Cold Climate Passive House Product Facility
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NYPH17 conference seminars are approved for PHI CPD Credits
Project Background

- **Client**: Manufacturer of health products
- **Building**: Production facility and staff offices
- **TFA**: 1,400m² (15,000 ft²)
- **Location**: Central Ontario
- **Design Temp**: -27°C (-17°F)
Project Requirements/Goals

• **Business:** Serve the current and future needs of a fast growing business
• **Well-being:** Healthy, comfortable environment for staff
• **Longevity:** Lifespan of 7 generations!
• **Sustainability:** LEED or Passive House
Cold Climate Overview

• Cold temperatures
  – Every decision matters more
  – Airtightness has huge impact
  – Frost protection, (low) humidity become problematic
  – Design temps influence functionality of equipment

• Product Availability
  – No local manufacturer of cold climate products
  – Very few on EU market
  – Some EU companies won’t export
Building Design

- **Design**: 3 storeys plus walk-out basement
- Compact Form
- Rational use of glazing
  - South: 25%
  - Other: 9-14%

North Facade
Massing

- Balance between daylight, solar gain, thermal, comfort, cost
- Glazing between offices enhances daylight
- Repeated window sizes
- Optimized shading elements
Shading

- Substantial south shading
Shading

- Substantial south shading
  - Basement window winter reduction factor = 21%
Floor Plans

Rooms grouped by use

• Basement
  – Storage, M&E rooms

• Ground
  – Production, packing, shipping

• Second
  – Office

• Third
  – Canteen, lounge, board room

• Exception: Washrooms spread out – longer pipes!
Original Layout

• Basement
  – Storage, M&E rooms

Storage with special extract

Cold Storage

Unexcavated
Thinking through the details early

- Cold store outside thermal envelope
  - Created thermal bridges
  - Introduced awkward insulation detailing
- Additional insulation required just to deal with thermal bridging
- Early TB model revealed substantial bridging at floor
  - \( \text{Psi-install} = 0.107 \, \text{W/mK} \) (0.062 BTU)!
Basement Layout

- **Initial Solution:**
  - Move rooms to outside of building outside envelope

- **Issue:**
  - Thermal bridging remains
Basement Layout

- **Alternative Solution:**
  - Bring everything within envelope
  - Use raft slab
  - TB-free!

- **Issue:** extract losses
Special Extract Requirements

- Liquid storage required spark-proof motors
  - Cost prohibitive to specify in ERV
  - Required separate extract
- **Solution**: Reduce:
  - Ventilation - Timer controlled – only ventilates when person enters room
  - Penetrations - Combine ducts into single vent
  - Convection - Airtight damper
Thermal Envelope
Basement Floor

- **Bedrock Site**
  - Shallow soil depth
  - Blasting required
  - Limited floor options

**Typical approach:**

- **Pinned footings**
  - Numerous penetrations of floor insulation

- **ICF Foundation Wall**
  - Lots of site work cutting EPS
Basement Floor

- **Solution:** continuous insulated raft
  - Engineered to avoid footings
  - Blasting fill provided level base
  - Slab edge element for continuous insulation
  - No penetrations
  - Includes elevator pit
Basement Floor
Walls

• Main
  – 2x8 structural wall with mineral wool batts
  – 8” ThermalWall EPS system
  – Gypsum board for fire rating

• Basement
  – Poured concrete with 13” ThermalWall EPS system (w/o steel track)
Intermediate Floors

- Ground Floor
  - 10” core concrete slab
- Second and Third
  - CLT
  - Foam filled
  - Acts as finish
Roofs

- **Top Floor**
  - Truss
  - 24” dense pack cellulose

- **Terraces**
  - 11” CLT
  - EPS above
  - Sloped insulation (various thicknesses)
Assembly Performance Summary

<table>
<thead>
<tr>
<th>Element</th>
<th>U-value [W/m²K]</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Slab</td>
<td>0.11</td>
<td>R52</td>
</tr>
<tr>
<td>Basement Wall</td>
<td>0.11</td>
<td>R52</td>
</tr>
<tr>
<td>Main Wall</td>
<td>0.10</td>
<td>R56</td>
</tr>
<tr>
<td>CLT Roof</td>
<td>0.07 – 0.11</td>
<td>R52-R81</td>
</tr>
<tr>
<td>Top Roof</td>
<td>0.07</td>
<td>R81</td>
</tr>
</tbody>
</table>
Terraces

- CLT prevents insulation installation above floor if flush threshold is desired

Psi-value = 0.064 W/mK (0.037 BTU)
Terraces

- **Solution**: raised floor above CLT
- **Issues**:
  - Lose CLT floor finish
  - Additional construction
- Deemed acceptable by client
Airtightness Strategy

- **Basement Floors & Walls**
  - Taped 15 mil Stego membrane

- **Main Walls**
  - Intello – required to avoid dew point issues
  - Protected by service cavity where services are installed
  - Wrapped around intermediate floors

- **Roofs**
  - Intello
  - Blueskin along CLT (exposed floors)

- **Windows**
  - Intello taped to window frames
Windows

- Comfort Requirement: $U_{w,\text{installed}} \leq 0.70 \text{ W/m}^2\text{K (0.12 BTU)}$
- Only **one** certified cold climate window available
  - Price was comparable to cool-temperate certified windows
- Could relax performance by including heat source by window
  - Would increase space heating demand
  - Layout and heating system not conducive for this
  - Baseboard heaters would cause issues with total electrical capacity
HVAC
Ventilation

- Building Layout facilitated centralized approach
- Flow rates can be controlled based on occupancy
  - Working hours → office & production
  - Lunch → shift to canteen
- Extract in production rooms enables more balanced flow
- Only **one damper pair** per floor required
Ventilation

Issues:

- Floor Layout only allowed for **heating/cooling ducting in suspended ceiling**, not additional ventilation ducting
- Engineer and designer were hesitant to rely on single HRV
- Opted for semi-decentralized with 7 HRVs
  - Numerous issues...
Issues with Decentralized Ventilation Approach

- **Over-ventilation**
  - Extract rooms → Supply rooms
  - Code rates much higher than PH

- **Only condensation recovery**

- **Uncertified Performance**
  - 95% claimed by manufacturer
  - PH testing: initial results: 75%

- **Longer ducts**
  - Up to 10.5m (35 ft)!
  - Up to 6% ↓ in HRE

- **Dual core**
  - Cycling of airflows

- **Ducts shared with heating/cooling system**
  - Mismatch in flow rates
Heating & Cooling

- **Residential VRF system**
  - Heads installed in suspended ceiling above corridors and ducted to each room
- **Total Electrical Capacity limited by utility company**
  - Process, elevator loads
- **No products small enough for heating/cooling capacity**
- **Heat Pump system**
  - Manufacturer claimed it could operate below design temperature
  - Code requires backup system for peak loads when using heat pumps
  - Electric resistance not possible, due to capacity limit
  - No natural gas connection
  - **Solution**: Propane-fired boiler
  - Also used for DHW (small demand)
Summary

• Think through the details early
  – Initial thermal bridging modelling

• Simplified approach critical in cold climates

• Find engineers who are willing to explore options

• Cold climate product innovation required
Questions?

Thank you for your attention

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In Association with:
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