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
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Project Objective:

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

– IAQ
– Comfort
– Energy costs
– Water leakage
– Façade maintenance and repair issues
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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
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- Spalling concrete
- Energy costs!
- Odors
- Air quality
- Poor Comfort
- Outdated kitchens
- Aesthetics
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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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Testing and Measurement:

- Leakage to outside (guarded testing)
  \( \approx 2.5 \text{ ACH50} \)
  \( \approx 0.7 \text{ cfm50} / \text{sf exterior enclosure} \)

- Total leakage for apartment units (unguarded)
  \( \approx 10-17 \text{ ACH50} \)
  \( \approx 0.5-0.8 \text{ cfm50} / \text{sf total enclosure} \)
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: Investigation
Castle Square Mid-Rise: Analysis

Simple Analysis

• UA analysis
• Estimates of ventilation, infiltration
Castle Square Mid-Rise: Analysis

Midrise Building Heating Load Components Percent of Heating Energy Use

- Roof: 2%
- Ventilation: 23%
- Wall (infill): 28%
- Infiltration: 15%
- Windows: 19%
- Wall (slab edge): 9%
- PTAC: 1%
- Doors: 3%

Comparison of Existing Building and Proposed Systems:

- Infiltration
- Doors
- Windows
- Wall (balcony slab)
- Wall (concrete partition)
- Wall (infill)

Energy Use Comparison:

- Existing Building
- Proposed Systems

Energy Use Ranges:

- 0 kBtu/hr
- 100 kBtu/hr
- 200 kBtu/hr
- 300 kBtu/hr
- 400 kBtu/hr
- 500 kBtu/hr
- 600 kBtu/hr
- 700 kBtu/hr
- 800 kBtu/hr
- 900 kBtu/hr

Graphs showing energy usage distribution and comparison.
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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
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Testing, evaluation, analysis:

• High performance will require
  1. adding insulation to walls,
  2. controlling infiltration and ventilation,
  3. improving windows
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Performance Targets:

– R-40 Walls
– R-5 Windows
– R-40 Roof
– Improve compartmenting as much as possible
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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
Castle Square Mid-Rise Retrofit

2 air seal

- Air sealant (windbreaker)
- Insulation (sweater)

Compartmentalization
- Reduced stack effect
- Hot air
- Cold air

Air sealing between apartments & outdoors
Air sealing between apartments & each other

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:

- Building does not afford interstitial space for distribution
- Hazardous materials (asbestos)
  - Coordination of façade penetrations
    - Coring
    - Clearances
    - Time and disruption to residents

8’ -3” floor-to-floor
Ventilation

Options investigated:

Ø HRV per apartment
  • Ceiling too low for dropped soffit in circulation areas
  • Asbestos made penetration of partitions impractical

Ø Central supply and Hx
  • Would need to refit or reconfigure riser
  • Distribution within apartment
Ventilation

Selected approach:
Ø 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
Compartmenting
Compartmenting
Compartmenting

Context:

• Odor complaints a major motivation for residents

• Project aspiring to LEED-NC recognition (apartment air tightness requirement)
Compartmening

Challenges:

Ø Occupied renovation severely limits opportunities
  • 2 – 3 days total for interior work
  • Belongings not moved from living and bedrooms

Ø Interstitial interconnected
  • Openings into shafts
  • Hollow walls

Ø Limited disruption beyond kitchen and bath
Compartmenting

How to identify effective and important measures?

Ø 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
- \textit{R-40 performance goal}
Castle Square Wall Insulation Strategy

Challenges:

– Occupied Retrofit
– Significant Thermal Bridging of Concrete Structure
– Existing Building Construction Tolerances
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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
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• Exterior air barrier, insulation, and cladding:
  – Large range of options
    • Insulation types
    • Air barrier materials
    • Cladding options
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• Exterior air barrier, insulation, and cladding:
  – Fire concerns
    • Lack of UL rated assemblies
  – Insulation thickness needed to achieve desired R-Value could be significant
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- Exterior insulation and finish system (EIFS)
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- Exterior insulation and finish system (EIFS)
  - Lower cost option
  - No need for design of cladding attachment system
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- Exterior insulation and finish system (EIFS)
  - Thick layers of insulation needed to achieve design goals
  - Insurance concerns (Fire, water, durability)
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- Insulated metal panels (IMP)
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- Insulated metal panels (IMP)
  - High R-Value – thinner overall thickness
  - Fire rated
  - Durable
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- 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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Insulated metal panels (IMP) as complete enclosure:
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Insulated metal panels (IMP) with separate water/air control:
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Insulated metal panels (IMP) with separate water/air control:
Castle Square Wall Insulation Strategy

- Wall System Approaches for Super Insulation (R40) Retrofit
  1. Field-constructed system: 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
Building Enclosure
Building Enclosure
Building Enclosure

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