Multifamily Construction Verification – Planning for Success

Mike O’Donnell

2018 PHIUS North American Passive House Conference
Overview of Presentation

• PH Basics
• Construction Phase QA/QC
• Case Study - Beach Green North
• Planning Final Blower Door Testing
• Recommendations for Success
PH BASICS
Multifamily

ELEMENTS OF A LARGE MULTIFAMILY PASSIVE HOUSE BUILDING

CONTINUOUS INSULATION & THERMAL BRIDGE-FREE CONSTRUCTION

HIGH PERFORMANCE WINDOWS & DOORS

AIRTIGHT ENVELOPE

ENERGY RECOVERY VENTILATION

FRESH AIR

EXHAUST AIR

DOMESTIC HOT WATER

EFFICIENT LIGHTS & APPLIANCES

MULTIFAMILY CONSIDERATIONS

Energy Recovery Ventilation
Determining the right system for any project can be challenging. There are pros and cons to both central and decentralized systems. A certified Passive House consultant can help the project team decide which system is best for your building.

Domestic Hot Water
In large scale multifamily buildings in the US the majority of DHW systems are central systems with recirculation loops and high efficiency, natural gas water heaters. Minimizing pipe lengths and optimizing pump sizes and insulation are essential to meet the rigid Passive House primary energy and cooling thresholds.

Efficient Lights & Appliances
Multifamily projects face special challenges here because they must run corridor and egress lighting 24/7. They are also faced with a greater number of appliances per square foot compared with single family homes. Both of these factors result in increased cooling and primary energy demands. The use of controls and daylighting should be incorporated wherever possible to reduce energy use.
# PHI vs PHIUS: Differences

<table>
<thead>
<tr>
<th>Requirement</th>
<th>PHI</th>
<th>PHIUS</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort criteria</td>
<td>Mandatory</td>
<td>Recommended</td>
<td>Leads to triple pane windows in NYC for PHI</td>
</tr>
<tr>
<td>Whole building energy demand</td>
<td>/ft² of conditioned envelope</td>
<td>/person</td>
<td></td>
</tr>
<tr>
<td>Heating demand</td>
<td>Same for all climates</td>
<td>Changes based on climate</td>
<td></td>
</tr>
<tr>
<td>Cooling demand</td>
<td>Changes based on latent load from climate and occupant density &amp; internal loads</td>
<td>Changes based on climate, sensible only</td>
<td>Temporary adjustment being allowed for cooling demand by PHIUS</td>
</tr>
<tr>
<td>Air Tightness</td>
<td>0.6 ACH50 required / 0.033 cfm/ft² of façade recommended for large buildings</td>
<td>0.08 cfm/ft² of façade for 5+ stories &amp; non-combustible, 0.05 cfm/ft² for all others</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>Not a lot of approved ERVs in US</td>
<td>Approve a lot more ERVs</td>
<td></td>
</tr>
<tr>
<td>Cooling &amp; Heating Loads</td>
<td>Can certify based on demand or load</td>
<td>Must meet both demand and load thresholds</td>
<td>Can be difficult to meet both</td>
</tr>
</tbody>
</table>
Blower Door Testing

- Basic Components
  - Gauge (manometer)
  - Shroud
  - Frame
  - Fan
Blower Door Testing – Whole Building
CONSTRUCTION PHASE QA/QC
PH Contractor Buy-In

• General contractor and subcontractor buy-in is critical to project success
• All trades have an impact on project results and may require a mind shift on performance testing
• Passive House Tradesperson training mandatory for key personnel
• GC needs at least two people who will be dedicated to PH scope and coordination
PH Contractor Buy-In

- Ensure GC & trades fully understand what’s included in respective work scopes
- Ask questions, dispel myths
- Discuss expectations with whole project team during bidding phase
Verification for Large Projects

- **Foundations**
  - Abutting neighbor(s)
  - Staging of foundation
  - Under slab / stem walls

- **Above Grade Walls**
  - Wall construction type: CMU, wood framed, etc.
  - Sequencing for hoistways, upper vs. lower floors

- **Roof**
  - Thermal breaks and roof membrane penetrations
  - Bulkheads, louvers & dampers
Verification for Large Projects

- MEP
  - In unit heat/cool duct testing
  - Ventilation
  - TAB process
  - Pipe insulation
  - Lighting wattages & controls
**Typical & Unique Checklists**

### Site Inspection Checklist - Unique Conditions

- **General Contractor:** L&M Builders Group
- **Project Lead:** Thomas Moore
- **Primary Contact:** Andrew Canete / TSO
- **Primary Inspector:** Mike O'Donnell
- **Date:** 4/17/2018
- **Project Manager:** Lois B. Arena
- **Project Number:** BCH11A

The following items must be inspected and/or tested by SWA before being made inaccessible.

<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Item #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Grade</td>
<td>U.1</td>
<td>Elevator Pit Insulation</td>
</tr>
<tr>
<td></td>
<td>U.2</td>
<td>Below Grade Insulation</td>
</tr>
<tr>
<td></td>
<td>U.3</td>
<td>Floor Insulation in Lobby Areas</td>
</tr>
<tr>
<td></td>
<td>U.4</td>
<td>Connection from Below to Above Grade</td>
</tr>
<tr>
<td></td>
<td>U.5</td>
<td>Connector Room</td>
</tr>
<tr>
<td></td>
<td>U.6</td>
<td>Gas Meter Room</td>
</tr>
<tr>
<td></td>
<td>U.7</td>
<td>Water Room</td>
</tr>
<tr>
<td></td>
<td>U.8</td>
<td>Laundry Room</td>
</tr>
<tr>
<td></td>
<td>U.9</td>
<td>Electrical Room</td>
</tr>
<tr>
<td></td>
<td>U.10</td>
<td>Refuse Rooms (Rooms 2-8)</td>
</tr>
<tr>
<td></td>
<td>U.11</td>
<td>Seismic Gap Corners</td>
</tr>
<tr>
<td></td>
<td>U.12</td>
<td>Field Vents</td>
</tr>
<tr>
<td></td>
<td>U.13</td>
<td>Detention Tank</td>
</tr>
<tr>
<td>Above Grade</td>
<td>U.14</td>
<td>Air Sealing at Garage Beams</td>
</tr>
<tr>
<td></td>
<td>U.15</td>
<td>Air Sealing of Garage Ceiling to Wall/Connection</td>
</tr>
<tr>
<td></td>
<td>U.16</td>
<td>EIFS Expansion Joint</td>
</tr>
<tr>
<td></td>
<td>U.17</td>
<td>Enslit Angle Attachments</td>
</tr>
<tr>
<td></td>
<td>U.18</td>
<td>Stairwell Air Sealing</td>
</tr>
<tr>
<td></td>
<td>U.19</td>
<td>Canopy Connection &amp; Drain Insulation</td>
</tr>
<tr>
<td></td>
<td>U.20</td>
<td>Connection from Wall to Roof</td>
</tr>
<tr>
<td></td>
<td>U.21</td>
<td>Mechanical Equipment Supports</td>
</tr>
<tr>
<td></td>
<td>U.22</td>
<td>ERV Mechanical Curb</td>
</tr>
<tr>
<td></td>
<td>U.23</td>
<td>PV Supports</td>
</tr>
<tr>
<td>Top Out</td>
<td>U.24</td>
<td>Roof Drain Insulation</td>
</tr>
<tr>
<td></td>
<td>U.25</td>
<td>ERV Roof Penetration</td>
</tr>
<tr>
<td></td>
<td>U.26</td>
<td>Typical Plumbing Penetration - Roof</td>
</tr>
<tr>
<td></td>
<td>U.27</td>
<td>Exhaust Ventilation Penetration</td>
</tr>
<tr>
<td></td>
<td>U.28</td>
<td>Smoke Dampers</td>
</tr>
</tbody>
</table>

*Please note that this guide is not meant to replace the drawings or specifications laid out by the architect or provide a fully exhaustive list of areas where these issues may occur.*

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**Start of Construction**

**Prior to Drywall / Start of Drywall Installation**

**Construction Completion**

**PH specific criteria in red**
Testing Tools and Protocols

- Window mockup testing
- Interim guarded blower door testing
- Interim whole building test if schedule and sequencing allows
- Envelope compartmentalization and window testing
- Unique component testing
- Whole building blower door test
Mock up

09/06/2018

09/06/2018
CASE STUDY
BEACH GREEN NORTH
Affordable Housing – 101 units
QUEENS, NY
Wall Inspections

• ICF doesn’t require as many inspections for insulation and air barrier
1st Window Mockup
2nd Window Mockup
### 2nd Floor Slab Edge Insulation

Refer to architectural details 20 A-356.

Detail 20 shows 4” thick insulation at the slab edge between the CUP and the Residential Tower extending 2” above and below the slab (highlighted area in detail at right).

This condition exists at the area highlighted on the plan to the right.
<table>
<thead>
<tr>
<th>SVR #</th>
<th>SVR Item</th>
<th>Issue Type</th>
<th>Location</th>
<th>Issue</th>
<th>Found by</th>
<th>Date Found</th>
<th>Action Required</th>
<th>Responsible Party</th>
<th>Reinspection Required?</th>
<th>Actions Taken/Updates</th>
<th>Date Verified/Update</th>
<th>Open/Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
<td>ENV</td>
<td>7th Floor</td>
<td>Panel Insulation at Joints: Insulation at the panel joints was found to be around 6 inches deep. Shop drawings indicate 9&quot; (EEWS Shop Drawings Sheet 501, Detail 1, second image right). SWA notified Monadnock of the issue. Monadnock followed up with a photo on 5/11/16 and informed SWA that EEWS will continue to install insulation at 9 inch depth. All panels below the six floor will need to be inspected for insufficient insulation and corrected if needed via exterior scaffolding when exterior caulk is applied.</td>
<td>SWA</td>
<td>5/10/16</td>
<td>Photo documentation using a measuring device will be required to verify PH compliance. SWA &amp; EEWS to agree on frequency of photos and method of depth verification.</td>
<td>Eastern</td>
<td>Y</td>
<td>On 9/22/16, Eastern issued photos of joint insulation being installed along two swing stage areas (Rig 3 Drop 2 and Rig 3 Drop 4). SWA will continue keeping track of Eastern's progress.</td>
<td>Ongoing</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>ENV</td>
<td>2nd Floor</td>
<td>Gap at the corner of storage room and condenser porch located behind the column is not air sealed at this time. Neither is the connection of Intesana to block. SWA to inspect when complete.</td>
<td>SWA</td>
<td>8/9/16</td>
<td>Monadnock to send photos of the area to SWA.</td>
<td>Monadnock</td>
<td>N</td>
<td></td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>3</td>
<td>HVAC</td>
<td>All Floors</td>
<td>Damaged Ductwork Covers: SWA observed numerous instances of damaged ductwork opening covers damaged or loose throughout the first and second floors. SWA believes a significant amount of dust has likely accumulated in the ductwork. The project is now at risk of losing a LEED point needed for LEED Platinum certification.</td>
<td>SWA</td>
<td>11/21/16</td>
<td>Monadnock to make sure that all ductwork openings have been covered on floors 1, 2, 15-25. Monadnock to issue written confirmation to SWA once this work has been complete. SWA to spot check these areas in its next visit.</td>
<td>SWA</td>
<td>Y</td>
<td>On 11/30/16, SWA observed that much of previously noted loose and damaged ductwork opening covers were repaired. Issues still persist on the various floors. SWA performed spot checks on floors 1, 2, 15-25 and found issues in all floors. On 12/1/16,Monadnock emailed SWA notifying that floors 1, 2, and 15-25 had been reinstalled and damaged ductwork covers had been repaired. On 12/12/16, SWA observed issues on floors 1, 2, and 17.</td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>ENV</td>
<td>2nd Floor</td>
<td>Insulation under 2nd floor condenser porch ballast was covered before SWA could inspect. Images showing insulation depth and coverage must be provided.</td>
<td>SWA</td>
<td>5/24/16</td>
<td>Monadnock possesses photo documentation that shows depth and coverage. Provide images to SWA.</td>
<td>Monadnock</td>
<td>N</td>
<td>On 7/28/2016, Monadnock sent photos showing depth of insulation at condenser porch ballast.</td>
<td>7/28/2016</td>
<td>Closed</td>
</tr>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>ENV</td>
<td>26th &amp; 27th Floor</td>
<td>Roof deck insulation inside AHU curb was covered before SWA could inspect. Images showing insulation depth and coverage must be provided.</td>
<td>SWA</td>
<td>5/1/16</td>
<td>Monadnock possesses photo documentation that shows depth and coverage. Provide images to SWA.</td>
<td>Monadnock</td>
<td>N</td>
<td>On 10/1/2016, SWA received photos from Monadnock showing blurry tape measurements of insulation at the AHU curbs.</td>
<td>10/24/2016</td>
<td>Closed</td>
</tr>
</tbody>
</table>

Sample from Cornell Tech
Progress

- AeroBarrier by Aeroseal was utilized
- 6/24/2017 - envelope leakage test performed but couldn’t finish, Building Department shut down site for working on Saturday
- 7/6/2017 - infiltration test for energy model passed!!
- ERV testing & commissioning completed
- 4/4/2018 - PHIUS Certification received!!!
PLANNING FINAL BLOWER DOOR TESTING
# Blower Door Test Conditions

<table>
<thead>
<tr>
<th>Intentional Opening</th>
<th>Test Setting</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows, doors, skylights in the building enclosure</td>
<td>Closed and latched</td>
<td></td>
</tr>
<tr>
<td>Doors and operable windows inside the test enclosure</td>
<td>Open</td>
<td>Use stairways to connect all zones of the building</td>
</tr>
<tr>
<td>Fire dampers</td>
<td>Remain as found</td>
<td></td>
</tr>
<tr>
<td>Dryer doors</td>
<td>Closed and latched</td>
<td></td>
</tr>
<tr>
<td>Gas meter room</td>
<td>Door to gas meter room closed and weather stripped</td>
<td></td>
</tr>
<tr>
<td>Waste handling system</td>
<td>Trash chute termination at roof taped off. Door to trash rooms closed.</td>
<td></td>
</tr>
<tr>
<td>ERVs (apartments)</td>
<td>Fan off, any dampers closed. Ducts to the outside sealed inside the ERV cabinet in each apartment.</td>
<td>Ventilation is continuous, so can remain taped off</td>
</tr>
<tr>
<td>Motorized dampers: ERV-4 (cellar)</td>
<td>Fan off, dampers closed. Taped off from the exterior</td>
<td>Ventilation is continuous, so dampers closed and sealed off</td>
</tr>
<tr>
<td>Motorized dampers: ERV-5 (1st floor)</td>
<td>Fan off, dampers closed. Taped off from the exterior</td>
<td>Ventilation is continuous, so dampers closed and sealed off</td>
</tr>
<tr>
<td>Motorized dampers: ERV-2A (1st floor)</td>
<td>Fan off, dampers closed. Taped off from the exterior</td>
<td>Ventilation is continuous, so dampers closed and sealed off</td>
</tr>
<tr>
<td>Motorized damper: Laundry Room (2nd floor)</td>
<td>Fan off, dampers closed. Taped off from the exterior</td>
<td>Untaped for Method A test</td>
</tr>
<tr>
<td>Motorized damper: ERV-2 (2nd floor)</td>
<td>Fan off, dampers closed. Taped off from the exterior</td>
<td>Ventilation is continuous, so dampers closed and sealed</td>
</tr>
<tr>
<td>Motorized dampers: EMR (1st floor), Stair A, Star B, Elevator, Boiler Room (roof)</td>
<td>Taped off from the exterior</td>
<td>Untaped for Method A test</td>
</tr>
<tr>
<td>ERV-2 (gas)</td>
<td>Fan off, dampers closed</td>
<td>Ventilation is continuous, so</td>
</tr>
</tbody>
</table>
Whole Building Test Logistics

• Enough fans, cruise manometers, frames, shrouds, tubing, CAT5 cabling, people?

• Is building access limited to avoid people opening and closing doors, windows, etc.?

• Thorough walkthrough the day prior to test date to confirm prep has taken place?

• GC and appropriate subs on site to help with building prep and issues that come up on the test day?

• Saturday work permits pulled?
Central ERVs & Blower Door

- Need to seal off ERVs for the final test
- Wrap rooftop ERVs or seal exterior intake and exhaust louver ports
Individual ERVs & Blower Door

• Typically can’t reach all vents to seal from outside

• Tape off both outdoor connection ports inside every ERV

• Some ERV’s can’t be sealed inside the cabinets
Whole Building Test Logistics

• A great resource is **Blower Door Applications Guide: Beyond Single Family Residential** PDF (Brennan, Clarkin, Nelson, Olson, Morin)
RECOMMENDATIONS FOR SUCCESS
Do This ✔

• **Insist on**
  – Training for construction staff
  – Mockups
  – Interim blower door testing

• **Advanced Planning**
  – Typical and unique checklists
  – Blower door testing plan

• **Quality Control**
  – Typical details readily available on site for all subs
  – Communication between GC and PH verifier
  – Panelized construction, if applicable
Do NOT Do This ✗

• Be wary
  – Assume if the GC has done a PH project that the second will automatically pass
  – Keep going without passing the window mockup
  – Depend on subs understanding contract docs without communication
  – Allow the GC to exclude meeting PH requirements from the contract
• Ignore your PH Consultant!!!!!!
Questions?
modonnell@swinter.com

THANK YOU!