

ON5 MASS TIMBER OFFICE BUILDING HIGH PERFORMANCE LOW CARBON CONSTRUCTION



ON5 is a four-storey office building located near the intersection of Ontario and E. 5th Avenue in Vancouver. Built on a narrow difficult-to-access mid-block site with only 7.54-metre wide street frontage, the commercial project has an all-timber structure. Cross-laminated timber (CLT) panels form the floors, walls and roof. The CLT floor panels use an innovative adhesive system. The adhesive bond allows for two-way slab performance, eliminating the need for additional beams.



Energy efficient design, with a total potential carbon benefit of 266 metric tons. (Images: KK Law)

KEY FEATURES

- Energy efficient, low carbon design.
- Full mass timber structure for a commercial office/light industrial.
- Prefabrication accommodates a tight urban site.
- New approaches to the structural design, fabrication and preparation of CLT assemblies.
- Uses an innovative CLT adhesive system.
- Demonstrates unique seismic damage avoidance design.

PROJECT TEAM

owner	fire suppression
1155776 BC Ltd	TC Engineering Ltd
architect	code
Hemsworth Architecture Inc	Evolution Building Science Ltd
structural engineer	geotechnical
Equilibrium Consulting Inc.	GVH Consulting Ltd
timber specialty engineer	CLT Fabricator
Timber Engineering Inc	Katerra
construction manager	Seismic dampers
Naikoon Contracting Ltd	Tectonus
electrical	structural adhesive
MCL Engineering Ltd	Timbertec
exterior envelope	
Dubas Engineering Ltd	

BUILDING STATS

site area	fsr
280.375m ²	3
site dimensions	major occupancies
32.185m long x	“D” Business and Personal
7.540m wide	Services; “F2” Industrial
gross floor area	applicable code
840m ²	Vancouver Building By-law
height	Article 3.2.2.59 (Group D);
17.3m	3.2.2.77 (Group F)

CARBON SUMMARY

Results

	Volume of wood products used: 214 cubic meters (7,571 cubic feet)
	U.S. and Canadian forests grow this much wood in: 1 minutes
	Carbon stored in the wood: 192 metric tons of carbon dioxide
	Avoided greenhouse gas emissions: 74 metric tons of carbon dioxide
	Total potential carbon benefit: 266 metric tons of carbon dioxide

Equivalent to:

	56 cars off the road for a year
	Energy to operate 28 homes for a year

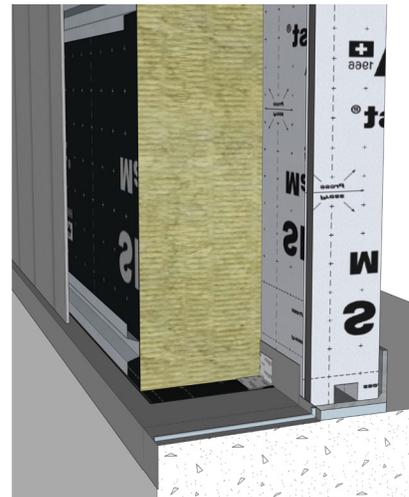


ON5 MASS TIMBER OFFICE BUILDING HIGH PERFORMANCE CLT ENVELOPE

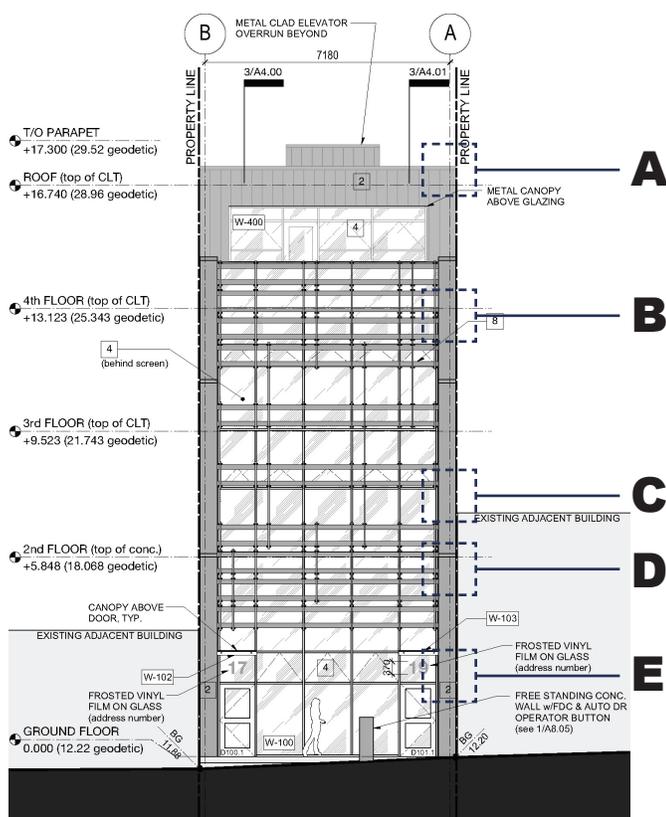
The ON5 project demonstrates how to achieve an airtight and thermally efficient envelope for a commercial building using prefabricated CLT panels and a high-performance, triple-glazed curtain wall system.

The exterior envelope panels arrive on site fully finished with 200-millimetre-thick mineral wool exterior applied insulation and rainscreen cladding pre-installed. Custom envelope details provide an airtight structural connection between the panel, the concrete floor slab below and at the roof. The project is targeting an airtightness rating of 0.6ACH @ 50Pa. The 5-ply CLT panels were typically 3-metre-wide and oriented vertically, with the largest being more than 11-metre-long and spanning over three storeys.

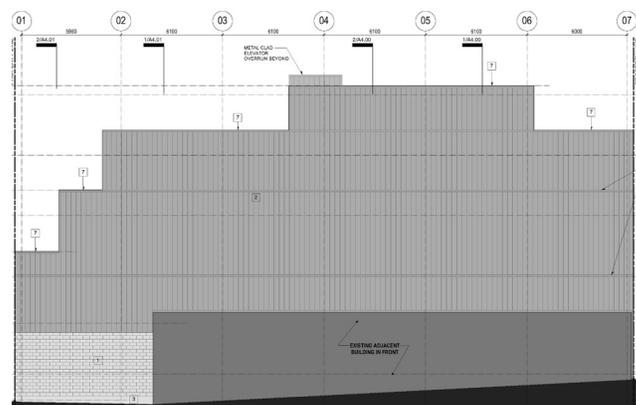
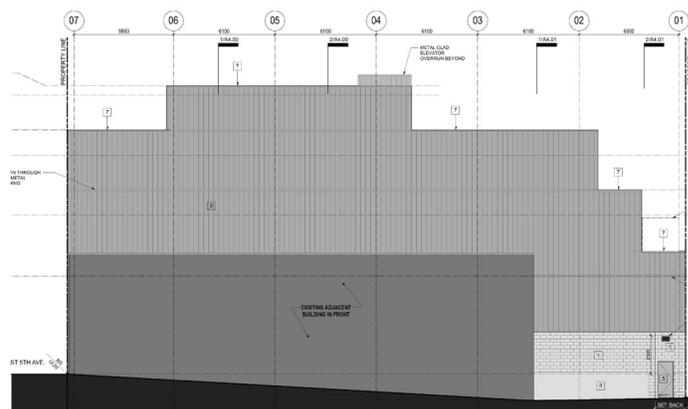
Combining the high thermal performance of the wood envelope with the low embodied carbon and reduced construction waste afforded by the prefabricated mass timber structure results in a low carbon building. This approach offers a simple and scalable solution to addressing climate change.



Rendering of key CLT to concrete suspended slab detail. (Rendering: Pacific Timberworks).



(Drawings: Hemsworth Architecture) See section innovative wood technology: key details on pgs 6-7 for descriptions of A-E.



ON5 MASS TIMBER OFFICE BUILDING

SITE CONDITIONS & DESIGN CONSTRAINTS

CLT wall panel site condition: zero-lot line

Site conditions and constraints influenced the team's decision to prefabricate the CLT envelope wall panels. Zero-lot lines east and west created "blind" conditions making the external face of the CLT envelope wall panels inaccessible once they are flown into position on-site. As a result, the most practical method was to prefabricate air-tight wall assemblies off-site, completing the structural and envelope connections on the inside once the panels were installed on-site.



Red, zero-lot line: East-west: 7.540m North-south: 32.185m. Adjacent buildings create inaccessible conditions for CLT wall panels. (Drone footage: Multivista)

Prefabricated CLT envelope panels

on5 is a four-storey post and plate pure CLT structure (structural wall and floor panels). The CLT panels were prefabricated off-site as units, complete with air-vapour membrane, insulation and exterior cladding. This was completed at Naikoon's laydown yard in North Vancouver.

ADVANTAGES

- **Wood is ideal for prefabrication:** CLT panels are available in large sizes, and can be easily milled and fastened to. Panels can typically be attached together with simple connections.
- **Panel modules are easy to assemble:** Assembling the CLT envelope panels off-site, 30 centimetres off the ground and horizontal, was safer, quicker and easier to construct quality, air-tight wall details.
- **CLT is light and durable:** CLT panels are relatively light and durable, possessing rigidity characteristics that lend itself to being moved and lifted.

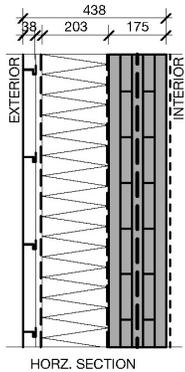
CHALLENGES

- **CLT needs to be protected from moisture:** From off-site assembly and storage, to on-site delivery and erection, CLT panels need to be protected from moisture exposure.
- **Wood details need to be thoughtfully designed for on-site assembly:** Connection details need to be developed to safely, easily and quickly connect structural and envelope together.
- **Services need to be planned out early:** CLT come as solid panels, with service penetrations ideally made off-site during fabrication or have penetrations lay-out in advance of on-site assembly.



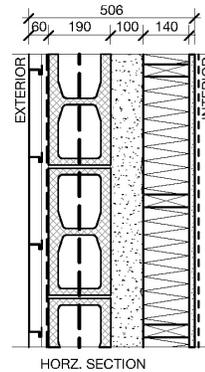
ON5 MASS TIMBER OFFICE BUILDING ENVELOPE DETAILS & OFF-SITE PREFABRICATION

Envelope details: major wall types



W1 ASSEMBLY

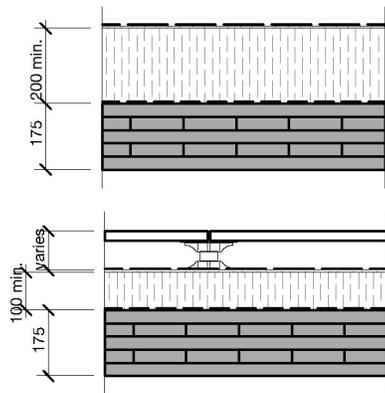
5-ply structural CLT panels, milled at the factory and delivered to Naikoon's off-site laydown yard. The panels were prefabricated with self-adhered air/vapour wall membrane, air barrier paper-wrapped insulation, Cascadia clips and z-girts, finished with pre-formed metal cladding. The air barrier paper-wrapped insulation provides protection for the insulation during off-site fabrication and on-site assembly (water-logged insulation can significantly increase the weight of panels). Once installed, the air barrier wrap also reduces moisture absorption in the insulation in service, protecting its rated performance.



W2 ASSEMBLY

Built on-site, structural 190 concrete masonry unit (CMU) (1-hr fire-rated) wall for the double height, ground floor commercial level. Depending on the location of the CMU, this wall type either has the same pre-form metal cladding, or a water repellent finish on the CMU's exterior face.

Envelope details: roof and roof-deck types



R1 ASSEMBLY

5-ply CLT milled at the factory and partially prefabricated with the self-adhered air/vapour roof membrane at Naikoon's off-site laydown yard. The minimum 200-millimetre thick sloped, rigid roof insulation and 2-ply modified styrene-butadiene-styrene (SBS) roofing on protection board was installed after the primary CLT structure was erected on-site.

R2 ASSEMBLY

Occupiable roof decks on either a 5-ply CLT or 225-millimetre concrete structure. The self-adhered air/vapour roof membrane was pre-installed at the laydown yard. Both structures have tread-able surface consisting of pavers on pedestals, on minimum 100-millimetre sloped, rigid roof insulation, installed on top of the membrane, installed after the primary structure is erected on-site.

(Drawings: Hemsworth Architecture)

Life of a panel: off-site prefabrication



1. CLT panels at delivery; note the milled key way from the factory, and protective wrapping on panels.

(Photos: Scius Advisory)



2. Envelope assembly, membrane wrapped panels, Cascadia clips, semi-rigid insulation and z-girt. Interior face of CLT panels is exposed.



3. CLT panel envelope complete with air barrier-wrapped insulation and flashing at base. Envelope membrane & air barrier paper laps are all taped.

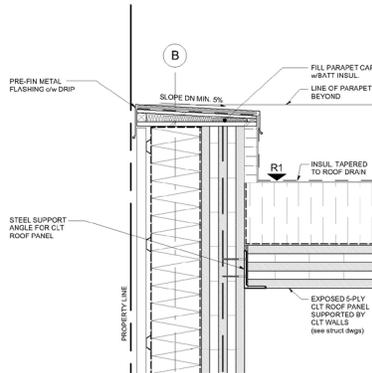


4. Finished panels with metal cladding, compared to in-progress panel. Note the portable shelter used when panels are exposed during envelope assembly.



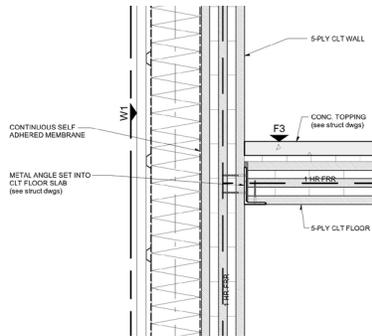
ON5 MASS TIMBER OFFICE BUILDING

INNOVATIVE WOOD TECHNOLOGY: KEY DETAILS



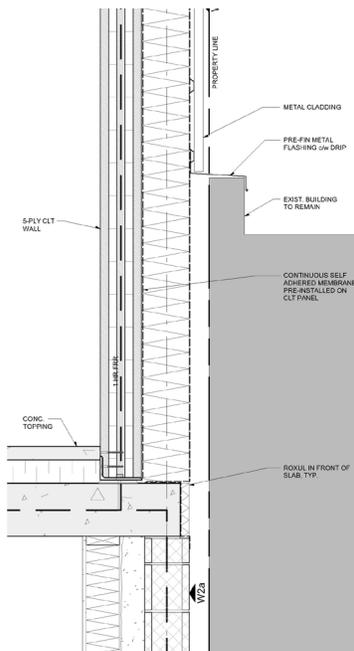
CLT parapet

CLT structural wall and roof panel connection via flush steel angle, running down the east and west zero-lot line walls. The roof assembly's sloped insulation was not pre-installed, to accommodate service runs (on top of roof surface, cut into the insulation). Pre-installing the air/vapour barrier provided moisture protection of the roof panels during delivery and erection, and during insulation and modified-SBS membrane installation.



CLT floor panel

CLT structural wall and floor panel connection via flush, site installed steel angles for bearing, running down the east and west zero-lot line walls. Prefabricating the wall detail off-site made site construction easier and safer, with better quality installation than working off of ladders and lifts. The steel bearing angles, installed during site assembly, provided a level of on-site adjustment. By the time the panels were completed at the laydown yard, the wall panels were almost fully protected. There was no rainfall during site assembly.



Zero-lot line CLT-CMU transition

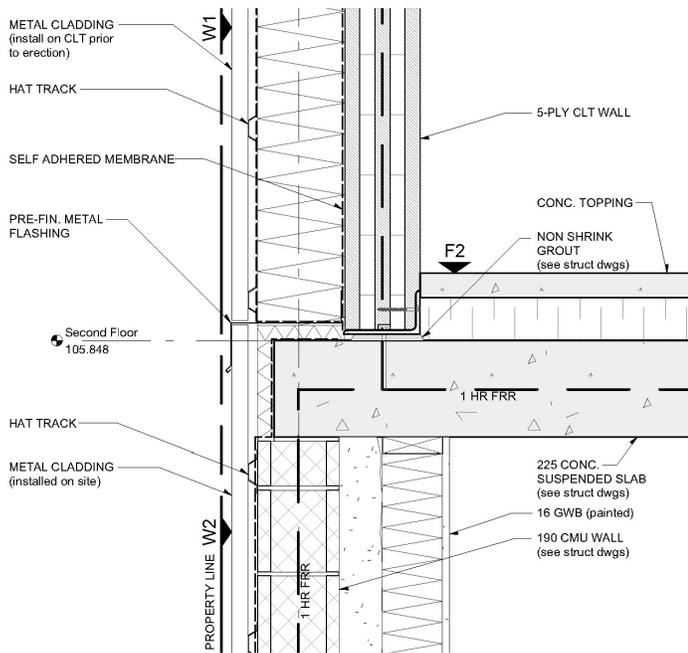
Transition from CMU to rated CLT wall panels. This assembly requires an alternative solution (See: Regulatory Perspectives Bulletin). This transition detail for the "blind" lot-line wall condition has a neighbor parapet flashing at the top, with the membrane continuing down lapping the second level concrete suspended slab and CLT panels, transitioning from exterior to interior insulation. In the blind condition, the CLT panels and exterior CMU had very low exposure, requiring only a surface sealant on the CMU walls.

(Renderings: Hemsworth Architecture)



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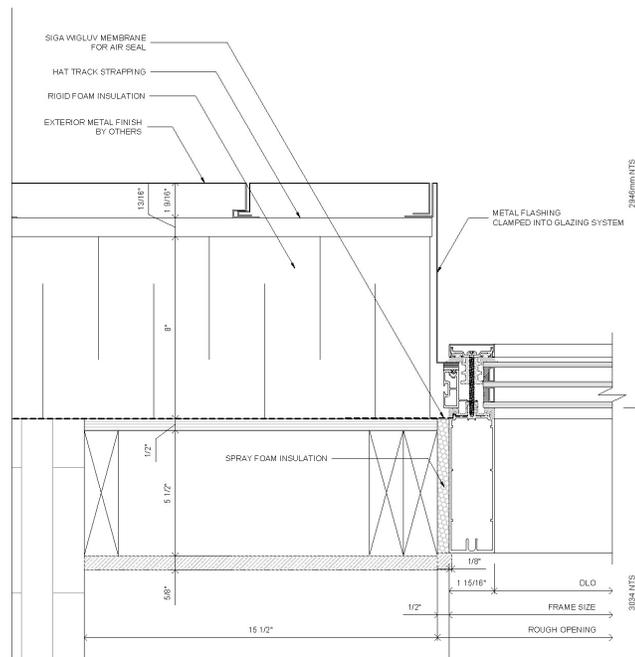
INNOVATIVE WOOD TECHNOLOGY: KEY DETAILS



(Rendering: Hemsworth Architecture)

Typical CLT-CMU connection

The east and west CLT wall was flown and installed onto a base consisting of a bolted steel angle, with non-shrink grout for leveling. The key-way milled into the base of the CLT panels for the bolts, had an expanding foam strip to fill in the void, providing a back-up air barrier to continuous beads of mastic. The non-shrink grout, expanding foam strip and mastic bead all provided some room for field adjustment during panel erection. This fine level of detail coordination was critical to achieving the speed and quality benefits offered by the high degree of off-site prefabrication.



(Rendering: Blackcomb Glass)

Curtain wall detail

The German-origin "Raico Therm+ A-V" curtain wall system was supplied by Blackcomb Glass, who coordinated with the oN5 team during design to ensure the details met the ambitious building performance. The curtain wall feature at the south (front) elevation was installed into light wood frame infill walls, between the CLT structural walls. The critical air barrier connection was made by lapping the SIGA Wigluv tape into the curtain frame, with spray foam applied to the air gap between the frame and infill to reinforce the air barrier and for thermal continuity with the mineral insulation.



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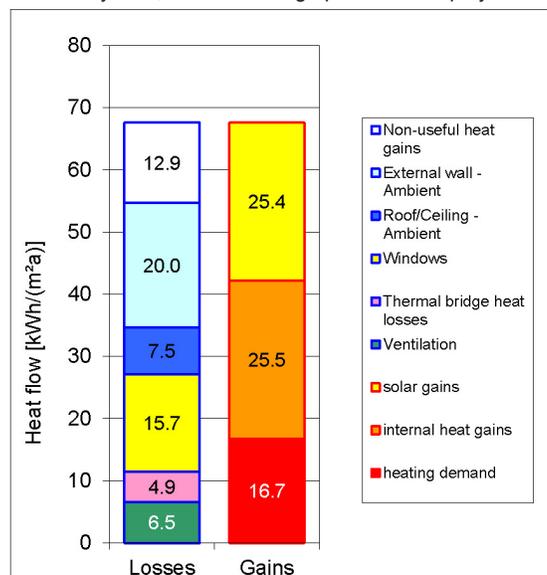
ENERGY PERFORMANCE: SIMULATION

Passive House Planning Package

While oN5 will not seek Passive House certification, the team utilized Passive House Planning Package (PHPP) to simulate energy performance to achieve the team's goal of <15kwh/m2a. Post-occupancy environmental performance of the building will also be monitored. Environmental sensors were installed and data will be collected, including moisture infiltration from outside, interior temperature and relative humidity.

HIGH-PERFORMANCE WINDOWS

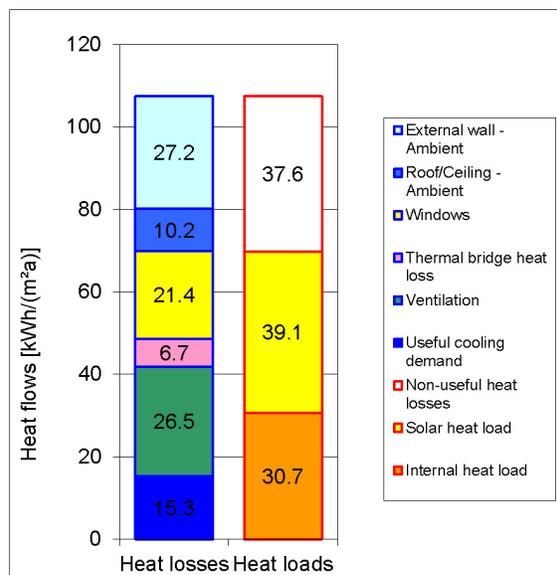
Blackcomb Glass supplied oN5 with the main feature curtain window wall at the front, with awning windows and doors serving the various levels, selected from Raico's Thermo+ A-V and Frame+ 75 systems respectively. Raico's system was selected as they are Passive House certified system, suitable for high performance projects such as oN5.



PHPP heating energy balance results.

MECHANICAL SYSTEMS

For HVAC systems, Rocky Point Engineering designed an energy-efficient system of energy recovery ventilators from Renewaire, and variable refrigerant flow units from LG to handle building conditioning, combined with an 85-gallon domestic hot water heater from Rheem.



PHPP heating energy balance results.

Specific building characteristics with reference to the treated floor area		Criteria	Alternative criteria	Fullfilled? ²
Space heating	Treated floor area m ²	387.7		
	Heating demand kWh/(m ² a)	17	30	yes
	Heating load W/m ²	14	-	yes
Space cooling	Cooling & dehum. demand kWh/(m ² a)	15	-	-
	Cooling load W/m ²	11	-	-
	Frequency of overheating (> 23 °C) %	-	-	-
	Frequency of excessively high humidity (> 12 g/kg) %	0	10	yes
Airtightness	Pressurization test result n ₅₀ 1/h	0.6	1.0	yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m ² a)	249	-	-
Primary Energy Renewable (PER)	PER demand kWh/(m ² a)	112	75	no
	Generation of renewable energy (in relation to projected building footprint area)	-	-	-

² Empty field: Data missing; '-': No requirement

PHPP building performance results. (PHPP reports and diagrams: Hemsworth Architecture)



ON5 MASS TIMBER OFFICE BUILDING

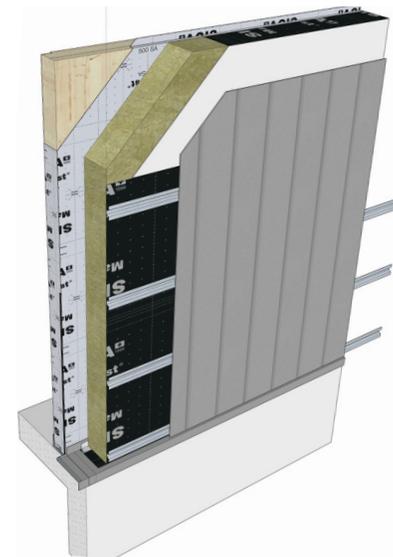
OFF/ON-SITE ENVELOPE CONSTRUCTION

Off-site prefabrication of the CLT wall panels condensed the on-site construction schedule, achieving envelope substantial completion much quicker. Naikoon only had to connect the CLT wall panels and the roof/balcony assemblies to the CLT wall panels during site assembly.

The trade-off was the need to design details robust enough for delivery and crane flying, and simple enough to be connected quickly and safely, without compromising performance. The oN5 team developed a squashed type connection detail between butt-jointed CLT wall panels, where adjacent panel's air/vapour membrane squashed a double bead of mastic to form a weather-resistant joint. On the exterior face of the pre-formed metal cladding, this joint is protected behind metal flashing. At the blind sections of the zero-lot line firewalls, the parapet neighbour flashing at the top provided similar protection. Joint tape was applied across all wall joints behind the interior-side structural plywood spline (structural connection between CLT panels) to ensure the joint is air-sealed.

Digital mock-ups of key connection details

The prefabricated CLT panels required thorough planning of the assembly operation. The structural engineer, with experts Johannes Schneider & Pacific Timberworks, created digital mock-ups of the CLT to concrete slab connection and the panel-to-panel connection in SketchUp, to ensure the combined envelope and structural connection was virtually rehearsed and sequenced properly prior to construction.



CLT wall panel detail. (Rendering: Timberworks)

Off-site production

The oN5 team planned the off-site scope of work extensively, forming a production line, complete with movable rain shelters and tarping to minimize moisture exposure during assembly. The work was performed on the ground rather than with the CLT panels vertical—which yielded significant cost savings, was quicker, and was much safer without the need to work off ladders and lifts. The on-site assembly of the structural/envelope panels was scheduled for 14 days but was completed in 10 days.



Assembly line.



Moveable work shelters.



Patching procedures.

Off-site test lift

Lifting, transporting and installing the finished panels came with unique challenges. The team used computer simulations and a physical test lift of the heaviest panel (4,080 kg 7-ply core panel) to verify deflection was within acceptable tolerances.



Lifting system: custom, proprietary solution by Naikoon, to facilitate panel maneuvering and precise installation.



Test lift: for maximum deflection during crane flying.

Innovation Partners:

naturally:wood



Partially Funded by
Natural Resources Canada
GCWood Program

Financé partiellement par
Ressources naturelles Canada
Programme CVBois



This is the second in a series of bulletins regarding oN5. Other bulletins include: high performance low carbon construction; off-site construction; on-site construction & project delivery; and regulatory perspectives. All bulletins can be found at www.naturallywood.com/project/on5-building

May 2022

