Passive House Goes to Work: Western Canada’s First Passive House Office Building

Presented by

GRAEME VERHULST – Waymark Architecture
PASSIVE HOUSE FOR COMMERCIAL OFFICE

OVERVIEW

1. Introduction to Charter Telecom
   • design brief
   • location & climate
2. Design Challenges and Process
   • site geometry & constraints
3. Construction Status and Lessons Learned
4. Take-Aways and Recommendations
5. Questions
• Private development – build, hold, occupy, maintain
• Not driven by typical build-to-lease pressures (LEED)

• Desire for:
  • Occupant Comfort and Quality Work Environment
  • Resilience and High Quality of Construction
  • Reduced Operating Costs
  • ... without major premium on construction cost
PROJECT INTRODUCTION

CONTEXT

• 2 levels office + 1 level amenity/meeting/exec suites

• 16,186 sqft [1,504 sq m] gross floor area
  (Floor Area Ratio calculation)

• 9,718 sqf [902.8 sq m]
  TFA (Passive House Calculation)
PROJECT INTRODUCTION

LOCAL CONVENTIONS

• BC Energy Code:
  • ASHRAE 90.1-2010 or
  • (Canada) NECB
  • “Baseline vs. Proposed”

• BC Energy Step Code
  • “Net Zero Energy Ready” by 2032
  • Absolute Metrics:
    • TEUI ~ PE
    • TEDI ~ Qh
    • Mandatory energy model
    • Mandatory air tightness testing
PROJECT INTRODUCTION

CLIMATE

- Langford, BC (Greater Victoria, BC, Canada)
- Pacific NW - Climate Zone 4 (~2950 HDD18ºC or 5310 HDD65ºF)
PROJECT INTRODUCTION

CLIENT AND TEAM

• Client
  • Tech Company; recent expansion
  • Project will consolidate 55 staff from 2 existing locations

• Design & Construction Team
  • some PH experienced, others new to PH
PROJECT INTRODUCTION

SITE CONSTRAINTS

• Narrow (20m)
• Adjacent properties expected to be developed
• South elevation – primary entrance and frontage
• Significant east and west exposures
• Commercial Office PH in Canada – unique

• External climate is heating dominant

• Most local PH examples and experience regionally are in smaller and residential-use projects.

• Key difference...?
DESIGN CHALLENGES AND PROCESS

BROAD STROKES
DESIGN CHALLENGES AND PROCESS

BROAD STROKES
PROJECT DESIGN

SITE CONSTRAINTS
DESIGN CHALLENGES AND PROCESS

THERMAL ENVELOPE BOUNDARY

• Conditioned vs. Unconditioned Space
  • Elevator lobbies and stairs are outside of thermal building envelope
  • Reduce complexity, exposure, articulation, interface with unconditioned parking
  • Transient occupants anyway
DESIGN CHALLENGES AND PROCESS

SPACE PLANNING - PROGRAM

- Feature Stair/Gathering
- Open Office (admin)
- Open Office (engineering)
- Lunch/kitchen
- Exercise etc
- Lounge
- Fire exit
- Elevator
- Entry stairs
- Lobby
- Lab/shop
- Washrooms
- Circulation

WAYMARK
DESIGN CHALLENGES AND PROCESS

SPACE PLANNING - SERVICES
DESIGN CHALLENGES AND PROCESS
DESIGN CHALLENGES AND PROCESS

CONSTRUCTION SEQUENCING
DESIGN CHALLENGES AND PROCESS

CONSTRUCTION SEQUENCING
DESIGN CHALLENGES AND PROCESS

STRUCTURE AND PENETRATION COORDINATION

• Cross-Laminated Timber (CLT) Construction
DESIGN CHALLENGES AND PROCESS

STRUCTURE AND PENETRATION COORDINATION

• Mass Timber Construction - Cross-Laminated Timber (CLT) & Gluelam
One reason we didn’t go with concrete
DESIGN CHALLENGES AND PROCESS

STRUCTURE AND PENETRATION COORDINATION

• Mass Timber Construction - Cross-Laminated Timber (CLT) & Gluelam
DESIGN CHALLENGES AND PROCESS

FINAL ENVELOPE SYSTEM

MEMBRANES & INSULATION

STRUCTURAL TRADES

CLADDING TRADES
DESIGN CHALLENGES AND PROCESS

FINAL ENVELOPE SYSTEM
### DESIGN CHALLENGES AND PROCESS

#### PASSIVE HOUSE STATS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated Floor Area</td>
<td>903 sq m</td>
<td>[9,718 sqft]</td>
</tr>
<tr>
<td>Envelope Area</td>
<td>2025 sq m</td>
<td>[21,797 sq ft]</td>
</tr>
<tr>
<td>Ratio TFA: Envelope</td>
<td></td>
<td>2.24</td>
</tr>
<tr>
<td>Wall Insulation</td>
<td>U-value 0.123 to 0.142</td>
<td>[R 40 to 41]</td>
</tr>
<tr>
<td>Roof Insulation (average for sloped insulation)</td>
<td>U-value 0.128</td>
<td>[R 40]</td>
</tr>
</tbody>
</table>
Passive House Certification Criteria:
• Cooling + Dehumidification Demand < 15 kWh/m²-yr + dehum contribution
  OR
• Cooling Load < 10 W/m²

Typical Office Cooling Loads…
• Sedentary Office Occupant…
  • 245 BTU/h (71 W) per person
• Typical Lighting…
  • 0.7 to 1.1 W/sqft
• Typical Computers “Medium Density”…
  • 1.0 W/sqft
• Typical Photocopier…
  • 550 W
• Typical Coffee Machine…
  • 1200 BTU/h (350 W)

10 W/m² criteria barely covers office lighting → unrealistic to this criteria for commercial buildings
## DESIGN CHALLENGES AND PROCESS

### COOLING DEMAND INTENSITY

• Comparison of Cooling Loads:

<table>
<thead>
<tr>
<th></th>
<th>W/m²</th>
<th>W/sqft</th>
<th>sqft/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive House Criteria</td>
<td>10</td>
<td>0.93</td>
<td>3778</td>
</tr>
<tr>
<td>ASHRAE Internal Gains at:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 1.0 W/sqft lighting</td>
<td>25.4</td>
<td>2.36</td>
<td>1489</td>
</tr>
<tr>
<td>• 1.0 W/sqft equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 5 people/1000sqft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Commercial Office Rule of Thumb</td>
<td>63</td>
<td>5.85</td>
<td>600</td>
</tr>
</tbody>
</table>

• Actual design capacity for Charter Telecom

18.5 tons over 12,000 sqft = 650 sqft/ton = 58 W/m²
• Missed Opportunity to reduce CDI and PE using Natural Ventilation and Passive Cooling
VENTILATION & EQUIPMENT LIMITATIONS

• HRV-1 – Office Level 1 (2000 CFM)
• HRV-2 – Office Level 2 (2000 CFM)
• HRV-3 – Executive Hospitality Suites (200 CFM)
• HRV-4 – Amenity/Meeting (1200 CFM)
• Variable Refrigerant Volume (VRV) System
CONSTRUCTION STATUS & LESSONS LEARNED

CONCRETE TO WOOD
CONSTRUCTION STATUS & LESSONS LEARNED

ENGINEERED MASS TIMBER
CONSTRUCTION STATUS & LESSONS LEARNED

ENGINEERED MASS TIMBER
CONSTRUCTION STATUS & LESSONS LEARNED

ENGINEERED MASS TIMBER
CONSTRUCTION STATUS & LESSONS LEARNED
AIR AND WEATHER BARRIER
CONSTRUCTION STATUS & LESSONS LEARNED

INTERIOR
CONSTRUCTION STATUS & LESSONS LEARNED

COSTS Envelope

- Framing/finishing costs similar to any other building of this type
- Envelope ~$22/sqft
- I-joist, insulation, air barrier, WRB, rain screen
- Some of these costs are not “extra”, they are just different
- Total extra envelope cost works out to about $200,000
CONSTRUCTION STATUS & LESSONS LEARNED

COSTS Mechanical

- $125K  Plumbing ($10/sqft)
- $309K  VRV HVAC System ($25/sqft)
- $213K  HRVs + Sheet Metal ($18/sqft)
- $80K  Insulation, Firestop, T.A.B.
- TOTAL = approx $60/sqft

- Mechanical is on-par with comparable non-PH office.
Total Construction Cost = $6.0M CAD
(approx. ~$375 / gross sqft)

Vancouver Island region has seen recent surge in construction costs, driven by recent demand for residential development.

Steal of a deal for a signature building. Represents higher-end range of Class A low-rise office construction including full interior fitout.
1. Passive House principles can offer comfort, quality, and value for private commercial developments.
2. Beware cooling requirements. Consider an Engineered Natural Ventilation System if climate allows.
• On track for certification

<table>
<thead>
<tr>
<th></th>
<th>Treated floor area m²</th>
<th>902.8</th>
<th>Criteria</th>
<th>Alternative criteria</th>
<th>Fullfilled?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space heating</td>
<td></td>
<td></td>
<td>≤ 15</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Heating demand kWh/(m²a)</td>
<td>7</td>
<td></td>
<td>≤ 15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Heating load W/m²</td>
<td>8</td>
<td></td>
<td>≤ 10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Space cooling</td>
<td></td>
<td></td>
<td>≤ 15</td>
<td>15</td>
<td>yes</td>
</tr>
<tr>
<td>Cooling &amp; dehum. demand kWh/(m²a)</td>
<td>5</td>
<td></td>
<td>≤ 15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Cooling load W/m²</td>
<td>0</td>
<td></td>
<td>≤ 15</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Frequency of overheating (&gt; 25 °C) %</td>
<td>-</td>
<td></td>
<td>≤ -</td>
<td>15</td>
<td>yes</td>
</tr>
<tr>
<td>Frequency excessively high humidity (&gt; 12 g/kg) %</td>
<td>0</td>
<td></td>
<td>≤ 10</td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Airtightness</td>
<td>Pressurization test result n₅₀ 1/h</td>
<td>0.6</td>
<td>≤ 0.6</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Non-renewable Primary Energy (PE)</td>
<td>PE demand kWh/(m²a)</td>
<td>106</td>
<td>≤ -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Primary Energy Renewable (PER)</td>
<td>PER demand kWh/(m²a)</td>
<td>47</td>
<td>≤ 60</td>
<td>60</td>
<td>yes</td>
</tr>
<tr>
<td>Generation of renewable energy (in relation to projected building kWh/(m²a))</td>
<td></td>
<td>0</td>
<td>≥ -</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

注：空格：数据缺失；-：无要求

WAYMARK
CONCLUSIONS

TAKEAWAYS AND RECOMMENDATIONS

4. Integrated Design Process - the only way to design and build Passive House for a reasonable cost