At the Finish Line: How Two Affordable Passive Projects Crossed the Hardest Hurdles

Michelle Apigian (ICON Architecture)
Thomas Chase (New Ecology)
Maciej Konieczny (New Ecology)
Chris Becker (Callahan Construction Managers)

Curated by Beverly Craig (MassCEC)

Northeast Sustainable Energy Association (NESEA)
February 28, 2022
2017 Passive House Design Challenge

- Up to $4,000 per unit incentive
- 8 Affordable Projects: 540 Units
- 5 Occupied; 3 Under Construction
Incremental Cost of Achieving Passive House Standard: 2.4% average

Does not include final change orders for Kenzi and Mattapan Station; incentives not included
What are the biggest incremental costs?

- Much better ventilation
- Windows and Doors
- Efforts to reduce thermal bridging
- Higher level of construction verification

Heating and Cooling Equipment Cost Decrease:
- 6 out of 8 projects have **significantly lower size and cost for heating and cooling** equipment

- Window premium is coming way down. In some cases, cost neutral
LESSONS

- Architects with more PH training and experience had lower cost; better outcomes
- Decide early if you are seeking PH certification - if whole team on board coming out of charrette, more will go more easily
- There is a large learning curve on first PH project – expect it
- Give yourself plenty of room in PH model for things to go wrong
- All 7 of 8 projects likely to get PH certification successfully, MassSave fallback incentives still reward trying and above code outcome
- More complex roofline = more expensive
Performance: Distillery, Boston 2020

PH Uses 63% less energy per sq. ft. than median new multifamily in Boston

Data from Boston Energy Disclosure 2020 sorted for new construction multifamily built since 2010; Cross checked for LEED certification; properties with suspected lack of full building energy report are removed.
PH uses 57% less energy per sq. ft. than Median Code Built.

Data from Philadelphia Energy Disclosure 2019 cross checked for LIHTC multifamily; Credit to Green Building United, Katie Bartolotta
PH Performance 2019: Gilford Village Knowles III, NH

**PH uses 49% less** energy per sq. ft. than Gilford Village Knowles II LEED built 2008 (same building, different standard)

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**Graphic representation of study by Resilient Building Group (2020 Report of average 3 year energy usage data ending in 2019)**

<table>
<thead>
<tr>
<th></th>
<th>ENERGY USE PER SQ. FT (EUI)</th>
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<tbody>
<tr>
<td>Gilford Village Knolls III (Passive House-solar not included)</td>
<td>25.0</td>
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<tr>
<td>Gilford Village Knolls II (LEED)</td>
<td>49.2</td>
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Passive House
Multifamily Incentives

- 100% of feasibility study cost up to $5,000
- 75% of PH modeling cost up to $20,000
- $3,000 per unit for PH certification
Current Enrollment Stats

- 116 buildings enrolled for PH incentives
- Represents 6,500+ units
- 70 buildings have completed PH feasibility studies

Passive House Education

- PH Lunch & Learns/Workshops: 59
- Total Attendees: 2,497
- PHIUS/PHI Accreditation Reimbursements: 107

- See phmass.org video library
- See Passive House Accelerator videos for sessions like: “10 Easy Ways to Ruin Your Blower Door Score (& Remedies)
FREE TRAINING FOR MA EMPLOYERS <100

- Passive House Design Consultant
- Passive House Builder/Tradesperson
- LEED Green Associate Exam Prep
- Green Professional Training (GPRO)

- Intro to WELL
- Intro to Designing Net Zero Buildings
- Building Science Fundamentals

https://builtenvironmentplus.org/workforce-training-grants/
Building Inherent Value:
Executing a Passive House
PERFORMANCE—Building Inherent Value

Figure 2: Source Energy Use Intensity (EUI) Comparison

Source: New York City Local Law 84 Benchmarking Report, 2013
PASSIVE HOUSE: Building Inherent Value

INTENTION
TEAMWORK
INTEGRATED BUILDING SCIENCE
COMMUNICATION
CRAFT
CONFIRMATION
INTENTION

2015: MA Amendment to the IBC 2015
Accepted as Alternative Compliance path

2018: Mass CEC Passive House Design Incentives
Targeting Affordable Housing Developers

2019: Mass Save Incentives
Targets all Multifamily Developers
Builds Market-Rate attention

2020: DHCD QAP
Incents Passive House above other green building standards
Catalyzes Affordable commitment to Passive House

2022: Draft Net Zero Stretch Code
Considers Passive House as a Compliance Path

Ongoing....Community Advocacy - Municipal Policy – Future Codes?
TEAMWORK

Owner
Architect
Mechanical Engineer
Structural Engineer
Energy Modeler/CPHC
Rater/Verifier
Envelope Consultant
Commissioning Agent
General Contractor
Trades
INTEGRATED BUILDING SCIENCE

Analyze Intersections
COMMUNICATION

DESIGN INTENT

GRAPHIC SPECIFICATIONS ON SITE
ARTICULATE THE PRESSURIZED BOUNDARY

COMPARTMENTALIZATION LEGEND

NOTE: DRAWINGS A-119 THRU A-133 & A-303 SHOULD BE PRINTED IN COLOR

- COMPARTMENTALIZED SPACE. SEE SPEC SECTION 3.13 OF 090-116
- CONTINUOUS AIR BARRIER
- CONTINUOUS THERMAL & AIR BARRIER
- UNCONDITIONED SPACE OUTSIDE PASSIVE HOUSE ENCLOSURE
- CONDITIONED SPACE OUTSIDE PASSIVE HOUSE ENCLOSURE
- INSULATION
  - SPRAY FOAM INSULATION
  - CONTINUOUS EXTERIOR INSULATION: MINERAL WOOL
  - ROCK INSULATION
  - FIBERGLASS INSULATION

AIRTIGHTNESS DETAILS LEGEND

NOTE: DRAWINGS A-119 THRU A-133 & A-303 SHOULD BE PRINTED IN COLOR

- PEEL STICK APPLIED CONT. AIR BARRIER
  - AB-1A: BLUESKIN VP-180 (VAPOR OPEN)
  - AB-1B: BLUESKIN 5A (VAPOR CLOSED)
- POLY AIR BARRIER
  - AB-2A: VIPER II 10 ML VAPOR BARRIER (VAPOR CLOSED)
  - AB-2B: VIPER II PENETRATION BOOT (VAPOR CLOSED)
  - AB-2C: UNDER SLAB OR ROOF VAPOR BARRIER (VAPOR CLOSED)
  - AB-2D: ROOF VAPOR BARRIER (SMART BARRIER)
- FULLY GROUTED CMU OR CONC. AS AIR BARRIER. SEAL HOLES WITH BLUESKIN BEC 302
- CLOSED CELL SPRAY FOAM MIN R-30
- HIGH LIFT SPRAY FOAM WITH FLAME BLOCK (VAPOR CLOSED)
- CRYSALLINE WATERPROOFING
  - AB-5: KYDEX (VAPOR CLOSED)
- FLUID APPLIED AB
  - AB-6A: BLUESKIN AIRBLOCK 17 (VAPOR OPEN)
  - AB-6B: BLUESKIN CM-100 (VAPOR CLOSED)
- FIRESTOPPING
  - HILTI FIRESTOP SYSTEMS

COMPARTMENTALIZATION NOTES

1. PROVIDE SEALANT BETWEEN GW & TOP SILL PLATES AS WELL AS BETWEEN STUD FRAMING AND GW AT OPENINGS (DOORS, WINDOWS, HVAC UNITS, ETC.). SEAL PERIMETER OF ELECTRICAL/TELE DATA BOXES (OUTLETS, LIGHTS, SWITCHES, ETC.) IN WALLS AND CEILINGS. ELECTRICAL BOXES ARE TO BE 'AIR SEALED' BOXES AND SEALING OF BOX PENETRATIONS SHALL BE AS SPECIFIED.

2. AT DEMISING WALLS UNIT-TO-UNIT, UNIT-TO-CORRIDOR, AND UNIT-TO-COMMON AREA PROVIDE INTERIOR AIR BARRIER (AIRSEALING), PROVIDE SEALANT AS SPECIFIED BETWEEN SILL PLATE/TOP PLATE AND GW, TYPICAL.
ARTICULATE TRANSITIONS (including sequence)
COMMUNICATION – Speaking the same Language

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<th>Week 1</th>
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</table>
1. FOUNDATION: WATERPROOFING
2. STEEL POSTS
3. STRUCTURAL CMU WALLS
4. INTUMESCENT PAINT & STRUCTURAL THERMAL BREAKS
5. STRUCTURAL THERMAL BREAKS
6. VERTICAL SUB GRADE
7. SUB SLAB INSULATION
8. VAPOR BARRIER, LAPS UP, SLAB POURED
9. AIR BARRIER ON CMU
10. METAL STUDS AND NON STRUCTURAL CMU WALLS WITH AIR BARRIERS

LOBBY SEQUENCE

VESTIBULE
STAIR 1
ELEVATOR
LOBBY
MAIL
TRASH
OFFICE

DETAILS AT DOORS

1. PASSIVE HOUSE SILL DETAIL @ SLAB ON GRADE
2. PASSIVE HOUSE DOOR MTL JAMB DETAIL
3. ATTACHMENT BRACKET & FASTENED
4. BRICK COMPRESSION FOAM
5. METAL JAMB FRAMING
6. CORE VAPOR PERMEABLE AIR BARRIER
7. AIR SEAL COMPRESSION
8. MINERAL WOOL
9. 2" INSULATION
10. CARRY & TIE ABOVE DOOR
11. SEAL VAPOR PERMEABLE TAPE
12. METAL TRIM
13. BACKER ROD
14. BACKER ROD & SEALANT
15. HEAVY ALUM. SILL
16. AIR SEAL VAPOR PERMEABLE TAPE
17. FIBER CEMENT BOARD
18. 2" FOAM INSULATION
19. BED ALUM. SILL IN JOINT & GAP FLASHING
20. AIR SEAL COMPRESSION
21. JOINT & GAP FLASHING
22. FINISH FLOOR
23. STRUCT. CORN. SLAB POURING
24. VAPOR BARRIER

11. INSULATION ABOVE GRADE, & SPRAY FOAM UNDERSIDE OF DECK
INVEST IN CRAFT

SCHEDULE

SEQUENCE

TRADES

• Carpenters
• Insulators
• Plumbers
• HVAC Installers
• Electricians

ON SITE COMMUNICATION
Craft – Envelope Airtightness Continuity

Caio’s Team rocking the Air Barrier
Craft: Pipe/Penetration Airtightness

First Try – Not Approved

Ian Russell - Plumber

Second Try – Approved
CRAFT – HVAC
CRAFT– Electrician

Not Approved

Approved

Not Approved

Approved
CONFIRMATION: TESTING/VERIFICATION

REGULAR INSPECTIONS
INFRARED
BLOWER DOOR TESTING & TROUBLESHOOTING
COMMISSIONING
TESTING/VERIFICATION

Windows
Airtightness
Duct Leakage
Thermal Bridging/Gaps
CONFIRMATION: TROUBLE SPOTS

BLOWER DOOR TESTING
Adiabatic Transitions
Compartmentalization
TEAMWORK

Owner
Architect
Mechanical Engineer
Structural Engineer
Energy Modeler/CPHC
Rater/Verifier
Envelope Consultant
Commissioning Agent
General Contractor
Trades
Whole Building Air Tightness: Harbor Village
WBBD Test Protocol

• Testing Standard
  ASTM E779

• Testing Preparation
  Appendix F - ANSI/RESNET/ICC 380-2016: Procedure to Prepare the Building for Testing
  Phius Variance – Barometric/spring-loaded dampers to be sealed in the direction of the test for which they will be force-failed open. Fresh air intake dampers sealed during depressurization, exhaust dampers to be sealed during pressurization.

• Results Reporting
  Report both pressurization and depressurization testing, final result is average of the two.
  Pass-fail air infiltration target test.
  WUFI model test (can exceed pass-fail threshold, provided energy model results to not exceed threshold metrics).

• Best Practices for Mid-Point and Final Testing
  Test plan with: site information, testing and site staff contacts, building control plan, test type and targets, equipment list, building preparation protocol, temporary air sealing checklist, and schedule.
Allowable Effective Leakage Area

100 in²
Effective Leakage Area vs. Total Enclosure Area

34,600 ft²
## WBBD Results – Midpoint to Final

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<tr>
<th>Date</th>
<th>CFM50 (depress.)</th>
<th>CFM50 (press.)</th>
<th>CFM50 (avg.)</th>
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<td>1,953</td>
<td>2,190</td>
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What Worked
5/14/2021 – Midpoint 2
Other Approaches to Try
Squirrelwood
Across the Finish Line – PH Lessons
Squirrelwood - Speakers and Team

Callahan training

Maciej Konieczny  
CPHC/B, CEM, LEED AP BD+C, Homes  
Senior Project Manager  
konieczny@newecology.org  
617-557-1700 x7024

NEW ECOLOGY  
Community-Based Sustainable Development

Chris Becker  
CPHB  
Project Manager  
cbecker@Callahan-inc.com  
508-443-2381

Owner: Just-A-Start Corporation  
Cambridge, MA

General Contractor: Callahan Construction Managers  
Bridgewater, MA

Architect: Davis Square Architects  
Somerville, MA

Civil: Devellis Zrein, Inc.  
Foxborough, MA

Structural: Dan Bonardi Consulting Engineers  
Arlington, MA

MEP: BLW Engineers, Inc.  
Littleton, MA

Sustainability: New Ecology, Inc.  
Boston, MA

BECx: Building Enclosure Associates  
Boston, MA
SQW – Objectives

Agenda:
- Project Summary
  - PHIUS targets
  - Envelope, Systems
- Process Review
  - Design and pre-construction services
  - Start of construction/training
  - Mock-up
  - Collaboration
- Construction
  - Challenges and Solutions - Examples
- Q+A
SQW – Project Summary

• Owner/Developer: Just-A-Start
• 14 affordable family units
• PHIUS+ 2015
• iCFA: 13,400 ft²
• Opening Fall 2021

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<td>Cooling Demand; kBtu/ft²yr</td>
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<td>Source Energy; kWh/yr</td>
<td>6,200</td>
<td>5,541</td>
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<tr>
<td>Air Tightness</td>
<td>0.05 cfm/ft² (971 cfm)</td>
<td>653 cfm (0.27 ACH50)</td>
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3rd tightest MF building in US, excluding THs
**SQW – Envelope**

- **Double studded wall**
  - 2x6 structure; 1” space; 2x4 interior wall
  - Staggered studs, 24” O.C. as allowed
  - 3” CCSF inc. studs + 7” Cellulose
  - Siga AWB

- **Windows**
  - Triple Pane; clips
  - Insulated Headers
  - Siga Wigluv flashing
SQW – Envelope

Roof:
- 2” min Polyiso above roof deck
- 20” Truss depth with 4” of CCSF
- 16” cellulose

Foundation/Slab
- 5” EPS sub-slab insulation
- 15 mil Steggo Wrap VB taped to Siga WRB
- 2x2” EPS foundation
SQW – Systems

Ventilation:
- Ventacity VS1000;
- 82% Eff; 0.61 W/CFM
- 850 CFM

DHW:
- Instantaneous Electric
- Stiebel Eltron

Heating/Cooling
- Mitsubishi SUZ-KA HPs
SQW – Process

Design and pre-construction services
- Commit to PH early
- Include GC at DD or earlier
- Schedule multiple integrated design meetings
- Submit project to PHIUS at ~50% DD for Round 1 review
  - Experienced energy modeler is critical
- CPHC to participate in VE
- Use color in drawings
SQW – Process - Training

Start of construction/training
- Reach out to GC before kick off
- Include PHIUS verifier, BECx
- Foremen of each trade required
- Involve subs in motivation behind the PH goal
  - People like to understand what and why?
- Focus meeting on working through details
- **Collaborate** – NOT just a lecture

Collaboration
- Between design and construction teams
- Between GC and sub contractors
- GC and Subs are very knowledgeable even if this is their first PH
- Listen to constructability suggestions
SQW – Process – Mock-Up

Dedicated Mock-Up
- Most important stage of construction Assume multiple visits from CPHC and BECx
- Bring window and AWB manufacturer on site
- Identify critical details and transitions:
  - Foundation/slab/wall
  - Wall: AWB/insulation, inside/outside corners
  - Window flashing/install
  - Wall/Roof transition
  - MEP Penetrations
  - Doors – Leave up until building reaches the same level of completion
- COLLABORATE
SQW – Process – Mock-Up

Require proper tools

Document each step

Involve all related subs
SQW – Process – Mock-Up

Pay attention to details and adjust as needed

Track the details

Finalize and confirm approach

Leave up until installed in situ
SQW – Challenges and Solutions

Detail created after design – PREPRUFE membrane and mat slab required due to high water table.
**SQW – Challenges and Solutions**

**VB to AWB Continuity**
SQW – Challenges and Solutions
Awkward transition for AWB
SQW – Challenges and Solutions

Challenging AWB transition

Challenging AWB transition

Mat Slab, PREPRUFE

Vapor Barrier @ M - Slab on Grade at Wood

Vapor Barrier @ L - Slab on Grade at Wood
QUESTION
During our Passive House meeting on 12/4/19, we reviewed the TIM Bearing pad on detail G9/A530. There is a space above the bearing pad that is not marked. Please advise what this material is. Also, the vapor barrier was discussed and the TIM bearing pad’s penetration through the vapor barrier in (4) locations. After review with New Ecology and Bridgeline we agreed the best way to maintain the vapor barrier in these locations is going to be by caulking the TIM bearing pad making it part of the vapor barrier. Please confirm this is acceptable in these (4) locations.
SQW – Challenges and Solutions

Maintain unit compartmentalization
QUESTION

During our Passive House meeting on 12/4/19, we reviewed the vapor barrier in detail A1/A540. Per our discussions, the way the vapor barrier is currently drawn would not be constructible. Reviewing with New Ecology, Bridgeline, and Max Sontz roofing, we propose to add plywood to the bottom of the soffit (green), and have the vapor barrier (red) run on the outside of the soffit as shown in the attached. The trim on the exterior would need to be larger to account for the depth of the plywood and create the same profile as the original design. Please confirm this approach is acceptable.
SQW – Challenges and Solutions
SQW – Challenges and Solutions
SQW – Challenges and Solutions

Thermal Insulating Pads
SQW – Challenges and Solutions

Polyethylene Suspension Pipe Clips – insulation should go through the stud

Find insulated pipe hangers for large pipes like rain leaders
SQW – Challenges and Solutions

### General

**Status**
Open

**Type**
Issue

**Description**
Patch and seal around on Over cut electrical boxes

**Created**
Nov 18, 2020 2:07 PM
sbartley@callahan-inc.com

**Last Updated**
Nov 18, 2020 2:07 PM

**Sheet**
4 Punchlist Third Floor

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### GC Quality Control – Punchlist by trade

**#213 General**

**Status**
Open

**Type**
Issue

**Description**
Seal all penetrations

**Created**
Nov 19, 2020 1:51 PM
sbartley@callahan-inc.com

**Last Updated**
Nov 19, 2020 1:51 PM

**Sheet**
2 Punchlist First Floor

---

### Photos

- ![Photo 1](20201119_104648.png)
  - Steve Bartley
  - Nov 18, 2020 10:46 AM

- ![Photo 2](20201119_104659.png)
  - Steve Bartley
  - Nov 18, 2020 10:46 AM

- ![Photo 3](20201119_114102.png)
  - Steve Bartley
  - Nov 19, 2020 11:41 AM
SQW – Challenges and Solutions

**#210 Plumbing**

**Status**
Open

**Type**
Issue

**Description**
Seal all plumbing penetrations below

**Created**
Nov 19, 2020 1:50 PM
sbartley@callahan-inc.com

**Last Updated**
Nov 19, 2020 1:51 PM

**Sheet**
2 Punchlist First Floor

---

**#182 Duct Work**

**Status**
Open

**Type**
Issue

**Description**
Seal all ductwork

**Created**
Nov 19, 2020 1:45 PM
sbartley@callahan-inc.com

**Last Updated**
Nov 19, 2020 1:45 PM

**Sheet**
2 Punchlist First Floor

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**Photos**

20201119_113740_photo
Steve Bartley
Nov 19, 2020 11:37 AM

20201119_113716_photo
Steve Bartley
Nov 19, 2020 11:37 AM

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**Photos**

20201119_111014_photo
Steve Bartley
Nov 19, 2020 11:03 AM

20201119_110246_photo
Steve Bartley
Nov 19, 2020 11:03 AM
SQW – Challenges and Solutions

Ventilation testing ... and failure.

Squirrelwood Bldg L Ventilation

<table>
<thead>
<tr>
<th>UNIT DESIGN</th>
<th>FLOW</th>
<th>DELTA</th>
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<tbody>
<tr>
<td>SUPPLY TOTAL</td>
<td>850</td>
<td>724</td>
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<tr>
<td>EXHAUST TOTAL</td>
<td>850</td>
<td>845</td>
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</tbody>
</table>

CFM of Supply needed to get within 10%

- 724
- 764
- 40

CFM of Supply per unit need to get within 10%

- 3
SQW – Challenges and Solutions

AeroSeal –
- Saves time and hassle
- Include on every project

https://makeitright.ca/holmes-advice/home-renovation/aeroseal-the-new-way-to-duct-sealing/
Even with open corner framing, insulation had to be fixed in some locations
- Continuous QC
SQW – Challenges and Solutions

Window testing – in situ and early
- Consider test on mock-up

<table>
<thead>
<tr>
<th>Testing Specifications</th>
<th>Specimen Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>b) Pressure differential, Pa:</td>
<td></td>
<td>298.7</td>
<td>298.7</td>
<td>298.7</td>
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<tr>
<td>c) Allow infiltration rate, cfm/sf:</td>
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<td>0.15</td>
<td>0.15</td>
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<tr>
<td>d) Specimen, total square feet:</td>
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<td>12.0</td>
<td>15.0</td>
<td>15.0</td>
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<tr>
<td>e) Total, cfm:</td>
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<td>12.75</td>
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<td>7.0</td>
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<td>f) Extraneous, cfm:</td>
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<td>8.25</td>
<td>6.0</td>
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<td>g) Specimen, cfm (g=e-f):</td>
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<tr>
<td>h) Total, cfm/sf (h=e/d):</td>
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<td>0.60</td>
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<td>i) Specimen, cfm/sf (i=g/d):</td>
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<td>0.05</td>
<td>0.07</td>
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</table>
SQW – Challenges and Solutions

Envelope Testing – Passed – first attempt.
THANK YOU.
Take Aways

- Make it a conversation, not a lecture.
- Learn from others.
- There is a big learning curve on the first one: expect it!
- Test and inspect early and often, especially on the first one.
- Invest in Craft – every trade is ready to execute, if empowered & given the tools.