BUILDER INSIGHT

BC HOUSING RESEARCH CENTRE

FACTS AND FIGURES

Construction timeline:
January 2019 – May 2021

Construction budget:
$18.99m

Residential units:
102

Site area:
3,820m^2 (41,103 ft^2)

Total Gross Floor Area:
8,323m^2 (89,555 ft^2) inc. Parking

Gross Floor Area, Residential:
6,121m^2 (65,862ft^2)

Building Height:
23.9m (78.4ft)

Occupancy Classification:
BCBC 2012, Group C- Residential (6 levels), Group F3 – Garage (2 levels)

PROJECT TEAM

Owner:
Greater Victoria Housing Society

Architect:
Cascadia Architects

Envelope and Energy modelling:
RDH Building Science

Structural Engineering:
RJC Engineers

Building Code and fire science:
GHL Consultants Ltd.

General Contractor:
Kinetic Construction

Timber and prefab. installer:
Ron Anderson & Sons

Timber panel fabricator:
ZyTech

Siding contractor:
Brytar Contracting

Research management:
Scius Advisory

Lean coach:
Shift2Lean

Video, webcam and photography:
Multivista

Bulletin No 3 | 330 Goldstream Avenue

Energy Efficient Light Wood Social Housing Project

Located in the City of Colwood in the Capital region of Vancouver Island, 330 Goldstream Avenue comprises 102-units of nonmarket housing for individuals, couples, and families with low-to-moderate income.

Developed by the Greater Victoria Housing Society (GVHS) and funded by BC Housing, the six-storey wood frame building comprises 6,121m^2 (65,862ft^2) of gross floor area over two storeys of underground parking.

The building accommodates a range of unit sizes – 50 studios, 39 one bedroom, one two bedrooms and 12 three bedrooms.

Energy Efficient Building

GVHS chose to voluntarily achieve Step 4 of the BC Energy Step Code – the highest step for multi-family residential buildings. The objective was to attain the highest level of occupant comfort and to manage ongoing operations costs while protecting against overheating.

Brytar Contracting installing the cladding (Source: Multivista)

Right: RDH performing the blower door test (Source: Scius)

This bulletin series covers different aspects of this innovative social housing project. Find them all in the BC Housing Research Centre Library.

Building Performance Targets

At the time of design, 330 Goldstream was required to comply with the 2012 BC Building Code. After early discussions, GVHS accepted the recommendations of the project architect (Cascadia Architects) and building science consultant (RDH Building Science) to set an energy performance goal similar to those defined in the Passive House standard and Step Code 4 of the yet to be adopted BC Energy Step Code.

Cascadia Architects and RDH Building Science had prior experience with the Passive House standard, which favoured an "envelope first approach", with particular attention paid to insulation and airtightness. The project team aimed for an airtightness target of 0.6 ACH50. The lower the air leakage, the more stable the interior conditions, and the less energy being wasted to maintain it.

Building Performance Strategies

The consultants applied their Passive House expertise to 330 Goldstream to achieve excellent energy performance in one of the largest multifamily residential buildings in Colwood.

Using Passive House and Step Code 4 as a start point, the consultant team set demanding criteria for energy consumption, airtightness, and overall energy demand. The project team opted for the following performance:

Performance Standard	
Required for Step 4: Thermal Energy Demand Intensity (TEDI)	15 kWh/m²/yr
Required for Step 4: Thermal Energy Use Intensity (TEUI)	100 kWh/m²/yr
Additional Performance Goal: Air tightness	0.6 ACH @ 50pa
For Victoria (>3000 Degree Days)	

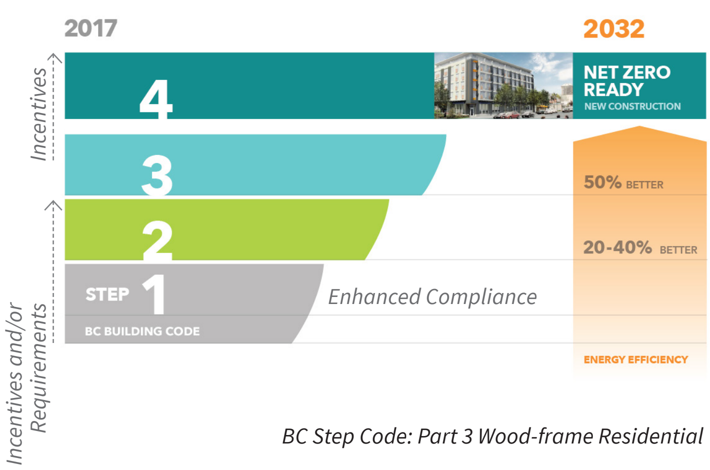
Building Modelling

To inform 330 Goldstream's design, the consultants utilized the Passive House Planning Package (PHPP) to model the building's energy performance during early design. While PHPP modelling was not required for regulatory approval, it is a powerful, intuitive software application that works well for mid-rise multi-family buildings. It helped the design team assess building heat loss, energy demand and summertime overheating risk. It also provided a good assessment of the project's potential carbon emissions.

During construction, the project team proposed two formal blower door air tests at key milestones (at envelope completion and construction completion) to verify that actual performance will be similar to the model. With the adoption of the BC Energy Step Code today by many Authorities Having Jurisdiction, blower door testing is now a requirement.

330 Goldstream Airtightness Performance		
Blower Door Target ACH @ 50 pa	Blower Door Test: Envelope Completion	Blower Door Test: Construction Completion
0.6	**0.44**	**0.55**

Pathway to 2032: Part 3 (Wood-Frame Residential)



BC Step Code: Part 3 Wood-frame Residential

The Wood Story

The exterior and interior light wood frame wall panels were prefabricated not only to condense building erection time through "just in time" delivery, but also to achieve the high-performance envelope. Prefabrication in a dry, controlled environment and the use of computer-aided manufacturing delivers the precision, predictability and quality control necessary to construct a building that has to exceed an airtightness target of 0.6 ACH quickly and efficiently.

Kinetic, the specialist panel installer (Ron Anderson and Sons) and envelope contractor (Brytar Contracting) used Lean planning principles to coordinate the prefabrication and site assembly processes. This also included the pre-installation of the sheathing membrane onto the plywood face of the wall panels at the factory. The result of this effort was the project achieving an impressive ACH of 0.55 at Substantial Completion. See Bulletin #4: The Prefabrication Process, for more details.

Off-site pre-installation of the wall air barrier membrane

Kinetic and Brytar Contracting proposed the pre-installation of the air barrier sheathing membrane at the panel manufacturer's (Zytech) plant in Langley, BC. They then worked with the architect, envelope consultant, prefab panel installer, panel manufacturer and the membrane supplier to develop details, application solutions and training for the installers. See Bulletin #4 for more information.

A key supplier for the prefabricated project envelope was SRP Canada, which provided the "AirOutshield SA 280" Air Vapour-Moisture Membrane. SRP supported the team by sending a representative to develop novel envelope details, and to assist with SRP's patching procedures and specifications for the pre-installation, delivery and site connection tasks.

ZyTech's Langley prefabrication plant, production floor
(Source: Scius)

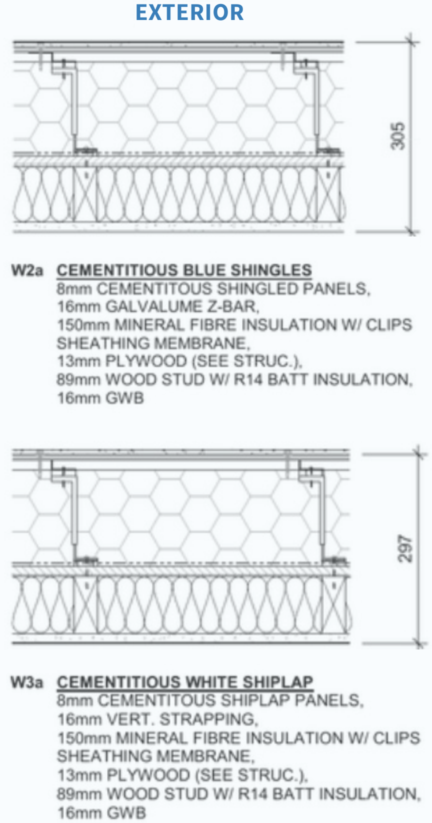
Key Envelope Details

Wall Detail

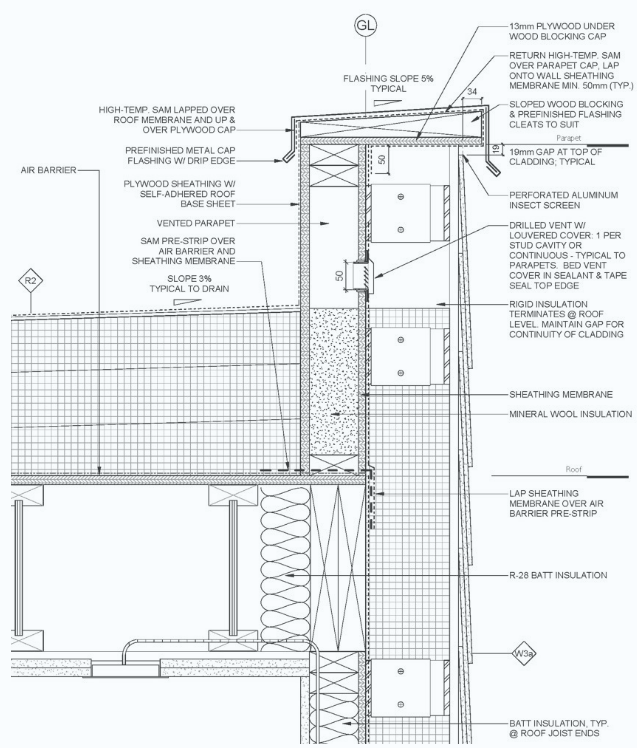
The wall and envelope details were originally designed as traditional light-wood frame site built construction. With the shift to prefabrication for the exterior and interior walls, the project team modified the details and pre-applied the sheathing membrane. With the decision to prefabricate occurring late in the design phase, the project team also had to build full-scale mock-ups on site to test and, where necessary, modify the wall details to optimize constructability, for both the cementitious shiplap cladding panels and the shingles.

Roof Detail

The flat roof was a modified SBS roof over insulation that sloped to roof drains. The pitched roof sections were constructed as unheated mechanical sheds, built over a SBS roof assembly similar to the flat roof portions.



Typical Wall Detail



Typical Parapet Detail

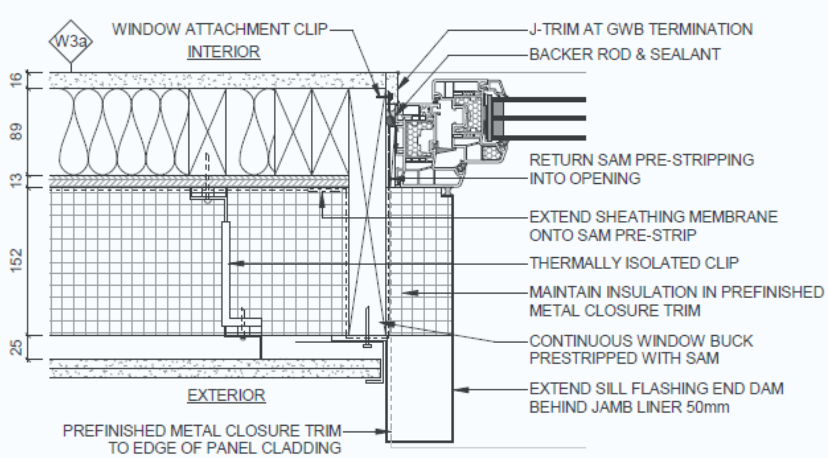
(Source: Cascadia Architects)

Window Details

The window details required "thinking in 3D". The architect, envelope consultant and envelope contractor collaborated on a series of full-size mock-ups to develop solutions after construction was under way. While pre-applying the sheathing and membrane to the wall panels at the prefabrication plant offered the benefit of speed of installation, it also resulted in some challenges at panel connections, windows and balconies:

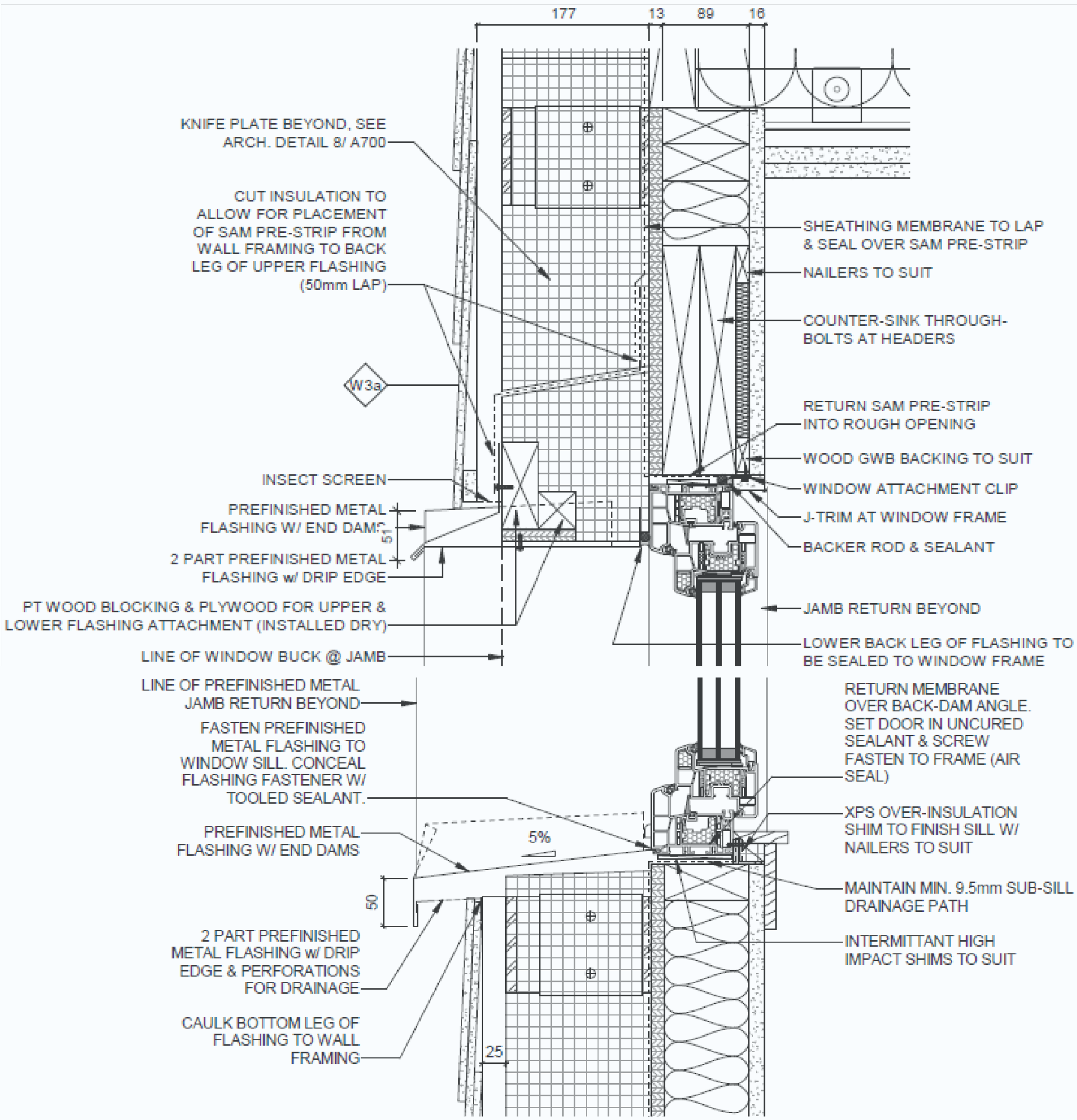
- The pre-applied membrane lapped at the panel edges and openings had to be secured open. This trade-off increased the chances of damage during transportation, but simplified membrane connections on site.
- The panel to rim board detail was particularly sensitive to prefab panel tolerances. During panel erection, this became a major challenge for Brytar Contracting who had to make numerous repairs. The first framing crew was replaced as they were not experienced with site assembly of prefabricated panels.
- 2x10 window bucks interrupted the wall membrane. The installation sequencing had to be resolved through mock-ups to ensure that moisture protection was continuous.
- The window head flashing to window buck details were tricky to execute given the membrane needed to slope and cut through the insulation and then lap over the buck.

Tricky membrane flashing connections
(Source: Scius)



Window buck detail
(all dimensions in mm)

(Source: Cascadia Architects)



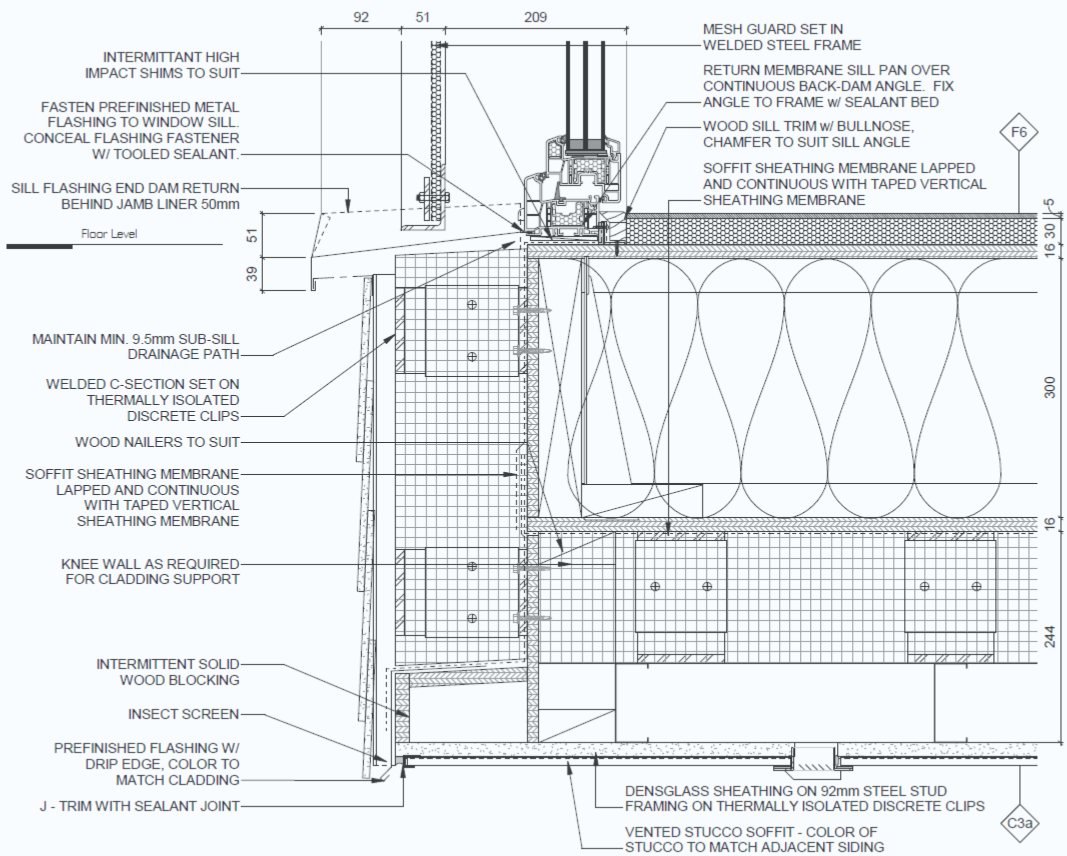
Typical window head/sill detail (all dimensions in mm)

(Source: Cascadia Architects)

Balcony Sill Detail

At each building level, balcony sills had a flashing and vent detail that extended beyond each side of the balconies, acting as a rainscreen vent for each level. This was a difficult detail, requiring mock-ups to determine the best construction sequence to achieve the following:

- **Structural support:** The flashing had to be structurally supported while, at the same time, minimizing thermal bridging. With 150mm (6") of exterior insulation outboard of the timber framing, each piece of flashing was quite long.
- **Installation:** The flashing assembly extended out from each balcony sill close to the window bucks (a feature shared with the window details). The narrow clearances made the construction sequence and connections tricky.
- **Finished appearance:** The flashing had to be level along large spans at each building level.
- **Insulation performance:** The vents had to function while maintaining continuous insulation.



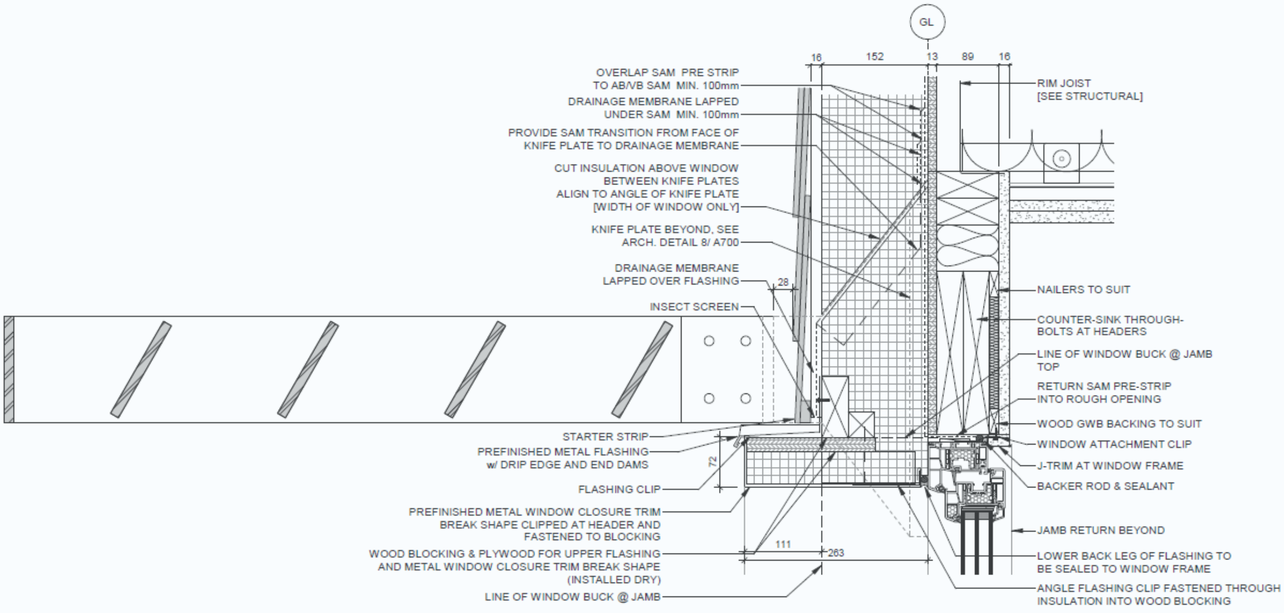
Building level rainscreen flashing detail (all dimensions in mm)

(Source: Cascadia Architects)

Sunshade Detail

The sunshade structural connection was a complicated envelope detail that required the team to carefully think through thermal, moisture and air barrier continuity during installation.


Image series: Complex flashing and cladding connections at building levels
(Source: Scius)



Sunshade connection detail
(all dimensions in mm)

(Source: Cascadia Architects)

Lean Tips: Envelope Construction and Optimal Energy Efficiency

Lean and Last Planner's principles provide methods that can help project teams to resolve the multi-dimensional challenges affecting envelope and energy efficient design (See Bulletin #2: Lean Construction Practices, for more details). The 330 Goldstream team's adoption of Last Planner exposed the difficulties with design-construction coordination that could have been resolved if Lean had been adopted earlier. The following tips have been distilled from the 330 Goldstream experience.

Design-construction Technical Workshops

Last Planner attempts to ensure that upstream tasks address the requirements of downstream tasks by clearly defining what is needed as early as possible. To achieve this, the project team suggests convening technical "workshops" with trades during design (or ideally before design) to incorporate constructability earlier into envelope and design for energy efficiency. Bringing trades on early needs to be planned for the start of the project.

Front-end collaboration between consultants and trades can minimize or eliminate a lot of re-design and re-work. The fact that this process started later on 330 Goldstream resulted in the need for time-consuming mock-ups and several design iterations during the construction phase, where mistakes are more costly, and the schedule more sensitive to delays.

Constructability Planning

A foundational tenet of Lean is respect for people. Last Planner achieves this by ensuring that each team member communicates and understands what they need to do a good job. The project team recommends the use of 3D models, physical scale models or even white board sketches to visualize and resolve envelope constructability ahead of time, using TIMMESS to catalogue predecessor and successor requirements to ensure error-free and efficient, sequential construction.

On 330 Goldstream, the consultants and the envelope contractor worked together exhaustively on full-scale mock-ups to successfully resolve issues, but this put pressure on the schedule and required the consultants to attend more site meetings than planned.

Construction Sequencing

Lean focuses on the "production sequence" to ensure that the hand-offs between team members are smooth and efficient. Last Planner and the meetings that occur weekly in the Big Room are directed towards eliminating superfluous or duplicated tasks (i.e., waste). The team recommends an open-minded approach focused on meeting the owner's requirements and clearly defined (and agreed-to) conditions of success.

Given how critical the envelope details and connections are, the project team eliminated contractual "grey areas" where it was unclear whose package of work a key task falls under. For 330 Goldstream this meant amalgamating the fenestration connections, back-framing and flashings into the envelope contractor's scope to ensure continuity and that critical connections were under the direct responsibility of one trade. Kinetic Construction also retained a full-time field engineer to coordinate and review the work of trades with an impact on the building envelope, ensuring penetrations and connections were dealt with correctly.

Incorporate Mechanical and Electrical Into the Lean Process

Ideally, all consultants should be integrated into the Lean planning process. However, for 330 Goldstream, the "Lean team" did not extend to the mechanical and electrical design, which was already complete by the time the contractor came on board.

For 330 Goldstream, the mechanical and electrical design was deliberately kept simple for efficiency of construction and ongoing operations. Space heating, cooling and ventilation is provided by three roof top Swegon Gold RX Heat Recovery Ventilators (HRVs) serving three building zones, supported by electric baseboards in each suite. A pair of Lochinvar Knight XL high efficiency natural gas boilers provides all the domestic hot water for the building. Third-party system commissioning was completed by Morrison Hershfield.

Overcoming Constructability Challenges

Constructability Review

Pre-construction, Kinetic was brought on too late in the design process and for too short of a period, which limited the benefit of the constructability review. It would have been preferable to have closer collaboration during the detail design stage with all the project team members, to ensure "what is designed, is what can be efficiently built".

More substantive pre-construction planning might have avoided, for example, an SRP representative having to fly out to BC from Toronto to provide advice on detail revisions and unique procedures to accommodate pre-installation, transportation, patching, etc.

Late Adoption of Offsite Prefabrication

The late decision to prefabricate the wall panels and to pre-install the sheathing membrane meant that the building had to be re-designed for prefabrication as construction was getting under way. This meant that the consultants were working within limited fees, and the contractor and trades adjusting the schedule "on the fly" to accommodate the changes. Prefabrication offers tremendous opportunities for efficiency, but it is a decision that must be made early on with the fabricator directly involved in structural design.

Design Tweaks During Construction

As design-construction coordination on 330 Goldstream fell behind schedule, details had to be revised and approved by two separate teams: the consultants who would take responsibility and the trades who were to build it. Inevitably, changes and rework were unavoidable. However, the experience and attention to detail of the consultants and trades teams working together minimized major negative impacts.

Accommodate Variations

Aligning the prefabricated wall panels with the rim joists was time consuming to address given the limited adjustability of the thermally broken "L" clips for the cladding. Kinetic's own forces and the envelope contractor had to complete extensive back-framing and other modifications to ensure that the substrate variation did not show through in the exterior finish or affect performance of the building envelope.

Membrane-first Approach

Once installation of the wall membrane was complete and prior to starting the exterior insulation and cladding, Kinetic conducted several diagnostic airtightness tests. While this slowed down the envelope contractor's work, it allowed the interior fit out to start sooner than planned which was a benefit to the project overall. It also enabled the team to identify, assess and remediate any issues before the final recorded test was conducted – achieving 0.55 ACH.

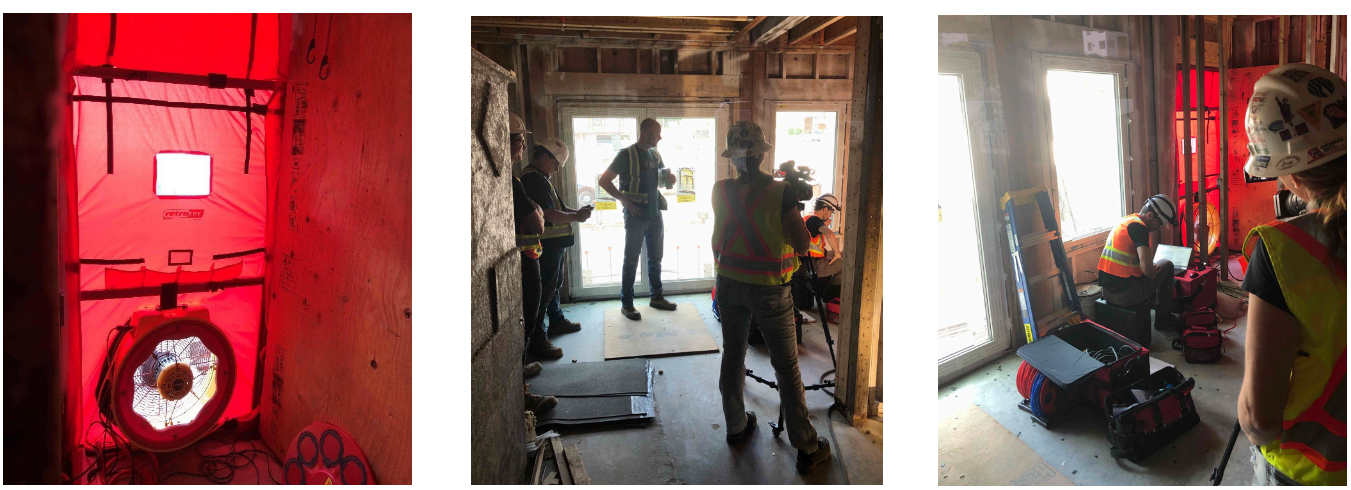


Image series: RDH blower door testing
(Source: Scius)

Construction Strategy: COVID-19

Field-based mock-up procedures:

To work within the constraints imposed by the COVID pandemic, the project team developed a simple photo and video based "pre-mock-up" procedure to allow continuous collaboration while limiting the need for consultants to attend or interrupt work on site – an efficiency measure that continued after COVID restrictions were lifted.

1. The envelope contractor-built mock-ups and documented step-by-step construction with photographs and/or video and shared them with the architect and envelope consultant.
2. The envelope contractor discussed the step-by-step documentation with consultants online or by phone.

When the architect and envelope consultant were satisfied, they met on site to inspect the mock-ups as required.

Envelope Testing

Moisture testing:

On May 2020, the envelope consultant performed the water penetration testing per "ASTM E1105 Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference".

The primary issues identified were:

- The window bracket and fasteners required caulking to ensure moisture and air resistance.
- Metal L "back-dams" can make the sill corners difficult to seal from moisture ingress. A combination of moon-shaped "scab" type membranes and caulking helped to moisture-proof these tricky areas.

Envelope substantial completion: Test #1:

The Envelope Substantial Completion test was held in June 2020, achieving 0.44 ACH which was well within the project goal of 0.6 ACH. With the test complete, the envelope contractor began the exterior insulation and cladding.

Envelope completion: Test #2:

In March 2021, as the building neared completion (complete with insulation, cladding, mechanical and electrical penetrations), a final blower door test was performed. The building's final performance was 0.55 ACH.

Acknowledgement

BC Housing gratefully acknowledges funding support from Forestry Innovation Investment for this bulletin series. Our sincere appreciation to the Greater Victoria Housing Society, and the entire project team for their cooperation.

About BC Housing Research Centre

BC Housing's Research Centre works in collaboration with housing sector partners to foster excellence in residential construction and find innovative solutions for affordable housing in British Columbia. Sharing leading-edge research, advances in building science, and new technologies encourages best practice. The Research Centre identifies and bridges research gaps to address homelessness, housing affordability, social housing challenges and the needs of distinct populations. Mobilizing knowledge and research expertise helps improve the quality of housing and leads to innovation and adoption of new construction techniques, Building Code changes, and enhanced education and training programs. Sign up to receive the latest news and updates from BC Housing's Research Centre at **www.bchousing.org/subscribe**.

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