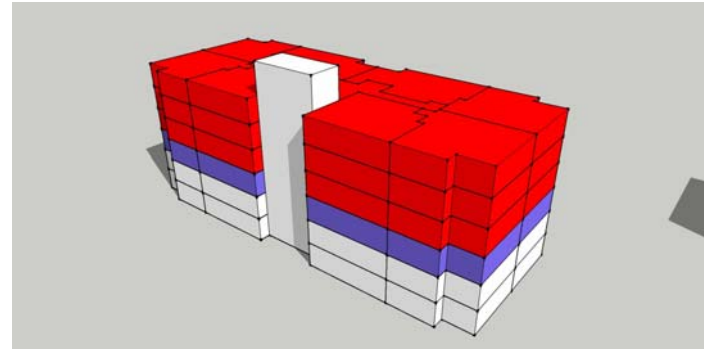
Castle Square DER

Castle Square Mid-Rise: Testing



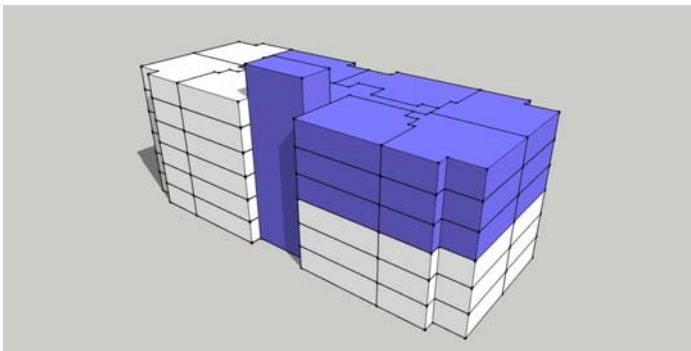
Castle Square DER

Castle Square Mid-Rise: Testing



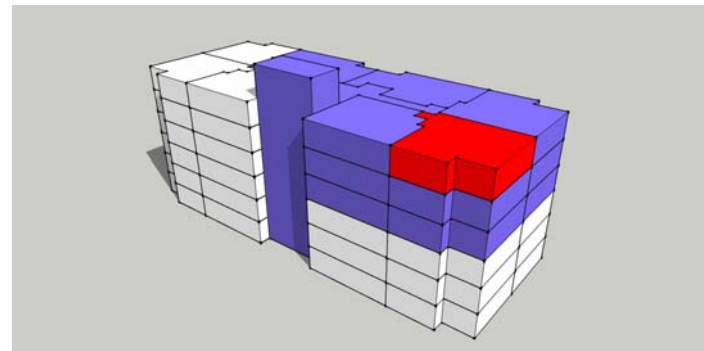
Castle Square DER

Castle Square Mid-Rise: Testing



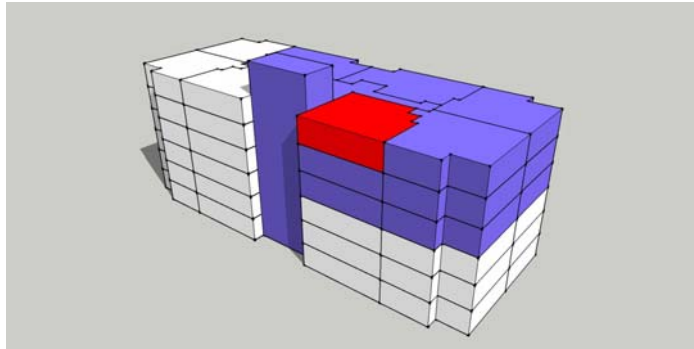
Castle Square DER

Castle Square Mid-Rise: Testing



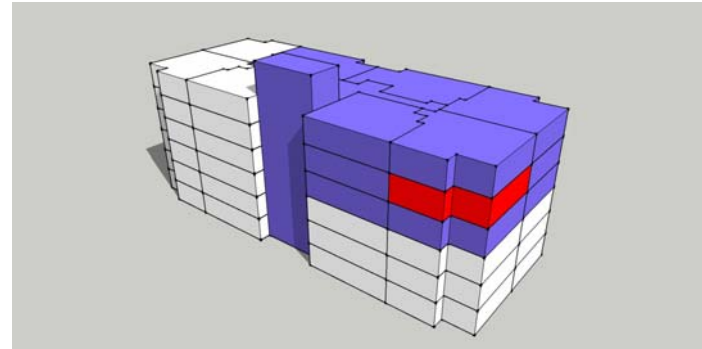
Castle Square DER

Castle Square Mid-Rise: Testing



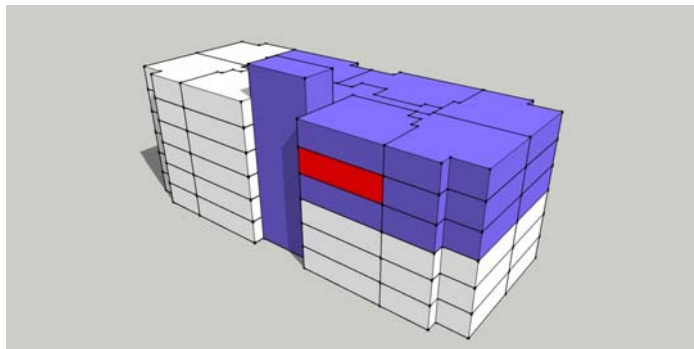
Castle Square DER

Castle Square Mid-Rise: Testing



Castle Square DER

Castle Square Mid-Rise: Testing



Castle Square DER

Castle Square Mid-Rise: Testing

Testing and Measurement:

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



Castle Square DER

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)

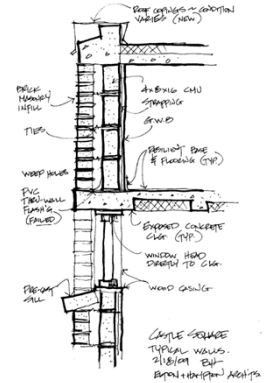
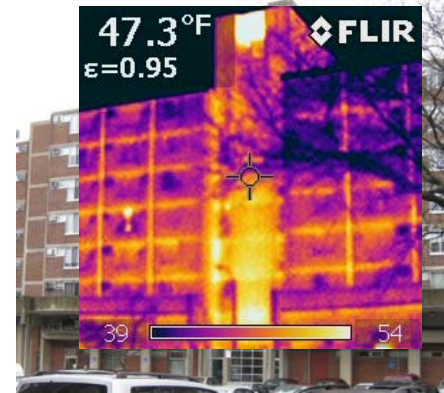


Image courtesy of Elton + Hampton Architects



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



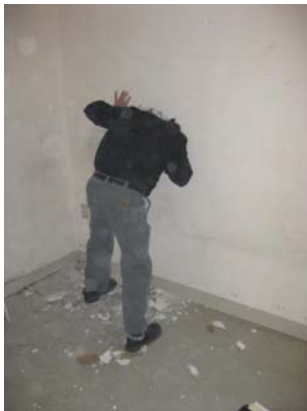
Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Investigation



Castle Square DER

Castle Square Mid-Rise: Analysis

Simple Analysis

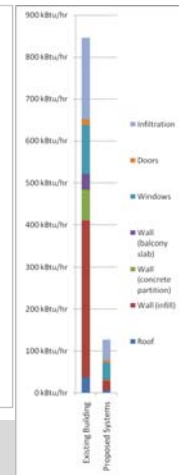
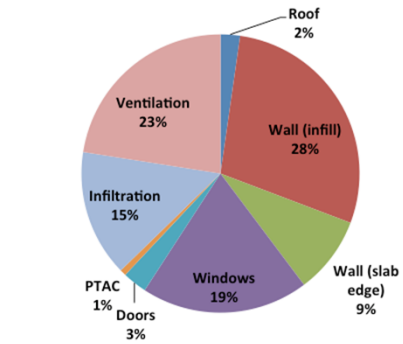
- UA analysis
- Estimates of ventilation, infiltration



Castle Square DER

Castle Square Mid-Rise: Analysis

Midrise Building Heating Load Components Percent of Heating Energy Use



Castle Square DER

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 DER

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 DER

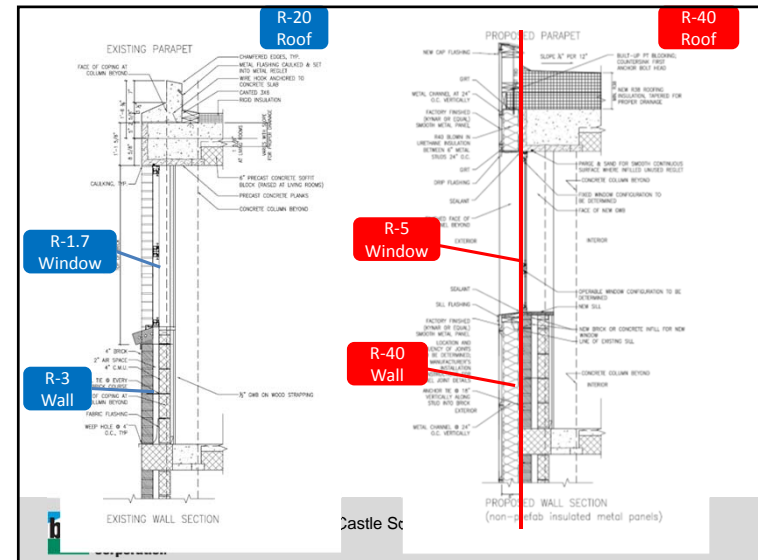
Castle Square Mid-Rise Retrofit

Performance Targets:

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

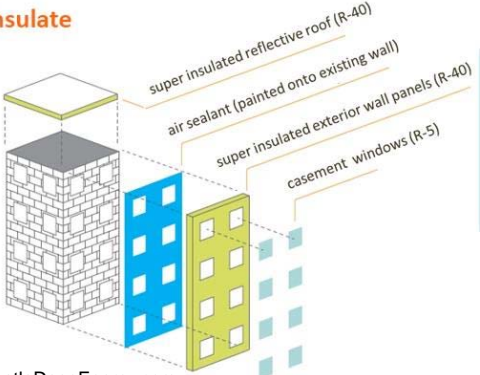


Castle Square DER



Castle Square Mid-Rise Retrofit

1 super insulate




super insulated reflective roof (R-40)
 air sealant (painted onto existing wall)
 super insulated exterior wall panels (R-40)
 casement windows (R-5)

Image credit: www.CastleDeepEnergy.com

bsc Building Science Corporation
 Castle Square DER

Castle Square Mid-Rise Retrofit

2 air seal



air sealing between apartments & outdoors
 air sealant (windbreaker)
 insulation (sweater)

compartmentalization
 hot air
 reduced stack effect
 cold air

air sealing between apartments & each other

Image credit: www.CastleDeepEnergy.com

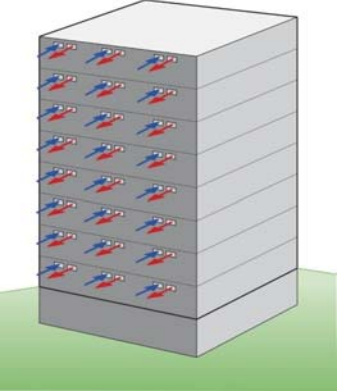
bsc Building Science Corporation
 Castle Square DER

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*

bsc Building Science Corporation
 Castle Square DER

Ventilation



bsc Building Science Corporation
 Castle Square DER

Ventilation

Context:

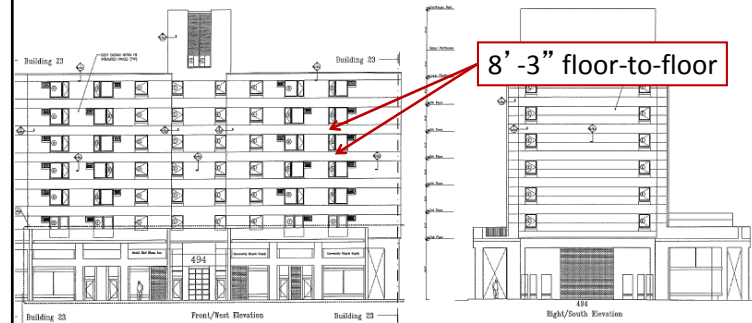
- Odor complaints a major motivation for residents
- Exhaust ventilation a part of existing infrastructure
- Project aspiring to LEED-NC recognition (ventilation distribution requirements)



Castle Square DER

Ventilation

Challenges:



Castle Square DER

Ventilation

Options investigated:

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



Castle Square DER

Ventilation

Selected approach:

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



Castle Square DER

Ventilation

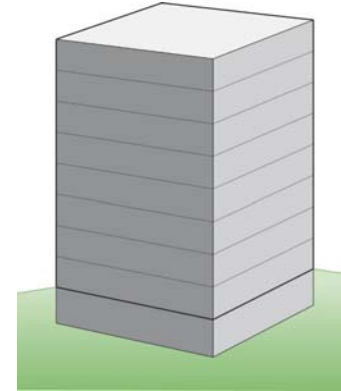
Whither the ventilation supply:

- 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?



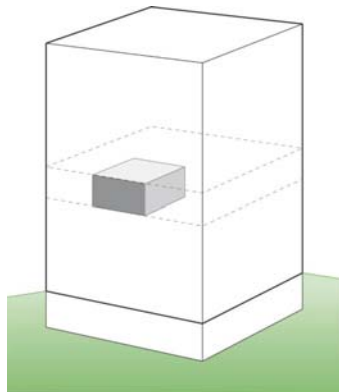
Castle Square DER

Compartmenting



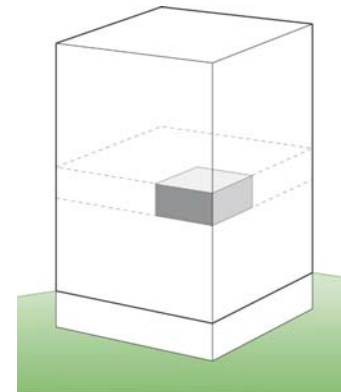
Castle Square DER

Compartmenting



Castle Square DER

Compartmenting



Castle Square DER

Compartmenting

Context:

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



Castle Square DER

Compartmenting

Challenges:

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



Castle Square DER

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.



Castle Square DER

Compartmenting



Castle Square DER



Compartmenting






Castle Square DER

Compartmenting






Castle Square DER

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 DER

Castle Square Wall Insulation Strategy

Challenges:

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


Castle Square DER

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 DER

Castle Square Wall Insulation Strategy

- Exterior air barrier, insulation, and cladding



Castle Square DER

Castle Square Wall Insulation Strategy

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



Castle Square DER

Castle Square Wall Insulation Strategy

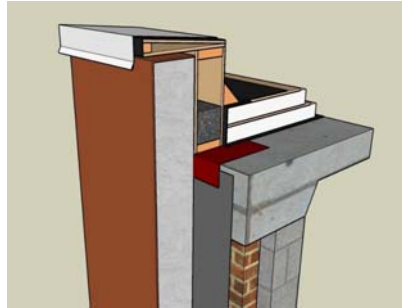
- Exterior air barrier, insulation, and cladding:
 - Fire concerns
 - Lack of UL rated assemblies
 - Insulation thickness needed to achieve desired R-Value could be significant



Castle Square DER

Castle Square Wall Insulation Strategy

- Exterior insulation and finish system (EIFS)



Castle Square DER

Castle Square Wall Insulation Strategy

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



Castle Square DER

Castle Square Wall Insulation Strategy

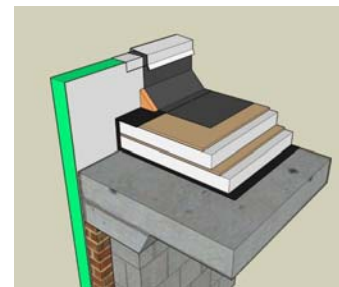
- Exterior insulation and finish system (EIFS)
 - Thick layers of insulation needed to achieve design goals
 - Insurance concerns (Fire, water, durability)



Castle Square DER

Castle Square Wall Insulation Strategy

- Insulated metal panels (IMP)



Castle Square DER

Castle Square Wall Insulation Strategy

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



Castle Square DER

Castle Square Wall Insulation Strategy

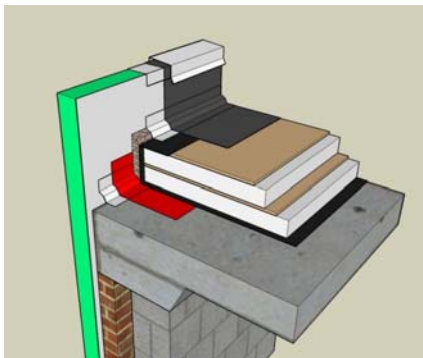
- Insulated metal panels (IMP)
 - Attachment due to building variances
 - Water and Air control approach:
 - Use panels as the complete enclosure? (air barrier, insulation, water management)
 - Use the panels as an insulated cladding with another air barrier and water management layer behind?



Castle Square DER

Castle Square Wall Insulation Strategy

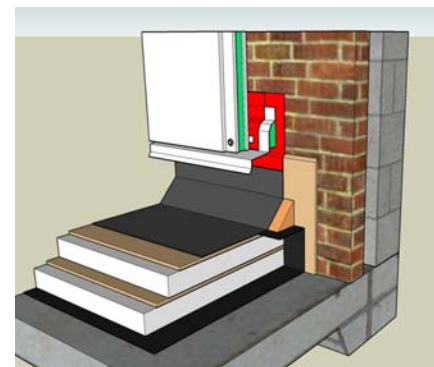
Insulated metal panels (IMP) as complete enclosure:



Castle Square DER

Castle Square Wall Insulation Strategy

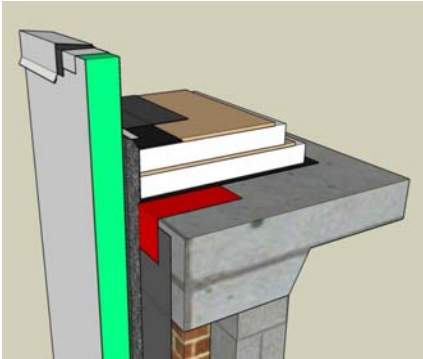
Insulated metal panels (IMP) as complete enclosure:



Castle Square DER

Castle Square Wall Insulation Strategy

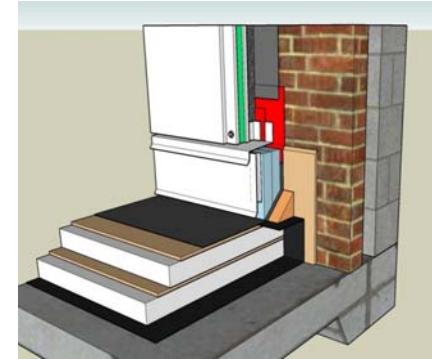
Insulated metal panels (IMP) with separate water/air control:



Castle Square DER

Castle Square Wall Insulation Strategy

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



Castle Square DER

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



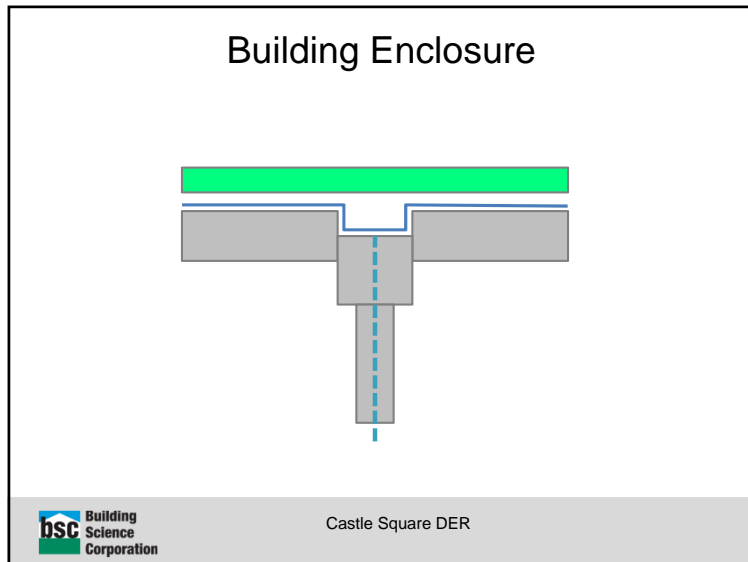
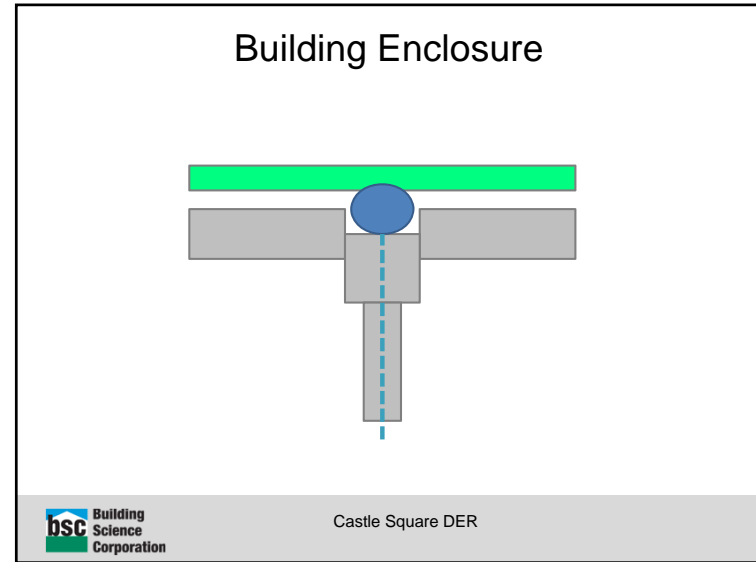
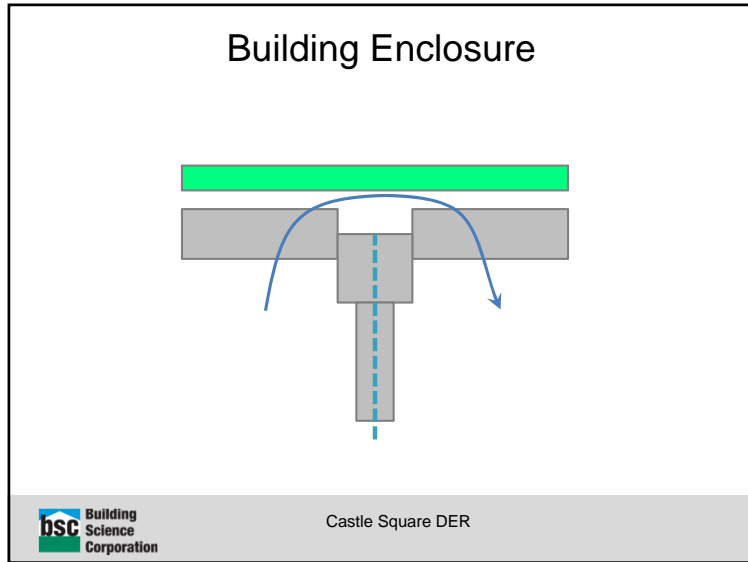
Castle Square DER


Castle Square Wall Insulation Strategy

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

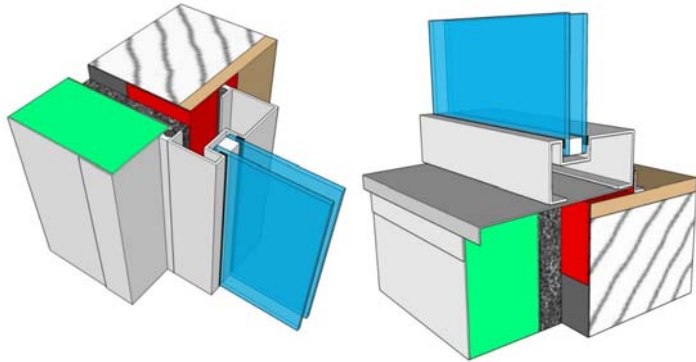


Castle Square DER



- ### Building Enclosure
- Insulated metal panels (IMP)
 - Integration of windows and other enclosure elements made at the air barrier/water resistive barrier location
-  Castle Square DER

Building Enclosure



Castle Square DER



Castle Square DER



Castle Square DER



Castle Square DER



Castle Square DER



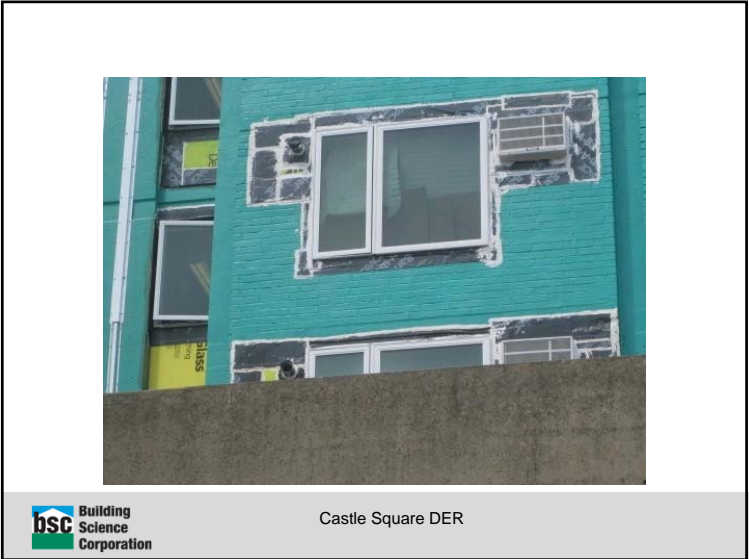
Castle Square DER



Castle Square DER



Castle Square DER





Castle Square DER



Castle Square DER



Castle Square DER

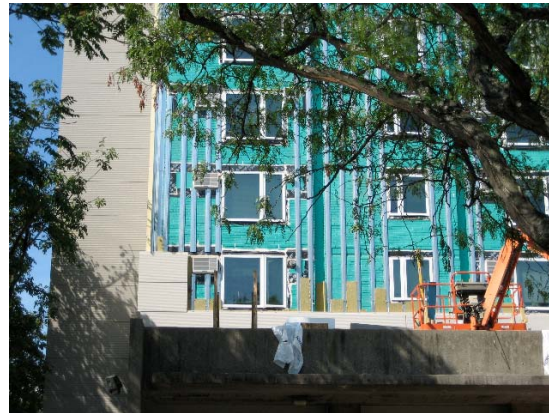
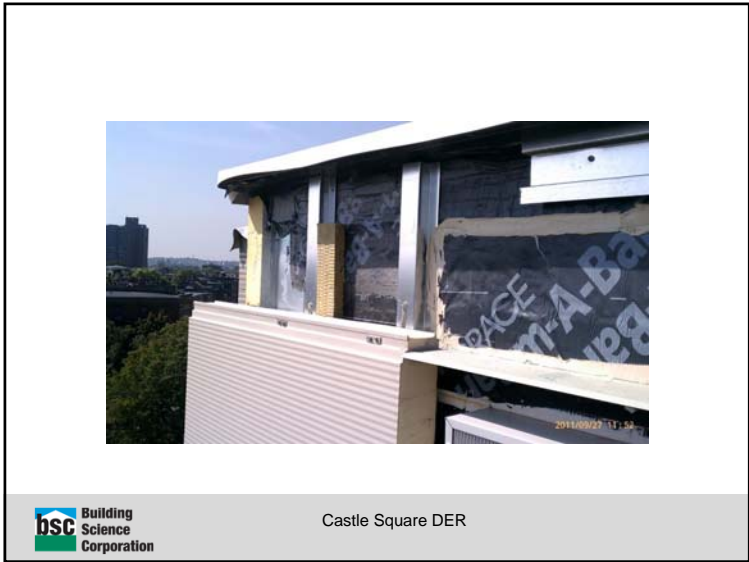
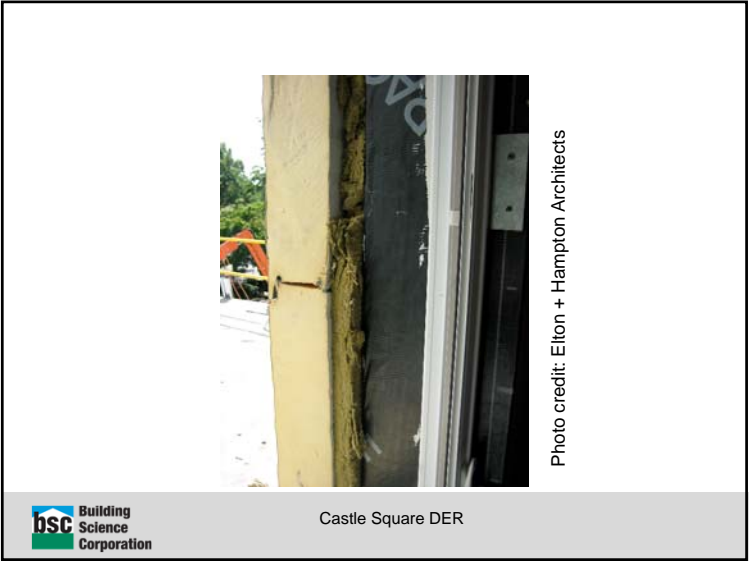
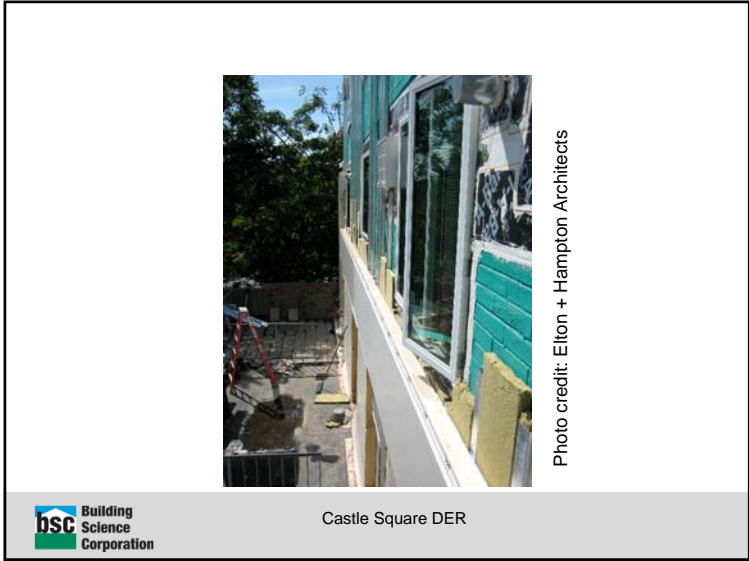


Photo credit: Elton + Hampton Architects



Castle Square DER







Castle Square DER