OUTLINE

Project & Design  (René Brakels AIA, CPHC, Centerbrook Architects)

Execution and Quality Control  (Gert Guldentops, P.E., SGH)

Q&A
CLIMATE
ZONE 6A
7,353 HDD
297 CDD
Main campus 13 miles
PH low loads

* RESILIENCY: longevity after a storm with partial buried electrical lines
* EFFICIENCY: Less demand on their solar farm
CONNECTION TO WATER
- Shell dominated
  - Higher internal gains
  - Lower internal gains
- Direct exhaust for lab
PHIUS+ 2018 METRICS: LLC

- Heating demand: 10.5 kBtu/ft²yr
- Cooling demand: 2.33 kBtu/ft²yr
- Heating load: 7.66 Btu/hr ft²
- Cooling load: 1.89 Btu/hr ft²

PHIUS+ 2018 METRICS: CABINS

- Heating demand: 14.86 kBtu/ft²yr
- Cooling demand: 1.32 kBtu/ft²yr
- Heating load: 8.32 Btu/hr ft²
- Cooling load: 2.16 Btu/hr ft²

- LLC envelope was leading
- Thanks to early modeling PH Cabins would require higher quality envelope because of low internal gains and more stringent requirements because of building type

* Space conditioning criteria is dependent on climate zone, building area, and building enclosure area; critical to leave a buffer in case iCFA changes
SENSE OF PLACE
SET RESPECTFULLY WITH NAVITIVE PLANTS
Project & Design
Execution and Quality Control
Q&A

HUB OF ACTIVITY
CONNECTED TO ITS SURROUNDINGS
1. Heating and cooling loads are minimized by using significantly more insulation than the building code requires under the foundation slab, within exterior walls, and especially under the roof.

2. Fully continuous vapor and air/weather barriers in the building envelope ensure air tight construction and proper moisture management.

PASSIVE HOUSE PRINCIPLES

3. Thermal bridging in the exterior envelope, which occurs when components span through walls, floors, and ceilings, should be minimized through careful detailing.

4. High performance windows in colder climates should have three layers of glass. Using fewer windows reduces winter heat loss, while optimizing their location encourages winter solar heat gain. Passive strategies, like solar shading to reduce summer heat gain, reduce energy consumption.

5. Mechanically-provided outdoor air is needed inside well-insulated and air tight buildings. As it is added, energy recovery systems transfer energy from the exhaust air to the incoming air stream.
LOW-E GLASS IN A WOODED AREA CAUSES REFLECTIONS. CONSIDER FIGHT FOR BIRDGLASS FILM.
Self contained air sealed chimney box with damper, coaxial direct exhaust and air intake
Tempered Air supply via ERV
‘Simple’ fully electric mechanical system:
- Air intake / exhaust with ERV (80% heat, 68% humidity)
- Local VRF heating / cooling
Different insulation approaches:

- Warm roof
- Cold roof
Different insulation approaches:

- **Warm roof**
  - visual appeal

- **Cold roof**
  - save on conditioned volume
  - shorter structural spans
  - cheaper insulation type

Interior thermal envelope modeled in WUFI
REALITY W/ STRUCTURE

@24" OC = 7%
WOOD VS INSULATION

6% LESS

@16+" OC = 16%
WOOD VS INSULATION

220% MORE
Cellulosic (dense pack insulation)
- ceilings
- cavity walls

XPS
- under slab
- below grade
- continuous ext.
FOCUSED ON OPERATIONAL CARBON REDUCTIONS, PRE-EMBODIED CARBON DISCUSSION: ENVELOPE WRAPPED IN XPS W/ ALUMINUM ROOFING
<table>
<thead>
<tr>
<th>Insulation type</th>
<th>Form / variant</th>
<th>GWP average kgCO2e per 1m2 Rsi-1</th>
<th>R-value per inch</th>
<th>$ per Ft2/R-1*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood fiber</td>
<td>board, unfaced</td>
<td>GBA -7.13 BEAM -0.26 EC3 6.00</td>
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<tr>
<td>Mineral wool</td>
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<td>GBA 3.25 BEAM 0.30 EC3 2.50</td>
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<td>0.07</td>
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<td>GBA 4.00 BEAM 0.25 EC3 2.50</td>
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</tbody>
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*note: installed cost varies per region / availability
Cellulosic (dense pack insulation)
- ceilings
- cavity walls

XPS
- under slab
- below grade
- continuous ext.

Wood fiber, High density mineral wool, EPS, Phenolic foam, NGX etc.
- under slab
- below grade
- continuous ext.
INSULATION: REFERENCE WALLS
INSULATION: REFERENCE WALLS

- EXTERIOR SHEATHING
- PHENOLIC FOAM
- THERMALLY BROKEN Z-GIRTHS
- LIQUID AIR BARRIER
## Insulation Type Comparison

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<td>Polyisocyanurate</td>
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<td>46.51</td>
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*Note: installed cost varies per region/availability

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### In-Office materials exploration – embodied carbon discussion

- **ENVELOPE INSULATION**
  - **A LOT**
  - **30x**
Project & Design  (René Brakels AIA, CPHC, Centerbrook Architects)

Execution and Quality Control  (Gert Guldentops, P.E., SGH)

Q&A
Building Enclosure Design

- Enclosure Assemblies
  - Exterior Walls
  - Slab on grade
  - Roofs
  - Windows

- Air Barrier Continuity

- Field Performance Testing
  - Whole building air leakage testing
  - Infrared thermography
Slab-on-Grade Design:
- Floor finish
- Reinforced concrete slab
- StegoWrap 15 mil reinforced vapor retarder
- 4 in. Extruded polystyrene insulation (R-20)
- Crushed stone with radon mitigation system
Exterior Wall Design Assembly Components:

- Board and Batten Siding
- Ventilated air space (1x4 PT strapping)
- 3 in. Extruded polystyrene insulation (R-15) over shims
- VaproShield SA (air/water-resistive barrier)
- 1/2 in. Advantech sheathing
- 2x6 wood framing with 5-1/2 in. Dense-Pack Cellulose Insulation (R-19)
- MemBrain (Smart) vapor retarder and air barrier
- Gypsum wallboard; painted.
Vented Roof Assembly (Adj Space w/Mech Mezzanine)

- Standing seam metal panels
- Self-adhering roof membrane underlayment
- 5/8 in. plywood
- Wood trusses (ventilated cavity)
- 18 in. Loose-fill cellulose insulation (R-60)
- MemBrain (Smart) vapor retarder
- Gypsum wallboard; painted

A – Vented Ridge

B – Vented Eave
Roof Assembly (Multi-Purpose Room)

- Standing seam metal panels
- Clad-Gard SA/MA Metal underlayment
- 4 in. nailboard insulation w/plywood (R-21)
- V-Force Vapor Barrier Membrane
- 5/8 in. T&G Advantech sheathing
- 2 in. nominal T&G wood deck
- Trusses and acoustic panels
BASE OF WALL

**Air Barrier Continuity**

- **Project & Design**
- **Execution and Quality Control**
- **Q&A**

**Air Barrier**

- CertainTeed MemBrain smart vapor retarder
- VaproShield WrapShield SA air barrier and water resistive membrane
- GCPAT Vycor membrane (air barrier transition)
- StegoWrap underslab vapor barrier
- Dampproofing

**Details**

- **Typ. Board and Battens Wall, See A5.02**
- Wrap flashing tape over penetrations
- Concrete dampproofing lap awb over flashing tape
- MTL DRIP EDGE
- HEAVY DUTY INSECT SCREEN
- Foundation insulation protection strip
- Stone drip edge see civil, sloped away from building
- **Typ. Below Grade Wall, See A5.02**
- Filter fabric - surround drainage gravel
- Perimeter footing drain to daylight

**Base of Wall**

- Seal flashing at each anchor bolt, TYP.
- 4" rubber base
- Lap wall VB over underslab VB with double sided Stego tack tape
- Sealant at edges, TYP.
- 1" rigid insulation
- Upturn
- Typ. Insulated concrete floor, see A5.02
- Underslab radon system, vented through roof
- Compacted gravel
- Concrete foundation, see structural
Air barrier plane
AIR BARRIER CONTINUITY
WINDOWS

- Salamander BluEvolution 82 uPVC windows
- Operability: fixed, tilt-turn, tilt
- Triple glazed IGU with applied muntins
  - Double low-e (#2 and #5 surfaces)
  - Argon-filled (90% argon)
  - Thermally-improved spacer (Swisspacer)
• PHIUS+ 2018 requirements for airtightness: 0.06 cfm/sq ft @ 50 Pa
  • Test 1: 0.088 cfm/sq ft @ 50 Pa (January 2020)
  • Test 2: 0.084 cfm/sq ft @ 50 Pa (March 2020)
  • Test 3: 0.066 cfm/sq ft @ 50 Pa (June 2020)
  • Test 4 (final): 0.053 cfm/sq ft @ 50 Pa (July 2020)
• We recommend preliminary tests during construction, when repairs are easier.
FIELD PERFORMANCE TESTING (AIR LEAKAGE)

Positive Pressurization

Neutral Pressure
Project & Design (René Brakels AIA, CPHC, Centerbrook Architects)
Execution and Quality Control (Gert Guldentops, P.E., SGH)
Q&A