Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing

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Building Performance Architecture
Project Sites

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Neighborhood Context

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Neighborhood Context

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Project Team:

Client: ACTION-Housing, Inc.; Pittsburgh, Pennsylvania

Tax Credit Financing: Pennsylvania Housing Finance Authority; Harrisburg, Pennsylvania

Architect: FortyEighty Architecture; Pittsburgh, Pennsylvania.

Certified Passive House Consultant: Kaplan Thompson Architects; Portland, Maine

Mechanical, Electrical & Plumbing Engineer: Iams Consulting; Pittsburgh, Pennsylvania

Structural Engineer: Keystone Structural Solutions; Pittsburgh, Pennsylvania

Civil Engineer & Landscape Architect: Langan Engineering & Environmental Services

Sustainable Design Consultant: Center for Building Performance and Diagnostics at Carnegie Mellon University; Pittsburgh, Pennsylvania.

PHIUS+ and HERS Rater: Building Performance Architecture; Pittsburgh, Pennsylvania

Constructor: Mosites Construction; Pittsburgh, Pennsylvania
PHFA *Innovation in Design* Award:

The project’s tax credit application was selected for an *Innovation in Design* award from the Pennsylvania Housing Finance Agency in special recognition of its:

- Excellence in Design
- Implementation of current and future energy efficient technologies
- Leveraging community and capital resources
Design Criteria:

**Applicable Building Codes:**
- Pennsylvania - 2009 ICC Building Codes
- 2012 IECC (R-values - Owner requested, DOE Challenge Home requirement)

**PHFA Energy Conservation/Green Building Criteria:**
- U-values of building enclosure must exceed 2009 IECC by 10%
- Meet Energy Star® Certified Homes (version 3.0)

**Additional North Building Criteria:**
- Passive House Certification (PHIUS+) and the companions programs:
  - EPA Indoor AirPLUS
  - DOE Challenge Home program
Typical One-Bedroom Apartment Unit

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
North Building - Ground Floor
South Elevation

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
Fiber Cement Rainscreen

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
## TECHNICAL DATA SHEET

### Air-Bloc® 33MR
Fluid Applied, Vapor Permeable, Air & Weather Barrier Membrane

<table>
<thead>
<tr>
<th>Typical Physical Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>-Color</strong></td>
<td>Black</td>
</tr>
<tr>
<td><strong>-Solids by Weight</strong></td>
<td>65%</td>
</tr>
<tr>
<td><strong>-Weight/Unit Volume</strong></td>
<td>12 lbs/gal (1.4 kg/l)</td>
</tr>
<tr>
<td><strong>-Drying Time @ 50% R.H., +20°C (68°F) on Dry Substrate</strong></td>
<td>2 Hours to touch dry, 24 Hours to firm dry</td>
</tr>
<tr>
<td><strong>-Service Temperature</strong></td>
<td>-40°F to +185°F (-40°C to +85°C)</td>
</tr>
<tr>
<td><strong>-Application Temperature</strong></td>
<td>40°F to 122°F (+4°C to +50°C)</td>
</tr>
<tr>
<td><strong>-Tensile Strength, ASTM D412</strong></td>
<td>125 psi (860 kPa)</td>
</tr>
<tr>
<td><strong>-Elongation, typical, ASTM D412</strong></td>
<td>200%</td>
</tr>
<tr>
<td><strong>-Aging - Long Term Flexibility, CGSB T1-SP-24M</strong></td>
<td>No fracturing</td>
</tr>
<tr>
<td><strong>-Nail Seability, ASTM D 1970</strong></td>
<td>Pass</td>
</tr>
<tr>
<td><strong>-Resistance To Mold, Mildew &amp; Fungal Growth, ASTM E385-93</strong></td>
<td>No Growth</td>
</tr>
<tr>
<td><strong>-Weather Resistance, Q-UV Exposure - 73 daily cycles of UV and water spray with no observable deterioration</strong></td>
<td>Pass</td>
</tr>
<tr>
<td><strong>-VOC content</strong></td>
<td>100 grams per liter, max.</td>
</tr>
<tr>
<td><strong>-Water Vapor Permeance, ASTM E96 @ 1/8” (3 mm) wet film</strong></td>
<td>11.6 perms (665 ng/Pa.m².s)</td>
</tr>
<tr>
<td><strong>-Air Permeability Tests, ASTM E283, Applied to CMU</strong></td>
<td></td>
</tr>
<tr>
<td>75 Pa @ 70°F</td>
<td>0.0016 cfm/ft²</td>
</tr>
<tr>
<td>250 Pa @ 70°F</td>
<td>0.0034 cfm/ft²</td>
</tr>
<tr>
<td>500 Pa @ 70°F</td>
<td>0.0050 cfm/ft²</td>
</tr>
<tr>
<td><strong>-ASTM E2367, Assembly Air Leakage Testing</strong></td>
<td>Pass</td>
</tr>
<tr>
<td><strong>-ASTM E2178 @ 75Pa</strong></td>
<td>0.0016 cfm/ft² (0.008 L/s.m²)</td>
</tr>
<tr>
<td><strong>-Resistance to Gust Wind Load</strong></td>
<td>Meets Mass/Canadian code requirements for air leakage @ 3000Pa gust load suction pressure</td>
</tr>
<tr>
<td><strong>-Chemical Resistance</strong></td>
<td>Resists mild acids and alkalies, oil, grease, petroleum solvents and salt solutions</td>
</tr>
<tr>
<td><strong>-Fire Testing, ASTM E94</strong></td>
<td>Complies with NFPA 285 in various wall assemblies</td>
</tr>
<tr>
<td><strong>-Flame Spread</strong></td>
<td>25</td>
</tr>
<tr>
<td><strong>-Smoke Developed, ASTM E84</strong></td>
<td>85</td>
</tr>
</tbody>
</table>
Thermally Broken Rainscreen Cladding Support

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Fiber Cement & Masonry Rainscreen – Typical Exterior Wall

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
PHPP Model – TFA Calculations

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
PHPP Model – Wall Assembly Types/Area Calculations

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Alpen 525 Series

- Fiberglass frames with 1-3/8” triple-pane glazing. High-SHGC low-E coated clear glass with interior suspended film, and argon gas.
- PHIUS Certified (Feb. 2015)

Windows & Glazing
Product

Performance Requirements

Air infiltration shall not exceed 30 CFM/ft² when tested in accordance with ASTM E-283 at a test pressure of 1.00 PSF. Actual test result was 30 CFM/ft².

There shall be no uncontrolled water entry when tested in accordance with ASTM E-331 “Water Penetration of Exterior Windows, Curtainwalls and Doors by Uniform Static Air Pressure Difference” at a test pressure of 0 PSF.

Thermal transmittance due to conduction (U) shall not be greater than .051 - thermal strut, BTU/Hr/Fe/F degree when tested in accordance with AAMA 1503-98. Condensation Resistance Factor (CRF) shall not be less than 50 - thermal strut, when tested in accordance with AAMA 1503-98.

Exterior Doors

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Thermal & Air Barrier Continuity Drawings

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Thermal & Air Barrier Continuity Details

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Fiber Cement Rainscreen – Parapet Wall

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Parapet Wall
Parapet Wall

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
Window Details

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Windows

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
Wall Construction Transition at Grade

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Wall Construction Transition at Grade
Wall Construction Transition at Grade

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
Thermal Isolation of Exterior Structure

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PHPP Model - Precertification:

Continued Development of PHPP Model:

- Building Enclosure Design Finalized
- CPHC continued to generate & update data related to Primary Energy & Internal Gains (Shading Analysis, Lighting & Plug Load calculations, Internal Heat Gains from equipment)

PHIUS+ Precertification:

- Design finalized in PHPP model, however mechanical submittal data still needed before Precertification could be given
- Precertification received 6-months into construction
- Most other product data submittals received by this time and incorporated into the PHPP model
- Roof Insulation construction change also incorporated
Roof Insulation:

- NFPA-13 compliance required filling the concealed roof truss space with non-combustible insulation.
- Original Design – 8” polyisocyanurate insulation (R-50) outboard of roof sheathing + 10-1/2” fiberglass batt insulation between trusses (R-30)
- Revised Design – 4” polyisocyanurate insulation (R-25) outboard of roof sheathing + truss space filled with blown-in fiberglass insulation (R48 average)
- Air- and vapor-control insulation (polyisocyanurate) close to < 35% of total assembly, PHIUS required a WUFI modeling to confirm that the mold/moisture risk to the assembly was acceptable low
Additional Critical Details

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Specified Construction Requirements:

**014000 Quality Requirements**
- PHIUS+ and Energy Star requirements & checklists
- Outline of anticipated tests & inspections
- Exterior Wall Mockup

**072700 Building Enclosure Air Sealing:**
- Air Sealing Representative
- Air Sealing Plan
- Preconstruction Meeting
- Air tightness pre-testing of assemblies
- Delineates specific areas required to be air sealing
- Penetrations between areas being tested for air leakage and adjoining interior spaces – refers to 078413 Penetration Firestopping & 079200 Joint Sealant.
- Additional requirements for Residential Unit Compartmentalization?
- Additional requirements for sealing of perimeters and penetrations in interior vapor barriers?

**079200 Joint Sealants:**
- Air sealing products
Exterior Wall Mockup

Designing and Constructing Multi-Unit Housing as a Comparison for Envelope Performance and Energy Savings
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**HERS Design Report**

**ENERGY STAR v3.0 Home Verification Summary**

- **Property:** Action Housing
- **Organization:** Building Performance Arch.
- **Projected Rating:** HERS Index = 69

**HERS Index = 69**

**2009 IECC Building UA Compliance**

- **Energy Star Rating:** 69
- **Insulation Levels**
  - Walls: 1.22
  - Windows: 6.50
  - Floors Over Unconditioned Basement: 10.5

**This home MEETS the overall thermal performance requirements and verifications of the International Energy Conservation Code based on a climate zone of 5A. (Section 402, International Energy Conservation Code, 2009 edition.) In fact, this home surpasses the requirements by 36.7%.
Preconstruction Meeting:

**Rater:**
- Summary of PHIUS+ and all partner certification requirements, testing & inspections
- Schedule of Inspections & Testing relative to construction sequence

**Architect:**
- PHIUS+ Thermal & Air Barrier Continuity Drawings
- Areas requiring special air sealing, verification required in air barrier shop drawings

**Constructor:**
- Air Sealing Representative & Air Sealing Plan
- Schedule of Inspections incorporated in the critical path project schedule

**Subcontractors:**
- Only those involved with the exterior enclosure attended; Mechanical, Plumbing & Electrical Contractors should be included
1. **Optional** Lead a preconstruction meeting, for a maximum of four (4) hours, to familiarize the Contractor’s staff and subcontractors with the inspection and testing processes, as well as ways to meet the requirements of PHIUS, ENERGY STAR Homes, EPA Indoor Air Plus, and DOE Challenge Home, for this project.

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**Uptown Lofts**

**ENERGY STAR Homes & PHIUS+ Testing & Inspection Contractor Orientation Meeting**

*June 10, 2014*

**Purpose of Meeting:** Familiarize the Contractor and subcontractors with the inspection and testing processes, as well as ways to meet the requirements...:

(North Building): of PHIUS, ENERGY STAR Homes, EPA Indoor Air Plus, and DOE Challenge Home, for this project.
Insulation Verification
Insulation Verification

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Insulation Verification
Insulation Verification

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Preliminary Blower Door Test
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Preliminary Blower Door Test
Air Sealing at Interior Framing
Blower Door Testing

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Blower Door Testing

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Building Enclosure Construction Sequencing

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Building Enclosure Construction Sequencing

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Project Closeout:

The Home Stretch - Can It All Happen At Once?

1. Full building blower door test (retakes)
2. Occupancy Permit inspections
3. Energy code compliance verification
4. Punch List inspections and repairs
5. HVAC Contractor testing & balancing
6. Other Rater inspections, tests & checklists completion (including blower door test in units)
7. Contractor checklists (responses to Raters earlier Inspection comments, including photographic records)
8. HVAC contractor’s (and HVAC engineer’s) checklist completion
9. Contractor’s Declaration (verification & documentation of as-built details)
Residential Unit Blower Door Testing
Hunting for Air Leakage

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Hunting for Air Leakage

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Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Hunting for Air Leakage
Updating the PHPP Model:

• From the Rater’s test results, all checklists, and the Contractor’s Declaration, PHIUS updated the PHPP model and confirmed Certification.
• For the Uptown Lofts this was limited to the Air Tightness and ERV unit power measurements.
• The Contractor’s Declaration, requires the Contractor to certify that the as built building matches the PHPP model and all details submitted to PHIUS. The Rater was not required to confirm the accuracy of all data in the PHPP model, as all the Rater inspections and tests are intended to provide this same confirmation.

Updating the REM/Rate Models:

• The Rater updated their REM/Rate model(s) with their test data.
• Greater air and duct leakage raised the unit HERS index to 70. After extensive optimization of the model data, the final unit HERS index is 60.
**ENERGY STAR v3.0 Home Verification Summary**

**Building Information**
- **Property:** Action Housing
- **Organization:** Building Performance Arch., 412-247-HPVS
- **HERS Confirmed:** Eric Gambel
- **Envelopes:** Builder: Mostos Construction Company
- **Confirmed:** No Registry ID

**Rating**
- HERS Index: 60

**Insulation Levels 2009 IECC Building UA Compliance**

**Mandatory Requirements**
- **Shell UA Check:** PASSED
- **Duct Leakage:** No, 0.00 cfm

**Insulation Levels**
- **R-Values:**
  - **Shell UA Check:** 23.0, 9.1
  - **Windows and Doors:** 22.8, 17.2

**Final HERS Design Report**

Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing

**HERS Index = 60**

**This home MEETS the overall thermal performance requirements and verifications of the International Energy Conservation Code based on a climate zone of 5A. (Section 402, International Energy Conservation Code, 2009 edition.) In fact, this home surpasses the requirements by 49.3%.**
As-Built PHPP Model

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Designing and Constructing a High-Performance Building Envelope for Multi-Unit Affordable Housing
Thank you for attending!

www.fortyeighty.com

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