

INNOVATION IN HYBRID MASS TIMBER CONSTRUCTION

# TALLWOOD HOUSE

BROCK COMMONS TALLWOOD HOUSE  
CONSTRUCTION OVERVIEW









## INTRODUCTION

The University of British Columbia, one of Canada's premier universities, is a community of academic, residential, commercial, and agricultural functions and facilities, adjacent to the west side of Vancouver, British Columbia. The University has a strong commitment to sustainability and the integration of research, teaching, and operations in capital projects, which has led to the development of a portfolio of innovative wood buildings. These have primarily been institutional and operational buildings, including the Forest Sciences Centre, Campus Energy Centre, and Wesbrook Community Centre. In May 2017, however, the University completed its first tall wood residential building: the 54-m-high (18-storey) Brock Commons Tallwood House.

Brock Commons was the tallest wood building in the world at the time of its construction. It is part of a student residential complex, with 404 beds in studios and four-bed units, plus amenities for the campus community on the ground level. The structure is a mass timber hybrid. The foundation, ground floor, second-floor slab, and stair/elevator cores are concrete, while the superstructure is composed of prefabricated cross-laminated timber (CLT) panel floor assemblies

supported on glue-laminated timber (GLT) and parallel strand lumber (PSL) columns with steel connections. The building envelope is comprised of prefabricated, steel-stud frame panels with a wood-fibre laminate cladding, and a traditional SBS (styrene-butadiene-styrene) roof assembly on metal decking.

Brock Commons Tallwood House was one of the demonstration projects supported by the 2013 Natural Resources Canada and Canada Wood Council competition—the Tall Wood Building Demonstration Initiative—which was aimed at advancing the design and production of wood products in Canada and demonstrating that wood is a viable structural option for mid-rise and high-rise buildings. This pioneering building showcases innovations in the application of engineered wood products and in design and construction practices. The project team used an integrated design process, enhanced by the use of virtual design and construction (VDC) modelling. Extensive construction planning and sequencing, highly controlled prefabrication of the building structure and envelope, and detailed coordination of on-site erection and installation activities all contributed to a successful project.

## FACTS

- HEIGHT IS 54 M (18 STOREYS)
- SITE AREA IS 2,315 M<sup>2</sup>
- GROSS AREAS IS 15,120 M<sup>2</sup>
- FOOTPRINT IS ABOUT 15×56 M, TOTALLING 840 M<sup>2</sup>
- TYPICAL FLOOR-TO-FLOOR HEIGHT IS 2.81 M FOR THE MASS TIMBER STRUCTURE ON THE UPPER FLOORS, AND 5 M ON THE GROUND FLOOR



Zahra Teshnizi

## FRONT COVER

Acton Ostry  
KK Law

## BACK COVER

KK Law

## CONSTRUCTION

### COMPOSITION OF CONSTRUCTION TEAM

Brock Commons Tallwood House is operated by the University's department of Student Housing and Hospitality Services. Because Brock Commons is a capital project, the University's Infrastructure Development department served as the owner's representative. The University of British Columbia utilizes a construction management project delivery method, in which the project manager, UBC Properties Trust, oversees the design, construction, and commissioning processes on behalf of the University. The project manager contracts directly with the consultants as well as a construction manager, who is involved from the design phase onward. In addition, stakeholders within the University were engaged throughout the design and construction process. This arrangement helped ensure the quality of the project, and that it stayed on budget and on time.

Properties Trust's extensive experience in managing capital projects enabled it to bring in, through a qualitative bidding process, an experienced team that could work well together. The selected firms were large enough to have the experience required but small enough to have their senior personnel involved on a day-to-day basis. The careful selection of the team, including key trades, was of critical importance, given the unique and innovative nature of the project.









### HIGHLIGHTS OF SPECIAL SKILLS

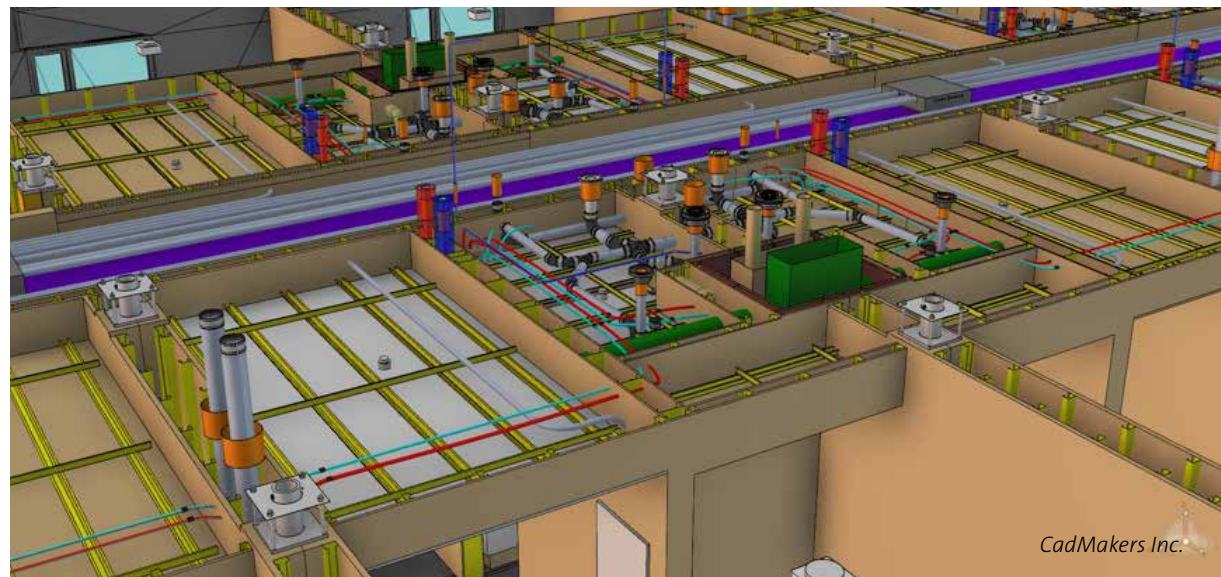
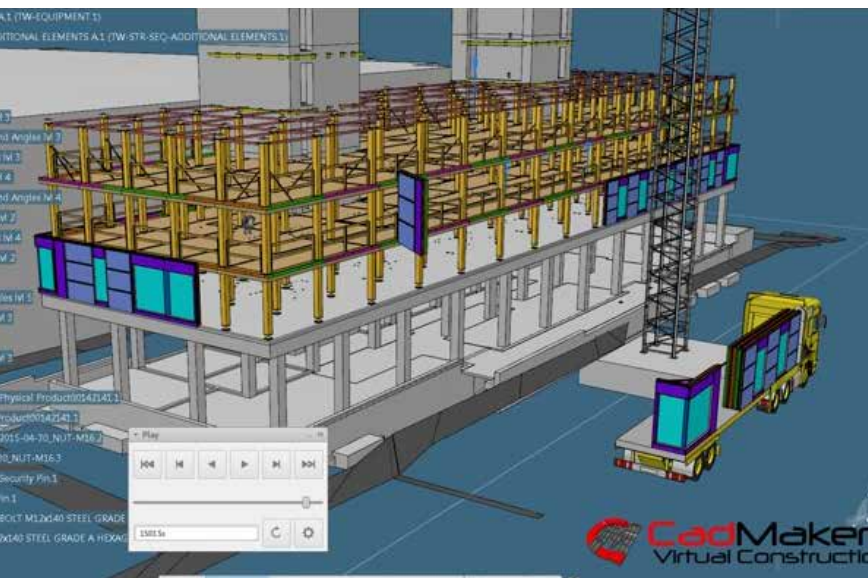
Many of the key construction team members were involved or consulted in the design and preconstruction phases—including the construction manager, the mass timber fabricator, the timber erector, and the concrete forming and placement contractor. Their input regarding the feasibility, constructability, and cost estimating of design decisions was crucial in facilitating and accelerating the construction phase.

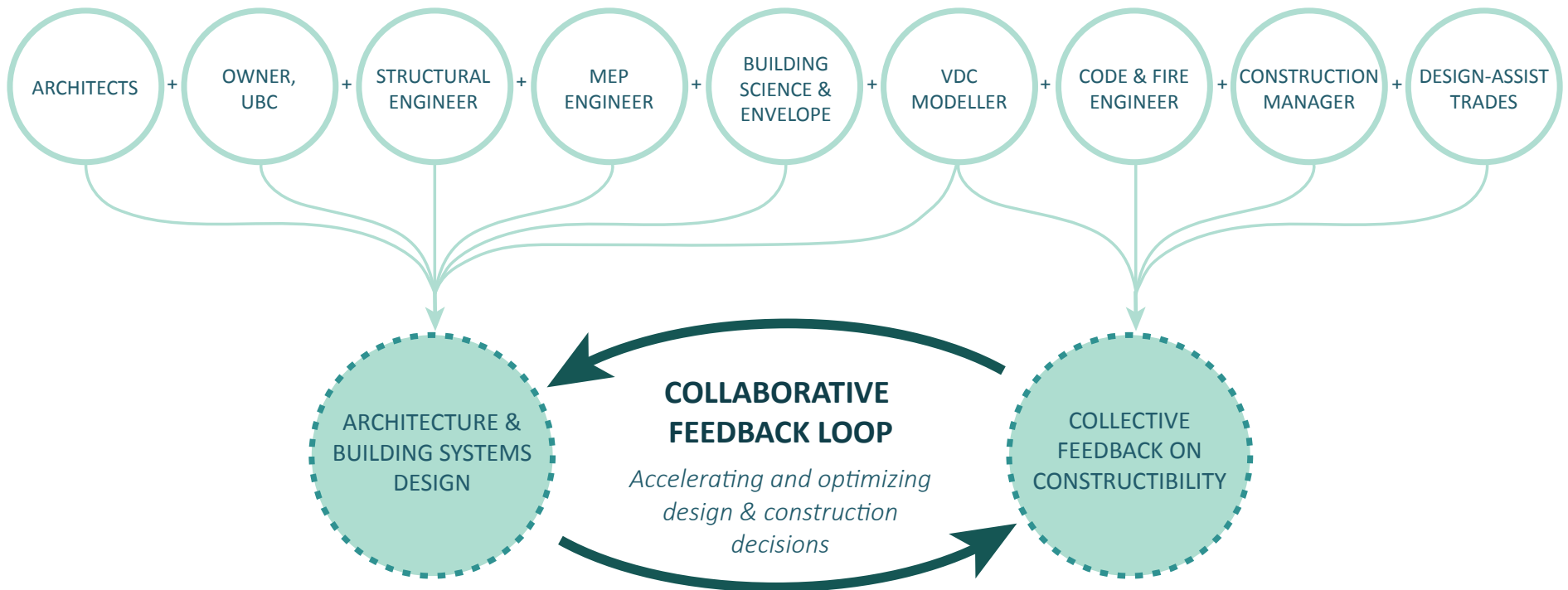
Essential to the success of the project was the on-going role of the virtual design and construction (VDC) modellers as facilitators among the team members. The modellers collected information throughout the design and construction phases from all the consultants, the construction manager, and the trades in order to develop a comprehensive and highly detailed 3D virtual model of the building. During design and preconstruction, the model was used to assess the constructability and cost of different options and identify conflicts, to communicate with trades during the bidding process, and to develop shop drawings for the proof-of-concept and lab mock-ups.

The modellers played an integral role in the construction planning.

Working in close consultation with the construction manager, they created animated sequences of the installation and assembly of all the components on the project. The VDC model was also used in the prefabrication of mass timber elements and to coordinate these with the mechanical, electrical, and plumbing (MEP) systems to ensure all the system pathways and structural penetrations were designed prior to on-site construction. The VDC modellers' role was significant in reducing the number of design changes during construction because the building was essentially constructed in virtual form before it was constructed in reality, making it possible to identify and address areas of potential conflict or improvements well ahead of time.

Throughout construction, all the trades, including fabricators, were involved in the planning and sequencing of all the construction processes, alongside the construction manager, site safety officer, and the VDC modeller. The trades' expert input not only helped in the development of a reasonable and reliable work plan and schedule, it also helped give them a sense of ownership in the project.





*A diagram of the collaborative feedback loop in motion during the project.*

Laura Gilmore

### OVERVIEW OF THE CONSTRUCTION PROCESS

The schedule for the Brock Commons Tallwood House project was very aggressive. Design and approvals took 8 months, and construction, starting in November of 2015 through to completion in May 2017, took 18 months. On-site construction was broadly divided into three phases: concrete, mass timber structure and building envelope, and interiors and building systems.

As part of the preconstruction phase a full-scale mock-up of a section of the building was built to test and validate a variety of the design solutions, to determine constructability and appropriate sequencing, and to inform the manufacturing and installation schedules and trade coordination. The mock-up experience was a unique opportunity for the project team to identify challenges and improvement opportunities in advance of the actual construction.

The concrete foundation, levels 1 and 2, and the two freestanding concrete cores were completed in 7 months. Concrete work was scheduled during the winter months and was completed entirely before the rest of the building. This allowed for the mass timber structure work to take place during the drier seasons (spring and summer). It also simplified the scheduling and use of the project's single crane, and minimized congestion of crews and materials on the narrow site. Although the elevator cores were in place, there was no construction elevator. Instead the crane was used to bring materials to the upper floors of the building by way of a cantilevered loading platform which was moved between floors, as needed.



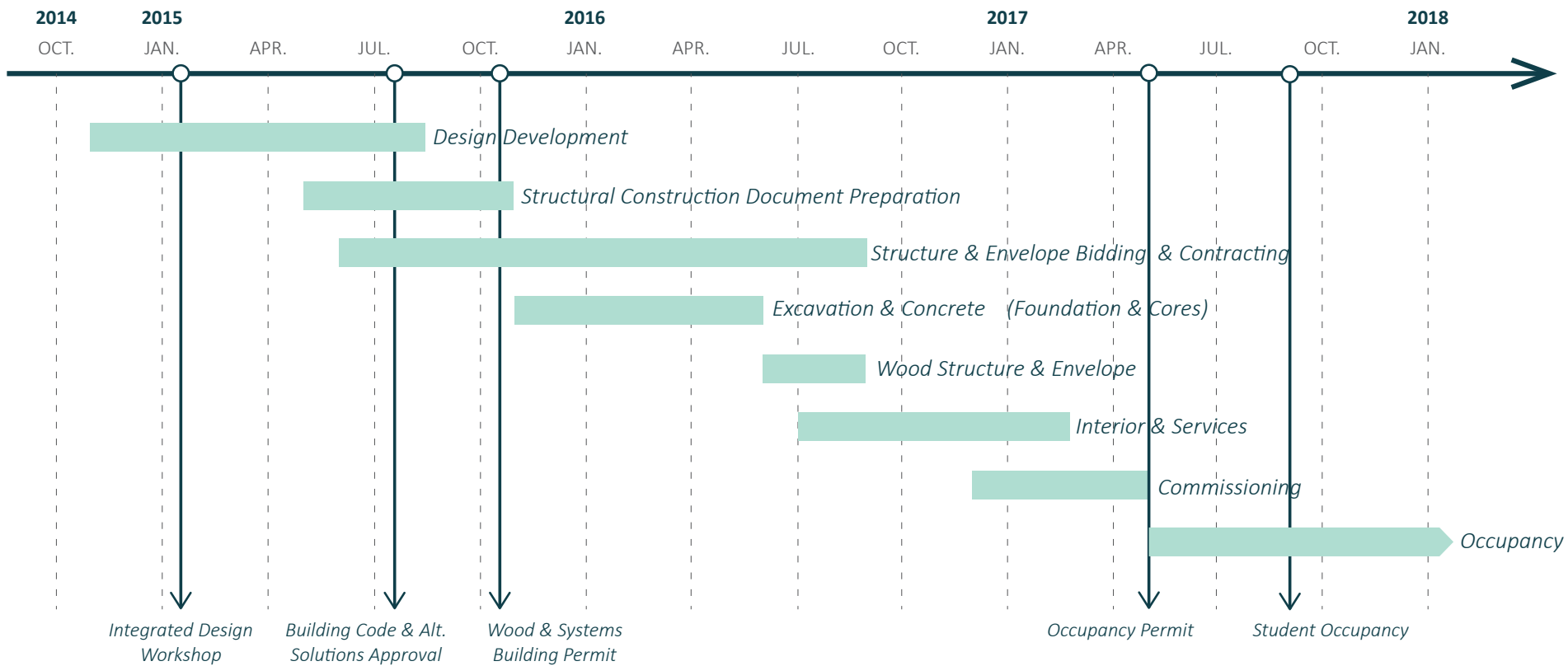
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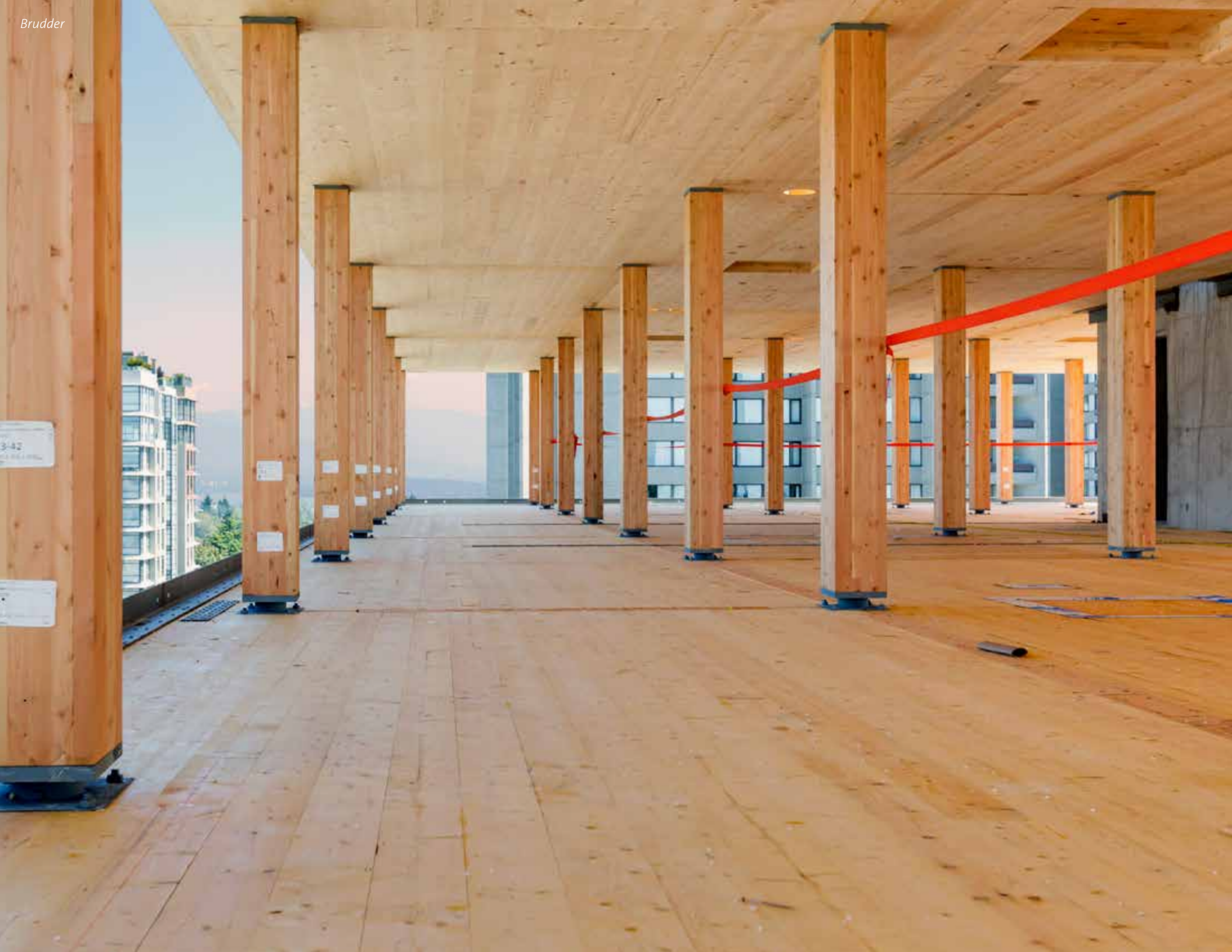
*While a CLT core may have reduced the construction time, the decision to use concrete cores helped streamline the structural design—in particular the lateral resistance—and reduce costs, as well as simplify the already complicated permitting and approval processes.*





*A overview of the project schedule.*

*Laura Gilmore*





While completion of the concrete work was underway, the mass timber structural components and the envelope panels were prefabricated concurrently by separate manufacturers over a 3-month period. The owner and the project team wanted to use prefabrication as much as possible due to its numerous advantages, such as increased accuracy and productivity in a controlled factory environment, reduced on-site construction time, and fast enclosure of the mass timber structure.

Erection of the mass timber CLT panels and GLT/PSL columns and installation of the building envelope panels were executed in a highly coordinated process, which took about 3 months. This was 2 months faster than planned. The original schedule was based on the singular mock-up experience and therefore could not fully take into account the increase in speed that occurred as the trades became familiar with the processes and techniques.

The average speed of the mass timber erection and envelope installation was two floors per week. This included the erection of the columns and CLT panels, encapsulation of the wood components with a single layer of gypsum board, the pouring of a concrete topping, and installation of all but one of the envelope panels. One envelope panel on each floor remained uninstalled until near the end of construction to provide an easy entry point for the delivery of interior materials and components via the cantilevered loading platform.

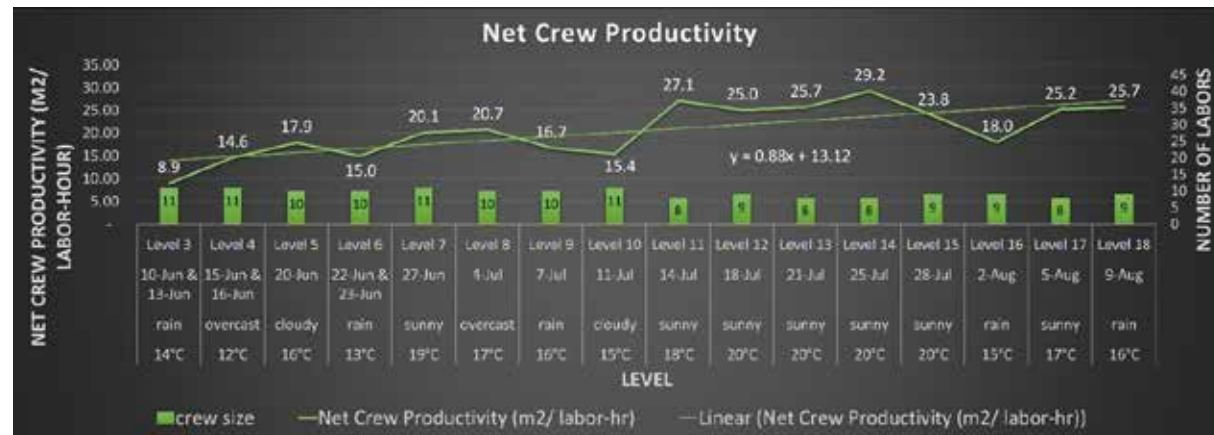
Construction productivity analysis shows the net crew productivity<sup>1</sup> related to the CLT panels increased from 8.9 m<sup>2</sup> per labour-hour at floor 3 to 29.2 m<sup>2</sup> per labour-hour at floor 14. A similar trend in productivity occurred for the envelope panels, which increased from 6.84 m<sup>2</sup> per labour-hour at floor 3 to 15.59 m<sup>2</sup> per labour-hour at floor 15. Although

factors such as weather, wind speed, and changes in the crew members created variations in this metric, the consistent increase in the net crew productivity indicates the learning curve effect which is often involved with the adoption of new building systems and technologies.

Work on the interiors, finishes, and building systems took about 10 months, at an average of about 65 working days (13 weeks) per floor, with crews working concurrently on multiple floors.

The VDC model was used to create a detailed bill of materials that included the exact dimensions and sizes for systems and interior components. This allowed for more of the MEP work to be completed off site—including the pre-assembly of the mechanical room equipment; cutting of ducts, pipes, and other systems components; and most of the welding work—thus reducing timelines and congestion on the site. For example, the mechanical room, which would typically take 3 to 4 months of on-site work, was assembled in less than 1 month.

<sup>1</sup> Net crew productivity is the ratio of total area of CLT panels in each floor (722 m<sup>2</sup>) to the net crew time. Net crew time is the product of the crew size and the duration of a crane cycle (hook time) to install CLT panels. Because of Brock Commons' repetitive design and construction, these metrics are an accurate tool for measuring variations in construction productivity.



Mohamed Kasbar

## CONCRETE COMPONENTS

### FOUNDATION, GROUND FLOOR, SECOND-FLOOR SLAB, AND CORES

The building foundation, the ground floor, the second-floor slab, and the stair/elevator cores are reinforced cast-in-place concrete. The second-floor slab acts as a transfer slab, which transfers the gravity load from the upper-level mass timber structure to the lower-level concrete structure.

The second-floor transfer slab was poured in two stages to allow work to start on one of the stair cores while the second half was poured. The VDC model was used to specify the exact locations of MEP penetrations in the concrete slab, to ensure they aligned with the locations on the higher floors and did not clash with any reinforcement. After the pour was done, the steel connections for the second-floor mass timber columns were installed by drilling the concrete and inserting steel anchors.

Cast-in-place reinforced concrete cores provide the building with the necessary rigidity to resist wind and seismic lateral forces. For pouring the core concrete, a special lifting formwork system was used. This wood and steel formwork system included a safety platform for workers, as well as an outside form box and an inside form box. The formwork trade contractor custom engineered and built a double-height core forming system to pour the concrete two storeys at a time. This enabled tighter control of the lateral tolerances of the freestanding cores including the elevator shaft internal tolerances.

The concrete work was completely finished before the construction of the mass timber structure. This facilitated site coordination because the concrete forms and the mass timber assembly required constant use of a crane and the narrow site was too restrictive for multiple cranes and construction crews.









## MASS TIMBER

### MASS TIMBER SUPERSTRUCTURE

The primary structure of the building is composed of cross-laminated timber (CLT) floor panels, and glue-laminated timber (GLT) and parallel strand lumber (PSL) columns with steel connections.

The mass timber elements were modelled in the VDC model and exported as geometric STP files containing all the base geometry including cuts, holes, and penetrations. The fabricator imported the STP file into its own software and made adjustments to account for manufacturing requirements, such as saw thickness and drill bit diameters, to create the fabrication model that was used directly by the CNC machines.

CNC machines cut all the mass timber components, including the penetrations in the CLT panels and the connection holes in both ends of the columns. The steel connections were fabricated separately and

installed on the columns by the mass timber fabricator as part of the prefabrication process. A unique identifier was assigned to each mass timber component for quality-assurance and quality-control tracking and on-site measurement of the structural system assembly heights.

The installation sequences of the mass timber components, along with the truck-loading and site-delivery schedules, were developed ahead of time with input from all the relevant trades. This helped ensure the sequences were repetitive and predictable and that the components were loaded on the trucks in the reverse order of actual installation. Trucks arrived at the construction site at regular intervals on the particular day of installation, and components were unloaded directly into position in the building.

*Initially the hollow structural steel connections for the columns were planned to be installed on site. However, as a result of experiences with the full-scale mock-up, instead the connections were included in the scope of the timber manufacturer. This facilitated coordination and ensured the  $\pm 2$ -mm fitted column length (floor-to-floor) tolerance could be met by assembly in the controlled factory environment.*







*Azadeh Fallahi*



*Tim Herron*



*KK Law*

KK Law



#### MASS TIMBER INSTALLATION

Lifting hardware for the CLT panels was custom engineered by the timber erector, based on the use of four lifting points positioned to balance the mass of each CLT panel during installation. The lifting points were incorporated into the CLT fabrication and the hardware was installed by the erectors prior to lifting each panel. The panels were lifted at an angle, to simplify positioning, i.e., one end could be lowered into place before the other, and then aligned with the help of a laser pointer. Once the panel was in position, the attached chains were released and the bolts tightened to secure it in place. When the floor's 29 panels were in place, plywood splines were nailed and screwed between the panels to connect them all into a single diaphragm. Finally, the steel drag straps were screwed to the panels and bolted to the cores at each floor to transfer the lateral loads of the CLT floor diaphragm to the concrete cores.

For each floor, ten bundles of columns were craned up, two bunches at a time, and then individual columns were manually placed at their prescribed locations. The steel tube connection of each top column was then fitted inside the bottom column connection and fixed with a steel pin. The erectors developed a special rig to lift the perimeter columns, while inside columns were manually lifted and fixed into place. Finally, prior to installing the upper-floor CLT panels, temporary diagonal supports and braces were placed to keep the columns from tilting and rotating. A small crew of nine workers was sufficient to install the mass timber components.



Fast + Epp



Zahra Teshnizi



The CLT panels were sealed to protect them against water damage. One layer of sealant was applied in the factory, the panels were covered during transportation, and a second layer of sealant was applied on site after the splines were installed. The tops of the slabs were covered with concrete topping, at a lag time of no more than five floors below the active construction. The concrete topping was designed primarily for acoustic purposes, but was used for water- and fire-management measures as well. Another fire-management measure was to encapsulate the bottom of the CLT slabs with one layer of Type X gypsum boards, lagging no more than six floors below the active installation of the CLT panels. Two additional layers of gypsum board were added later during the interior work.

To achieve the tight tolerance requirements, multiple layers of quality-control and quality-assurance measures were put in place and the results were communicated to the project team. For example, laser measurements were used to ensure the accuracy of every installed component. Additionally, a worker was tasked with logging column compressions by shooting the benchmark elevation of a representative sample of 19 columns on every floor after every installation of the next level of CLT panels. The results were used to determine whether shimming was required to level the columns or to reach the required height for the next floor.



## ENVELOPE

### PREFABRICATED ENVELOPE

The building envelope panels for the upper floors are comprised of steel-stud frames with punched windows, a rainscreen system, and a wood-fibre laminate cladding. The envelope fabricator developed a new panel system specifically for this project based on the requirements for aesthetics; on the need for secure and easy-to-install structural connections; and on the energy, weather, and acoustic performance.

At the factory, special jigs with exact dimensions of each panel type were welded to the ground to ensure the geometry was flush and the tight tolerances were met. Each floor has 22 panels: two corner panel types, which mirror each other, and twelve flat panel types, eight of which mirror each other. The parapet is comprised of two flat and two corner panel types. The exposed concrete cores are covered with similar site-installed cladding panels. Each panel was assembled in the following order: steel studs, a layer of fibreglass mat gypsum sheathing, a layer of semi-rigid stone-wool weather and thermal insulation, the exterior wood-fibre laminate panels, and the window assemblies. Detailed flashings and seals were used to ensure minimal-to-no leakages at the connections, and caulking was applied on the interior side to reduce failure due to weathering. The interior batt insulation, vapour barrier, and final drywall layer were added on site as part of the interior work.



*RDH Building Science Inc.*

### ENVELOPE MOCK-UP

- IN ADDITION TO THE FIRST MOCK-UP, THE ENVELOPE MANUFACTURER CONDUCTED LABORATORY TESTS ON A FULL-SCALE, 2-STORY, CORNER-PANEL MOCK-UP. THESE TESTS, WHICH INCLUDED STRUCTURAL (WIND AND DESIGN LOADS), THERMAL CYCLING, THERMAL PERFORMANCE, CONDENSATION, AND AIR AND WATER TIGHTNESS, WERE REQUIRED TO GET THE ENVELOPE CONSULTANT'S APPROVAL, PRIOR TO THE FINAL FABRICATION. THESE TESTS REQUIRED ADJUSTMENTS TO THE INSTALLATION SCHEDULE, AS THE PRODUCTION OF THE CORNER PIECES WAS DELAYED BEHIND PRODUCTION OF THE FLAT PIECES.



*Acton Ostry Architects Inc.*



On the construction site, a lifting I-beam spreader bar was used to rig each panel from the lifting points specified by the manufacturer. To place each panel, two workers fitted the panel's base connection into the header connection of the panel on the floor below. Then two workers, positioned on the slab above, fastened the bolts to the perimeter steel L angles, so that the panel effectively hung from the L-angle but was secured to the envelope panel below it.

The L angles, which also provide additional stiffness around each floor's entire perimeter, were installed slightly protruding from the CLT slab perimeter to ensure the envelope panels would be in-plane with the building face even if the CLT panels' edges were slightly out of alignment. In addition, the envelope panel connections were designed to allow enough tolerance to manually position the panels, with the help of shims. Once the correct positioning and alignment were achieved, the panel was unhooked from the crane and all the bolts were fully tightened. As a quality-assurance measure, a worker was assigned to the task of ensuring all the panels were in alignment.



Azadeh Fallahi



KK Law

### ROOF STRUCTURE

The roof structure of Brock Commons is composed of a traditional built-up roofing assembly, steel decking, and steel beams supported by GLT columns.

The project team initially looked into using panellized and prefabricated wood or steel roofing solutions, which would have included the decking and built-up roofing, to accelerate installation. However, these solutions were rejected because of the possibility of water damage to the mass timber superstructure due to leaks, and because of the

logistical and safety challenges of installing larger panels with the existing crane, which would have increased the cost and extended the schedule.

Combining a traditional roofing system with the prefabricated superstructure and envelope required the roof be constructed to a much tighter tolerance rate ( $\pm 3$  mm) than the industry norm, to ensure the interfaces between systems and materials were tight and connections were secure.





### INTERIORS AND MEP SYSTEMS

To keep the complexities and risks associated with Brock Commons at a manageable level, the design team selected interiors and mechanical, electrical, and plumbing (MEP) systems that are typical of high-rise residential construction. Primary distinctions include connection to the University's Academic District Energy System, consolidation of vertical runs in mechanical shafts and limitation of horizontal runs to minimize penetrations through the CLT floors, and limitation of penetrations through the envelope. Additional risk-mitigation measures were also added, such as the use of expansion joints, flex ducts, and suspended storm stacks at every fourth floor to accommodate differential movement of the building structure, and the installation of floor drains in all the bathrooms to minimize the risk of water accumulation in the case of a leak.

A unique aspect of this project was the comprehensive MEP system model developed by the VDC modeller. This model allowed the systems to be organized into modular spool packages, which could be conveniently cut off site and accurately and quickly assembled on site.

The interior partitions are conventional steel stud and gypsum board, while the interior cabinetry and other millwork are laminate particleboard. Detailed modelling and accurate prefabrication of the structural elements ensured the actual unit dimensions were very close to the designed dimensions, which minimized the need for on-site adjustments of interior framing and millwork.

The sequence of interior construction activities was planned in detail and highly coordinated, as is required practice in residential high-rise projects. In these projects, there is little flexibility of sequence or schedule, so any delay from one trade can impact the operations of all subsequent work. The modeling and prefabrication of MEP systems helped keep this work well organized and in sequence while substantially eliminating questions and providing clarification during on-site construction.



#### MANAGING THE RISK OF WATER DAMAGE

A comprehensive water-management plan, with multiple prevention and mitigation strategies, was also in effect throughout construction. The primary strategy was to enclose each floor of the building with the envelope approximately one floor behind erection of the mass timber structure, which meant the wood structure was exposed for only part of a week.

In addition, the original plan relied on sealant and conventional peel-and-stick products to prevent water from penetrating the joints between the CLT panels and to guide any water to the designated water-diversion pipes. The taping of the CLT holes was done in the manufacturing plant, but the panel connection points were taped on site.

The installation of the timber elements was scheduled during the driest season, i.e., the summer months. However, in the summer of

2016, Vancouver experienced the most rainfall in recent years. The first rain proved that the CLT panels were much more permeable than initially anticipated and water immediately travelled through the panels themselves to soak the floors below. Although ongoing moisture monitoring showed the CLT panels drained and dried to the acceptable moisture content levels within 2 days, the installation of the encapsulating drywall had to be delayed until the CLT panels were dry (moisture content no greater than 19%). Moreover, excessive wetting and drying could change the mechanical and chemical properties of the panels. Therefore, the water-management plan was revised to rely on the top surface of the acoustic concrete topping as protection for the CLT panels, and peel-and-stick products were applied to the concrete instead of to the CLT.

#### WOOD SEALANT

- THE BEST-AVAILABLE SEALANT WAS SELECTED THROUGH MOISTURE-MONITORING TESTS ON THE MOCK-UP MODEL. THE PURPOSE OF THE SEALANT WAS TO PROTECT CLT FLOOR PANELS FROM ANY EXPOSURE TO RAIN BEFORE COMPLETION OF THE ENCLOSURE, FROM THE CONCRETE TOPPING MOISTURE, AND FROM LEAKS IN THE BUILDING SYSTEMS. OTHER CRITERIA WERE ALSO CONSIDERED, INCLUDING ACCEPTABLE CURE TIME AND VOC LEVEL.





#### MANAGING THE RISK OF FIRE

A comprehensive fire-management plan was in effect throughout construction, with a particular focus on installation of the mass timber structural components. The original strategy relied heavily on Type X gypsum board, which was installed below the CLT panels for fire protection. However, the encapsulation speed held back the installation of mass timber, because the CLT panels had to be fully dry before the drywall could be installed. The management plan was therefore revised, with the permission of the authorities, to allow up to six floors of wood structure without gypsum board encapsulation. The mass timber columns did not require immediate encapsulation because they were separated from the CLT panels by the concrete topping. Nonetheless they were encapsulated concurrently with the ceiling encapsulation of each floor. The additional layers of gypsum board were added during the interior work.

Other fire-management strategies applied during the construction process include:

- FIRE STANDPIPES WERE INSTALLED IN THE CONCRETE AND CORES. AS A SAFETY MEASURE, THE FIRE STANDPIPES WERE NOT CHARGED DURING CONSTRUCTION BUT THEY COULD BE EASILY CHARGED BY THE FIRE DEPARTMENT IF NECESSARY.
- THE SITE WAS KEPT EXCEPTIONALLY CLEAN TO PREVENT THE BUILDUP OF FLAMMABLE MATERIALS AND TO ENSURE SAFE ACCESS TO EXITS WAS MAINTAINED AT ALL TIMES.
- HOT WORK, SUCH AS WELDING, WAS DONE AHEAD OF THE MASS TIMBER STRUCTURE INSTALLATION.
- ALL TRADES WERE REQUIRED TO TAKE FIRE-PREVENTION AND FIRE-RESPONSE TRAINING.
- TEMPORARY FIRE DOORS WERE INSTALLED ON THE TWO EXIT STAIRS AND CLEAR EXIT PATHS WERE MAINTAINED.





#### OTHER CHALLENGES AND SOLUTIONS/CHANGES

Rigorous safety measures, for the site overall and for the trades, were implemented throughout construction. Examples include the presence of a safety officer at all the construction planning meetings, the use of a re-usable guardrail system around the floor perimeter, and the use of fall protection to secure the trades when they worked near the edges of the exposed floors prior to enclosure by the envelope panels. The challenges associated with working on a small and narrow site were addressed through detailed sequence planning aimed at limiting the number of trades on site, optimizing the use of the single crane, and utilizing prefabrication and just-in-time delivery to organize the on-site work crews and limit the on-site storage of materials.

In addition, because a large portion of the construction processes were transferred to controlled factory environments through prefabrication, critical tasks could be completed in the shop rather than at heights at the construction site. This also limited the impacts of any work stoppages and delays caused by wind speeds and weather variations, e.g., the shutting down of crane operations.

Prefabrication also contributed to reducing construction-related noise and disturbance. The number of trucks and shipments was approximately one-third the amount for a similar sized, conventional Vancouver high-rise. Although the building was constructed in a dense residential neighbourhood, complaints received from the local residents were significantly fewer than would typically be expected for a project of this size.

*A single crane loaded the materials either directly onto the building (mass timber and envelope) or to the cantilevered loading platform (interior materials).*





## LESSONS LEARNED

Extensive and integrative planning and communication translated to direct benefits in the field.

- The use of comprehensive VDC visualization helped identify constructability issues and cost implications, which in turn reduced the number of changes and surprises during the construction phase.
- Continuous and consistent communications amongst the project team, including the site manager, trades, VDC modellers, and site safety officer, ensured the construction plan was realistic, efficient, and safe.

As an early adopter of novel construction solutions, the project team took extra steps to ensure the successful implementation of innovative solutions while meeting aggressive timelines.

- The project team tested and validated alternative designs and construction methods through iterative design and preconstruction processes, including the integrative design workshops, virtual modelling, and laboratory and mock-up tests, in order to optimize the actual construction process.
- Although the trades experienced a learning curve while adjusting to the aggressive schedule, the necessary high level of coordination, and the need to learn new techniques, they achieved the expected assembly tolerances and met or outperformed the schedule.
- The integrative design and construction strategy encouraged the entire project team—design consultants, construction manager, and trades—to take ownership of and actively contribute to the success of this innovative project.

One major advantage of using mass timber is the prefabrication opportunity it provides. Prefabrication increased the construction accuracy and productivity, reduced on-site construction time and waste, and allowed for concurrent off-site work to occur in controlled conditions.

- The VDC model was used to develop a full design of the MEP systems, which determined the exact locations for shafts and penetrations to be cut into the CLT panels during prefabrication. It also enabled the accurate off-site cutting of ducts, pipes, and other systems, and partial off-site assembly of the mechanical room.
- Prefabrication of the envelope panels allowed for fast enclosure of the mass timber components by dramatically reducing the number of fastening steps required on site.

The successful employment of innovative solutions in this project opened up a set of opportunities to be explored in future projects and through academic research.

- Further prefabrication opportunities exist in building typologies with repetitious layouts, including framing for demising walls, bathroom units, electrical cabinets, roof systems, and core walls.
- More advanced technologies can be used for water and fire management in order to reduce the required on-site work and keep up with the fast pace of mass timber erection.
- The stringent dimensional quality control that was applied to the mass timber elements proved to be somewhat excessive and costly. For future tall wood buildings, quality-control measurements, and levels of auditing of the mass timber components should be re-evaluated and linked to acceptable industry norms and standards, but without compromising on safety and performance.



**CASE STUDY**

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**PROJECT CREDITS**

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<b>TALL WOOD ADVISOR</b> Architekten Hermann Kaufmann ZT GmbH	<b>VIRTUAL DESIGN &amp; CONSTRUCTION MODELLERS</b> CadMakers Inc.	<b>STEEL REINFORCING</b> LMS Reinforcing Steel Group
<b>STRUCTURAL ENGINEER</b> Fast + Epp	<b>CONSTRUCTION MANAGER</b> Urban One Builders	<b>STEEL SUPPLIER</b> Bar None Metalworks Inc.
<b>MECHANICAL, ELECTRICAL, FIRE PROTECTION ENGINEER / LEED CONSULTANT</b> Stantec	<b>DESIGN-ASSIST TRADES</b> Structurlam Products LP Seagate Structures Whitewater Concrete Ltd. Trotter & Morton Building Technologies	<b>BUILDING ENVELOPE FABRICATOR</b> Centura Building Systems Ltd.
<b>BUILDING CODE &amp; FIRE ENGINEERING</b> GHL Consultants Ltd.	<b>COMMISSIONING CONSULTANT</b> Zenith Commissioning Consulting	<b>ROOFING TRADE</b> Raven Metapro Systems Ltd.
<b>BUILDING ENVELOPE &amp; BUILDING SCIENCES</b> RDH Building Science Inc.		<b>MECHANICAL TRADE</b> Trotter & Morton Building Technologies
		<b>ELECTRICAL</b> Protec Installations Group
		<b>DRYWALL</b> Power Drywall Ltd.

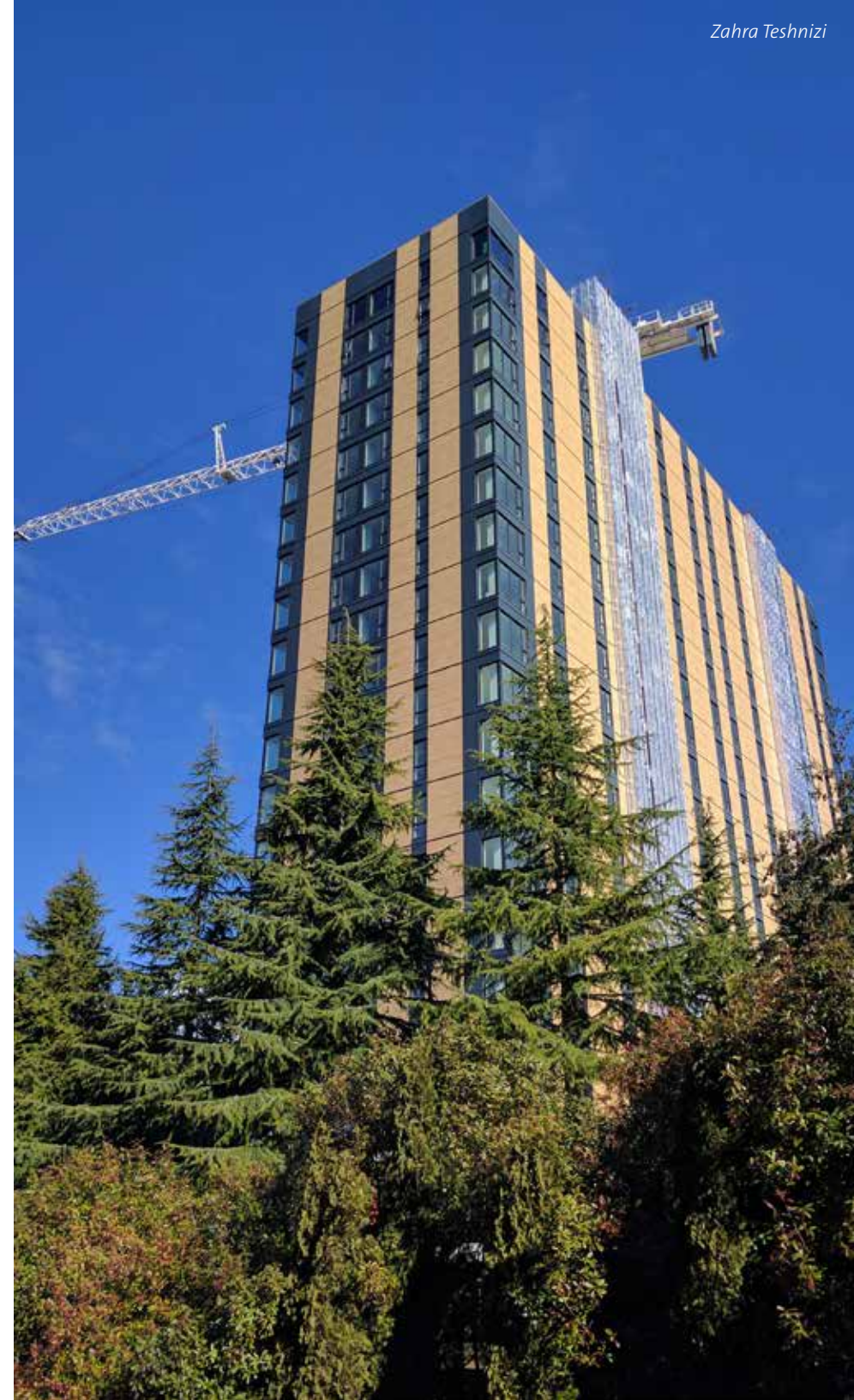
**IMAGE CREDITS**

<b>PHOTOS</b> naturally:wood Acton Ostry Architects Inc. Fast & Epp RDH Building Science Inc. Seagate Structures UBC Research Team UBC Centre for Interactive Research on Sustainability	<b>RENDERS</b> CadMakers Inc.
	<b>DIAGRAMS</b> UBC Research Team UBC Centre for Interactive Research on Sustainability

**OTHER CASE STUDY RESOURCES (WWW.NATURALLYWOOD.COM)**

Brock Commons Tallwood House: Design & Preconstruction Overview  
Brock Commons Tallwood House: Code Compliance  
Brock Commons Tallwood House: Design Modelling

Brock Commons Tallwood House: Construction Modelling  
Brock Commons Tallwood House: Performance Overview  
[www.naturallywood.com](http://www.naturallywood.com)





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