BUILDER INSIGHT

BC HOUSING RESEARCH CENTRE

Bulletin No 4 | 330 Goldstream Avenue

Prefabrication – High-Performance 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.

Condensing the Construction Schedule with Prefabrication

GVHS had a tight timeline. 330 Goldstream was built using prefabricated, light wood-frame exterior and interior wall panels with site-framed light-wood floor joists to condense the construction schedule.

330 Goldstream Prefab. Construction
(Source: Multivista)

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

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

Prefabrication Strategy

330 Goldstream used prefabricated, light wood-frame exterior and interior wall panels with site-framed floor joists. The project achieved very good energy performance (Step 4 of the BC Energy Step Code) within a tight construction schedule. The general contractor, Kinetic Construction, recommended prefabricating the walls for the following reasons:

1. Offsite wall panel production would run concurrently with on site construction of the lower concrete parkade floors.
2. Less storage and handling space would be required (where space was very limited) because the completed panels can be delivered "just in time" for installation.
3. The prefabricated structure (which included steel moment frames and a wood truss package in addition to the timber wall panels) could be assembled quickly, allowing for the envelope trade (Brytar Contracting) to tightly sequence the sheathing membrane installation right after the erection of the wood structure.
4. Overlapping the wood structure and building envelope schedules condenses the overall project timeline, allowing the air tightness testing to occur sooner. Once testing was passed, the interior fit-out can start much earlier than a conventional project.

Kinetic set the wood frame assembly and sheathing membrane installation (and blower door testing) as critical project milestones.

The framing and panel installation company (Ron Anderson and Sons) planned for panel erection to take 10 days per level. Despite being faced with inclement weather and a delivery delay for the roof trusses, the total erection time for the 6-storey structure was 69 working days – only 9 days longer than planned.

330 Goldstream Lean Project Timeline	
May 2018	Kinetic Construction retains Ron Anderson & Sons for Constructability Consultation – recommends prefabrication for 330 Goldstream
	Lean Planning Workshop #1 Lean Boot Camp
November 2018	Contract Award to Kinetic Construction
January 2019	Construction Start
	Lean Workshop #2 Lean On-boarding
February ? 2019	Lean – Big Room: Zytech/Ron Anderson and Sons prefabrication coordination
March ? 2019	Shop Drawings: Zytech light wood frame prefabrication packages
May 2019	Prefabrication Start: ZyTech
July 2019	Lean - Big Room: Wall membrane: Lean coordination with Brytar Contracting on site assembly planning
October 2019	Prefab light-wood panels installation starts
January 2020	Weather: Rain and snow delay
February 2020	Light wood structure substantial completion

Prefabrication and Lean

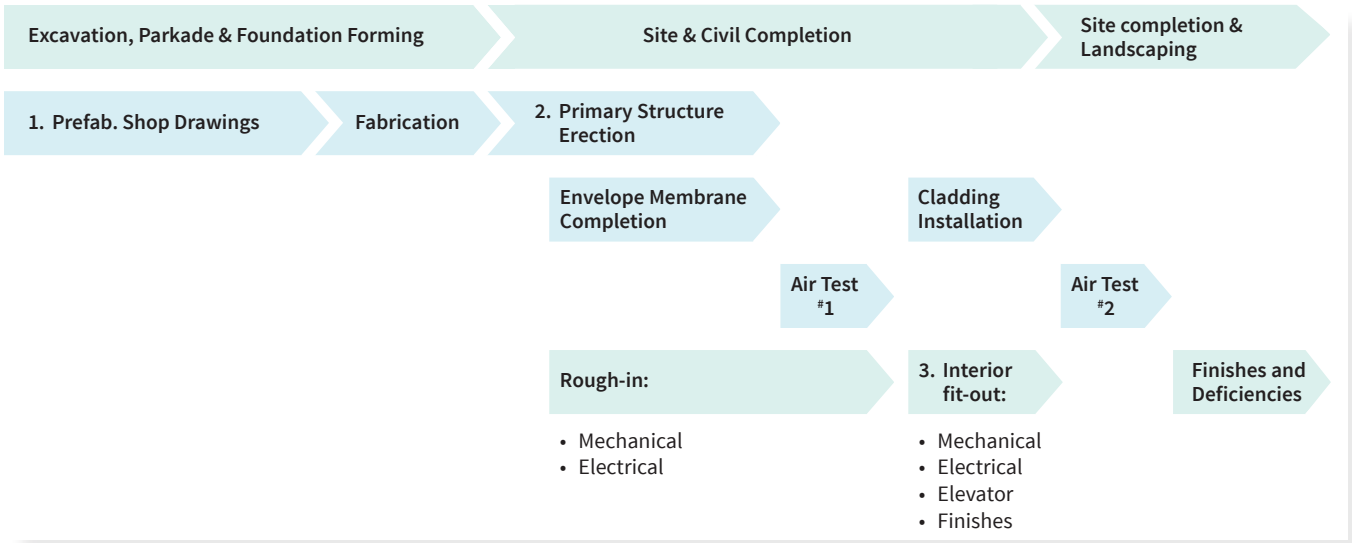
To realize the prefabrication strategy, an informal "prefab team", led by the contractor (Kinetic Construction) together with timber structure installer (Ron Anderson and Sons) and envelope contractor (Brytar Contracting) was formed early on.

330 Goldstream used Lean Planning Principles to deliver a high-performance project within a tight budget, on a constrained site within a tight timeframe. See Bulleting #2: Lean Construction Practices. Lean's roots in manufacturing is directly applicable to the production line for prefabrication of wall panels. However, Lean's emphasis on production sequencing – the assembly of components from different suppliers into a single system, makes it particularly useful for coordinating 330 Goldstream's prefabricated wood panels package with mechanical systems, sprinklers, etc. for rapid assembly on site in Colwood.

The prefab team leveraged **Last Planner** (See note, bottom of this page) to organize off-site fabrication and site assembly. Much of the detailed planning happened during site excavation and foundation construction. Last Planner allowed several key things to happen:

- **Site assembly coordination:** Kinetic Construction coordinated the prefabricated elements with the electrical, mechanical and fire protection trades and suppliers, incorporating modifications and revisions into shop drawings to minimize field modifications (penetrations, connections, fire protection, etc.).
- **Off-site fabrication modification:** The structural design did not anticipate prefabrication. Therefore, the framing shop drawings had to be revised to accommodate panel fabrication and on-site assembly.
- **Streamlined sequencing:** By using the Last Planning process in the Big Room, Ron Anderson and Sons and Brytar were able to sequence their respective scopes down to 2 weeks per floor level.

330 Goldstream: Lean Project Delivery Sequence



Kinetic Construction: Lean Champion

Kinetic has prior experience with deploying Lean and championed its adoption. **Last Planner®** is a system that designated persons closest to the work – with authority to make decisions regarding schedule, team and resource allocations, as key decision makers, who make reliable commitments to the project team.

Kinetic Construction base their practices on **Lean Construction Institute's** practices. For more detailed information as well as a free guide: leanconstruction.org/lean-topics/last-planner-system.

1. Wood Wall Panel Prefabrication

A tour of the Zytech fabrication plant for BC Housing staff was recorded by the Multivista video documentation team.

1. Material supply and selection

ZyTech purchases and stores lumber on an on-going basis to protect against price volatility. Straightness and quality of dimensional lumber is an important consideration for fabrication equipment (e.g., CNC machines) to work effectively. BC's lumber supply comes in widely varying quality, and timber suitable for prefabrication tends to be in high demand.

2. Wall panel fabrication

ZyTech's production system unifies design and "packaging" for delivery. What is approved in shop drawings is what will be fabricated, organized and packed for delivery to site. Zytech's production line automates 2x selection and layout, using both machines and a 2-person crew to complete assembly. The order is deliberate: the panels are produced and packed as "cassettes" to fit onto the fewest number of trucks and stacked in sequence for lifting from the truck and into place in the project.

3. Packaging, storage and delivery

At the end of the production line, all panels are inspected by ZyTech before being packed into cassettes. The entire process is planned by the design and fabrication program. For 330 Goldstream, over 400 panels were fabricated, packed and stored in order at ZyTech's yard, ready for truck transportation from Langley to Colwood, including a one-hour ferry ride.

(Photos: Scius)

2. Membrane Pre-installation

The off-site membrane fabrication sequence was captured by the Scius research team.

1. Off-site quality control

The pre-installation of the wall membrane required Kinetic to inspect and accept the panels prior to them leaving the prefabrication plant. A small area at ZyTech's busy yard was set aside for Kinetic and the envelope contractor (Brytar Contracting) to move, unpack, and inspect each cassette of panels without mixing up the carefully planned sequence generated by ZyTech's program. Just one improperly re-packed panel could halt site assembly for days while the correct panel was located.

2. Contractor to trade coordination

Kinetic set up a "production line" in Zytech's yard to organize the process of unpacking and inspecting the panels. Using ZyTech's shop drawings, Kinetic checked each panel for correct sequencing and fabrication, and also that the panels were square and flat. Once Kinetic accepted a panel and moved onto the next panel, the envelope contractor Brytar followed behind to complete their own inspection, including checking that the plywood substrate conditions met the specifications for the membrane.

3. Membrane application and panel repacking

The production line ensured that the chain of responsibility and hand-over that would have occurred on site was replicated for the offsite work. Working offsite also meant that fabrication issues could be fixed quickly by ZyTech. Once the panels were inspected and accepted, Brytar completed the sheathing membrane application and then repacked the cassettes per ZyTech's shop drawing schedule, and readied them for loading onto the delivery trucks.

(Photos: Scius)

2. Site Assembly of Prefabricated Panels

Construction sequence photos captured by Multivista via webcam.

October 2019

The underground parking structure is completed. Access to the site was constrained by excavated earth (left) and the need to maintain the adjacent site's access to the parking in front of the project (bottom-right). Therefore, delivery of cassettes came via Wale Road north of the site, down a temporary service road and beside the excavated earth. Ron Anderson and Sons begins panel erection.

October 21st 2019

The first cassette of wall panels arrived from Zytech's Langley plant 135 km away. Ron Anderson and Sons noted that most of the panels arrived in good shape, with only minor repairs to the sheathing membrane due to abrasion damage during transportation.

November 1st 2019

Ron Anderson and Sons planned for panel erection to take 10 days per level. The ground floor was completed in only 8 days. Brytar Contracting began wall membrane connections when panel erection reached level 3 of the building in mid-November 2019. Back-framing happened at the same time as membrane connection.

December 1st 2019

The 5th floor is approaching 50% complete, which is about 10 days behind schedule. The southeast section of the building progressed slower due to the integration of the steel moment frames. The difference in wood and steel tolerances required some site modifications. The interior rough-in started in December.

Level 4 of the building does not have the wall membrane pre-installed due to a gap in the production sequence.

January 15th 2020

Level 6 is at about 60% complete. Bad weather slowed down progress to Level 6 by 6 days. The project is a total of 10 days behind on the erection schedule.

Building erection was further delayed by the late delivery of the roof trusses from the Lower Mainland. Interior rough-in work continued on the completed levels below.

February 13th 2020

Ron Anderson and Sons completed erection in 69 working days – only 9 days longer than planned. The entire installation took a total of 80 days minus weather delay and 5 days for Christmas break. A large temporary heating unit and tarping was installed on the ground floor to dry the building. When Kinetic originally scheduled the panel erection, the project was expected to start August 26th, 2019 to take advantage of the dry season. Due to delays in permitting approvals, erection actually started December 12th, 2019. Erection during the rainy season meant significant moisture exposure requiring longer drying before the envelope could be finished and the air test completed (June 2020).

Lessons Learned

The contractor, framer / panel installer and envelope contractor highlighted several lessons that can be learned from the prefabrication process.

Design-construction coordination conflicts

After panel erection was completed, the project team discovered that the structural and HVAC designs were not coordinated. The ventilation ducts that ran in the ceiling space along the length of the corridors penetrated shear walls in the corridor to enter each suite. The ducts were found to be larger than the shear wall was designed for – a fact that was missed during design coordination and required structural modifications on site.

Limited constructability review

Kinetic Construction's brief constructability review recommended prefabrication just before tendering to trades and suppliers. Once prefabrication was selected, planning and coordination was pushed much later than required during the construction phase, when the needs of the project schedule often took priority resulting in some gaps in resolution of key design and installation details.

Considerations: wood prefabrication

Based on the issues encountered on the 330 Goldstream project, the project team also highlighted challenges specific to light wood frame prefabrication.

Sensitivity to schedule

The project team noted that adopting prefabrication after tender, the late approval of the project start and the found geotechnical conditions affected the original schedule assumptions for the prefabrication scope of work. This had several impacts:

- **Wood prefabrication requires careful scheduling to avoid weather exposure:** Panel erection was originally scheduled for the summer. The late start and found conditions pushed the start of the above-ground work into the rainy season, which further extended the schedule due to the need for a drying period prior to starting the interior fit out.
- **Fabrication capacity must be considered when planning a building project's schedule:** ZyTech had to repeatedly re-schedule their production runs for other projects due to 330 Goldstream's changing schedule.
- **Storage and handling risks must be planned for:** ZyTech had to store the panels for longer than anticipated, risking damage and weather exposure.
- **Construction logistics can have a big impact on schedule and costs:** Kinetic's logistics such as shipping to Vancouver Island and scheduling of the crane were difficult to plan given the schedule was volatility.

Sensitive to constraints

The project team highlighted the following challenges due to the regional and site-specific constraints:

- **Supplier locations and delivery must be considered:** Having no other available option on Vancouver Island meant 330 Goldstream had to source a prefabrication supplier on the mainland, reducing the benefits of "Just in Time" delivery.
- **Trade availability:** The changing schedule meant the trades with expertise in on-site panel erection was unavailable. In a heated construction labour market, Ron Anderson and Sons had no choice but to hire any available framing crew to keep the project on-schedule.
- **Quality control is vital to success:** The crew that Ron Anderson and Sons was forced to hire was found to be unsatisfactory. Panels were not properly aligned, and the back-framing was completed poorly. Brytar Contracting had to repair many of these flaws, which slowed down the installation of the sheathing membrane connections. The unsatisfactory crew was replaced, but the damage was done.

Considerations: Prefabricated high-performance envelope

The project team also specified considerations for building performance, when contemplating prefabrication.

- **A project-level strategy to building performance is critical:** The final blower door test result was 0.55 ACH, exceeded the target of 0.6 ACH. Last Planner partially supported this result by bringing Kinetic Construction, ZyTech, Ron Anderson and Sons and Bryter Contracting together to focus on coordinating the different components for optimal building performance.
- **The design consultants play a key role in realizing the benefits of prefabrication:** The construction team highlighted Cascadia Architects and RDH's commitment to the prefabrication and off-site work. Their support in working through the detailing and mock-ups ensured their expertise was leveraged, and their requirements were addressed during construction, and not as deficiencies when construction has progressed too far.
- **Envelope integration:** Amalgamating envelope elements such as the wall, windows and roofing membrane and flashing connections into one trade's scope of work meant that coordination was concentrated between the envelope contractor and panel supplier, rather than broken out across numerous trades and raising the risk of responsibility gaps and errors.

Recommendations

Prefabrication is a project decision

Prefabrication requires commitment by the entire project team at the outset as it impacts the building design from the ground up. Using prefabricated systems also requires the contractor and key trades to be on-boarded early enough to coordinate their work – prefabrication schedules are quite different from traditional project delivery. For 330 Goldstream, those that were most impacted by the decision to prefabricate the building were the general contractor, panel supplier, framer/ erection trade and the envelope trade.

Focus on design coordination

Prefabrication requires the design to be coordinated and "set" much earlier than for a traditional project. This includes mechanical, electrical and fire protection as well as the steel structural elements that are to be integrated into the prefabricated timber structure. It is important to ensure that the prefabricated components are accurate for rapid assembly and will facilitate interior fit-out with minimal field modifications. The early coordination and setting of the design is also key to fabrication scheduling, so that work in the plant can proceed concurrently with work on site.

Full adoption of Lean

The project team leveraged Lean's Last Planner to collaborate during construction and, specifically, to plan and integrate prefabrication, panel erection and envelope installation. However, the lessons learned from 330 Goldstream highlight the fact that only using Last Planner during construction has limitations.

Lean Project Delivery requires all key project team members to be on-boarded early, to collaborate fully during design to identify and resolve issues like those above before construction mobilization. If commitments to use Lean had been made at the outset, Lean could have helped the project team optimize the building's design for prefabrication and off-site construction, eliminating the "waste" caused by the Design-Construction gap. However, the Lean process started late and not all of the project team were involved.

Last Planner played an important part in delivering an innovative high performance housing project by helping to invest a great deal of good will across the project team. This meant that when pressures and challenges inevitably arose, there was a high level of collaboration and cooperation to resolve issues and complete the building efficiently.

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**.

BC HOUSING RESEARCH CENTRE
1701-4555 Kingsway, Burnaby, BC V5H 4V8
Phone: 778-452-6454
Toll-free: 1-866-465-6873
Email: research@bchousing.org
www.bchousing.org