Case study of the Scranton Passive House

Richard Pedranti of Richard Pedranti Architect

Provider name and number, September 11, 2015
Presentation Outline

Case Study: Scranton Passive House
Design and construction

1. The use of Perlite under a slab foundation
2. Our experience with testing, failure, and remediation of leaky OSB
3. An affordable Passive House IoT monitoring system
CLIMATE ZONE 5

MILFORD, PA
Birthplace of the American Conservation Movement

6400 HDD
600 CDD
Design Program

1. A simple, functional, and beautiful home for family of 4

2. A sustainable and energy efficient home

3. A construction budget of $150 per square foot
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Design 1

From 3 story
To 2 story

Design 2
Southeast view of the Scranton Passive House

www.scrantonpassivehouse.com
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Site Plan
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Optimized building morphology

- Compact building form
- Mechanical core
- Simple ventilation layout
- Efficient DHW piping
- Careful placement of auxiliary heating / cooling
- Careful window placement and sizes
- Optimized solar orientation
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FIRST FLOOR PLAN
1 ENTRY
2 KITCHEN
3 DINING ROOM
4 LIVING ROOM
5 SCREEN PORCH
6 OFFICE
7 POWDER ROOM
8 MECHANICAL

Service core

Auxiliary Heating and cooling

First Floor Plan
Second Floor Plan

- Bedroom 1
- Bathroom 2
- Bathroom 3
- Bedroom 2
- Bedroom 3
- Hall Closet
- Den

Service core
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East Elevation

West Elevation

North Elevation

South Elevation
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PASSIVE HOUSE METRICS

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Demand</td>
<td>4.16 kBTU/(ft²yr)</td>
</tr>
<tr>
<td>Heat Load</td>
<td>2.48 kBTU/(ft²hr)</td>
</tr>
<tr>
<td>Primary energy</td>
<td>31.4 kBTU/(ft²yr)</td>
</tr>
</tbody>
</table>

- 1,773 TFA
- 0.32 surface area to volume
- 14% glazing
- 47% south glazing

5KW PV to Net Zero

R=86
R=62
R=76
Installing 12” EPS foam over gravel setting bed
Formwork in place ready to pour concrete floor slab over 8” perlite and 12” of EPS Type 9 foam

EPS R-48+Perlite R-28 = Total R-76
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Why Perlite Works

Genesis in Fire

Rapidly heating perlite ore to temperatures of about 900°C (1,700°F) softens the volcanic glass causing entrapped water molecules in the rock to turn to steam and expand the particles like popcorn.

The expanded particles that result are actually clusters of minute, lightweight, insulating, glass bubbles. Broken bubbles and surface openings on the particles provide for water and air holding capacity—especially important in horticultural uses.

Crushed expanded perlite particles present a maze of microscopic pathways that can be used to filter and clean a wide array of liquids, beverages, and pharmaceutical products.

Sophisticated manufacturing techniques allow the expansion and collection of individual perlite bubbles, which are used as fillers or extenders for a wide variety of products.

SCRANTON PASSIVE HOUSE

Mining perlite rock

Forms of perlite
Perlite

THE VERSATILE MINERAL
Natural, Abundant, Lightweight, Insulating, Non-Flammable

Typical Applications
1. Green Roof Soils
2. Chimney Liners
3. Fireproof, Insulating Door Cores
4. Garden & Soil Amendment
5. Cast Stone, Brick and Statuary
6. Plaster Aggregate
7. Textured Paint
8. Tape Joint Compound
9. Cultured Marble
10. Insulating Concrete
11. Ceiling Tile
12. Masonry Loose Fill
13. Underfloor Insulation
14. Cement Stucco
15. Beverage Filtration
16. Pool & Pond Water Filtration

Perlite Institute, Inc.
www.perlite.org • (717) 208-9723

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SCRANTON PASSIVE HOUSE

**Physical Characteristics of Perlite**

- **R-value**: 3.7 per inch
- **Thermal conductivity at 75°F**
  - 0.27-0.41 BTUin/h·ft²·F
  - 0.04-0.06 W/m·K

<table>
<thead>
<tr>
<th>Typical Physical Properties</th>
<th>Typical Elemental Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color</strong></td>
<td>Silicon</td>
</tr>
<tr>
<td><strong>Refractive Index</strong></td>
<td>Aluminum</td>
</tr>
<tr>
<td><strong>pH (of water slurry)</strong></td>
<td>Potassium</td>
</tr>
<tr>
<td><strong>Free Moisture (maximum)</strong></td>
<td>Sodium</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>Iron</td>
</tr>
<tr>
<td><strong>Bulk Density (loose weight)</strong></td>
<td>0.27 - 0.41 Btu·in/h·ft²·F</td>
</tr>
<tr>
<td><strong>Softening Point</strong></td>
<td>0.04 - 0.06 W/m·K</td>
</tr>
<tr>
<td>1600 - 2000°F</td>
<td></td>
</tr>
<tr>
<td>871 - 1095°C</td>
<td></td>
</tr>
<tr>
<td>2300 - 2450°F</td>
<td></td>
</tr>
<tr>
<td>1260 - 1343°C</td>
<td></td>
</tr>
<tr>
<td><strong>Specific Heat</strong></td>
<td>Oxygen (by difference)</td>
</tr>
<tr>
<td>0.2 Btu/lb·°F</td>
<td>47.5</td>
</tr>
<tr>
<td>837 J/kg·K</td>
<td>Net Total</td>
</tr>
<tr>
<td><strong>Thermal Conductivity</strong></td>
<td>97.0</td>
</tr>
<tr>
<td>at 75°F (24°C)</td>
<td>Bound Water</td>
</tr>
<tr>
<td>0.27 - 0.41 Btu·in/h·ft²·F</td>
<td>3.0</td>
</tr>
<tr>
<td>0.04 - 0.06 W/m·K</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Solubility</strong></td>
<td>100.00</td>
</tr>
<tr>
<td>Soluble in hot concentrated</td>
<td></td>
</tr>
<tr>
<td>alkali and HF</td>
<td></td>
</tr>
<tr>
<td>Moderately soluble (&lt;10%)</td>
<td></td>
</tr>
<tr>
<td>in 1N NaOH</td>
<td></td>
</tr>
<tr>
<td>Slightly soluble (&lt;5%)</td>
<td></td>
</tr>
<tr>
<td>in mineral acids (1N)</td>
<td></td>
</tr>
<tr>
<td>Very slightly soluble (&lt;1%)</td>
<td></td>
</tr>
<tr>
<td>in water or weak acids</td>
<td></td>
</tr>
</tbody>
</table>

All analyses are shown in elemental form even though the actual forms present are mixed glassy silicates. Free silica may be present in small amounts, characteristic of the particular ore body. More specific information may be obtained from the ore supplier involved.

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Underslab Insulation Using Perlite in Bags

Concrete slab floors with direct thermal contact to the ground can present challenges to the maintenance of personal comfort in homes and add to heating bills. A solution to break that direct thermal contact is to use a natural insulative material such as perlite.

Perlite conforming to ASTM C549, and provided in easy-to-install, lightweight bags (either plastic or paper) may be used as insulation below concrete floors as demonstrated in the accompanying photographs and schematic diagrams.

Perlite underslab insulation is a natural, inorganic product that does not rot, support combustion nor provide a habitat for rodents. Because of its neutral pH, the product does not foster corrosion in piping and electrical wiring that may be in the underfloor area.

Benefits from installation of such a system can accrue in both summer and winter. During winter, heat loss through the floor of a building can be decreased, while in summer, differences between floor and air temperatures are minimized and condensation on cool floors is avoided—providing a more comfortable and energy-efficient environment. This system is particularly useful when radiant under-floor heating is employed since the thermal resistance of the perlite will reduce heat loss from the heated slab to the ground below. In addition, perlite is dimensionally stable under varying temperatures and it is not combustible.
Pennsylvania Perlite

www.pennperlite.com

Perlite Institute

www.perlite.org
Pouring concrete floor slab over 8” perlite and 12” of EPS Type 9 foam
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Homeowners Christie and Declan with contractor Rob Ciervo
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2x4 OVE structural frame
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Happy homeowners Christie and Declan
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RPA PASSIVE HOUSE WALL ASSEMBLY

- GYPSUM WALL BOARD
- 2x4 STRUCTURAL WALL @ 24" O.C. WITH ROCK WOOL INSULATION
- ZIP SHEETING TAPED AS AIR AND VAPOR BARRIER
- 11 7/8" TJI @ 24" O.C.
- SIGA MAJVEST
- 2 LAYERS OF 1x3 FURRING
- PINE BOARD AND BATTEN CLADDING
- SERVICE CAVITY FOR PLUMBING AND ELECTRIC
- AIR AND VAPOR CONTROL LAYER
- THERMAL CONTROL LAYER
- MOISTURE CONTROL LAYER
- INTERIOR FINISH
- VENT SPACE
- VAPOR OPEN
- EXTERIOR FINISH
Why this wall?

- Is a proven Passive House wall assembly
- High R value
- Uses conventional methods and materials
- Has an excellent vapor profile
- All 4 control layers are continuous and clear
- Cellulose is hygroscopic
- Cellulose is cheap
- Cellulose has low embodied energy
- The primary air seal is rigid and protected
- Includes a service cavity
- Is thermal bridge free
- Allows for Duclos method testing
OSB sheathing over 2x4 structural frame with entry door opening
Setting raised heel roof trusses
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Duclose Method

TEST 1
Initial test after slab/wall/ceiling close in
Prior to windows and door cutouts
Target benchmark
< 10,000 CF .25 ACH50
10,000 – 20,000 CF .20 ACH50
20,000 – 30,000 CF .15 ACH50
>40,000 CF .10 ACH50

TEST 2
Second air test after window and door installation
Prior to exterior or interior insulation
Target benchmark
< 10,000 CF .45 ACH50
10,000 – 20,000 CF .40 ACH50
20,000 – 30,000 CF .35 ACH50
>40,000 CF .30 ACH50

TEST 3
Third air test after MEP installation
Prior to exterior or interior insulation
Target benchmark
< 10,000 CF .60 ACH50
10,000 – 20,000 CF .55 ACH50
20,000 – 30,000 CF .50 ACH50
>40,000 CF .45 ACH50
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Sheathed and ready for blower door test #1
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Richard Pedranti, architect and Pete Vargo, PHIUS+ energy rater performing initial blower door test
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Leakage areas during blower door Test #1

- Second floor top plate / ceiling
- Second floor headers
- Missed field nails
- Mechanical penetrations

1.15 ACH@50Pa reduced to 0.93 ACH@50Pa
Preparing to positive test exterior after failed negative pressure test
Preparing positive pressure balloon test #1 on OSB panel and seam taped with SIGA wigluv
Ballooning of polyethylene over OSB during positive pressure test #1
“We have leaky OSB”

Pete Vargo

PHIUS + rater Pete Vargo - “I was right, we have leaky OSB”
Owner, Declan Mulhall and PHIUS + rater, Pete Vargo during balloon test #2 over OSB panel only
Balloon test #2 over OSB panel only
Air leakage Solutions

Concerns
• Needs to be 100% effective
• Cost effective
• Has a warranty
• Labor friendly
• Compatible with SIGA wigluv

Liquid applied
• Prosoco R-Guard Cat 5
• Dow Corning Defendair 200
• BASF Enershield
• Elastomeric paint

Membranes
• Pro Clima DA membrane
• SIGA Majpell 5
Installing SIGA Majpell 5 on exterior
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Richard Pedranti, architect and Pete Vargo, PHIUS+ energy rater performing initial blower door test
Second blower door test with first window installed
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WEYERHAUSER
MADE IN USA

APA
RATED SHEATHING
24/16

SIZED FOR SPACING
EXPOSURE 1
THICKNESS 0.418

537 (Elkin, NC)
PS2-10
HUD-UM-40C
7/16 CATEGORY

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Taping window interior

Preparing window exterior

South windows

Completed window installation
Transfer grill to bedrooms for cooling
**Transfer grill to bedrooms for cooling**

**Mitsubishi**
MSZ-FH09NA
MUZ-FH09NA
9,000BTU/h

**ASHP**

**GE Geospring**
HWHP
50 gallon
2.9 EF
Not ducted
700 CF required for operation
$1,000

**Renewaire EV200 ERV**
Renewaire EV200 ERV

HVI Certified

Static plate heat and humidity transfer

Can be mounted in any orientation

Merv 8 filter

At 157 watts produces 181 CFM and 78%

Intermittent operation

Measured 0.93 W/CFM

Cost $1,450 (unit, filters, and controls)

ERV single speed fan and Mitsubishi heat exchange core

Intermittent ventilation

Required = 94 CFM

Measured = 160 CFM

94/160 = 58%

Runtime = 60% or 40min/hr

Honeywell EARD motorized damper
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Scranton Passive House Duclose method test chart

- Test 1: Sheathed box
- Test 2: Windows
- Test 3: Mechanicals
- Final: PHIUS certification

- Duclose: 0.93 failed OSB, 0.41, 0.53, PH 0.6
- Tested: 0.32, 0.35, T=0.5, 0.43
Lessons learned

1. Based on our experience, OSB is not a reliable air control layer. We are specifying ZIP sheathing as the air control layer on all ongoing and future projects.

2. The Duclose method is a very effective approach to assuring high levels of air tightness. It’s also effective in teaching about air tight concepts to builders and stakeholders.

3. Perlite is a cost effective and easy to use sub slab insulation.

4. With carefully optimized design, it is possible to build an affordable Passive House in our region.
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Passive House cloud-based monitoring system
• Do it yourself
• Arduino based
• $300 +/-

The cloud
AWS
Table of data

Writing

Reading

Temperature and humidity sensors

Scranton PHlot

PHlot – Passive house Internet of Things

www.scrantonpassivehousedata.com
SCRANTON PASSIVE HOUSE

Passive House cloud-based monitoring system
• Do it yourself
• Arduino based
• $300 +/-

- 12V Power
- Mega 2560
- Shield
- Temperature and humidity sensor

LCD Readout

Internet
Passive House cloud-based monitoring system

All PHIUS projects should be PHIoT

The cloud
AWS
Table of data

PHIUS PHlot’s

PHIoT dashboard

Writing

Reading
South view of the Wylie Woods Passive House
South west view of the Wylie Woods Passive House
South view of the Keffer Passive House
KEFFER PASSIVE HOUSE

Gravel setting bed

Pouring slab over perlite and EPS foam

12” of EPS under slab foam

Completed slab with plumbing in place
KEFFER PASSIVE HOUSE

First floor 2x4 framing at 24” O.C.

Northwest view of ZIP sheathing over 2x4 frame

First floor framing at entry

Southeast view of ZIP sheathing over 2x4 frame
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Air tightness improvements
• ZIP sheathing
• Rolling the ZIP tape
• Redundant air tight detailing at the intersections
• Better quality construction
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0.03 ACH@50Pa
KEFFER PASSIVE HOUSE
KEFFER PASSIVE HOUSE

Bill Case and his crew, Pat, Bill, Drew, and Chris
SCRANTON PASSIVE HOUSE
Thank you