



June 2016

# BROCK COMMONS TALL WOOD BUILDING

## INTRODUCTION

### PROJECT CONTEXT

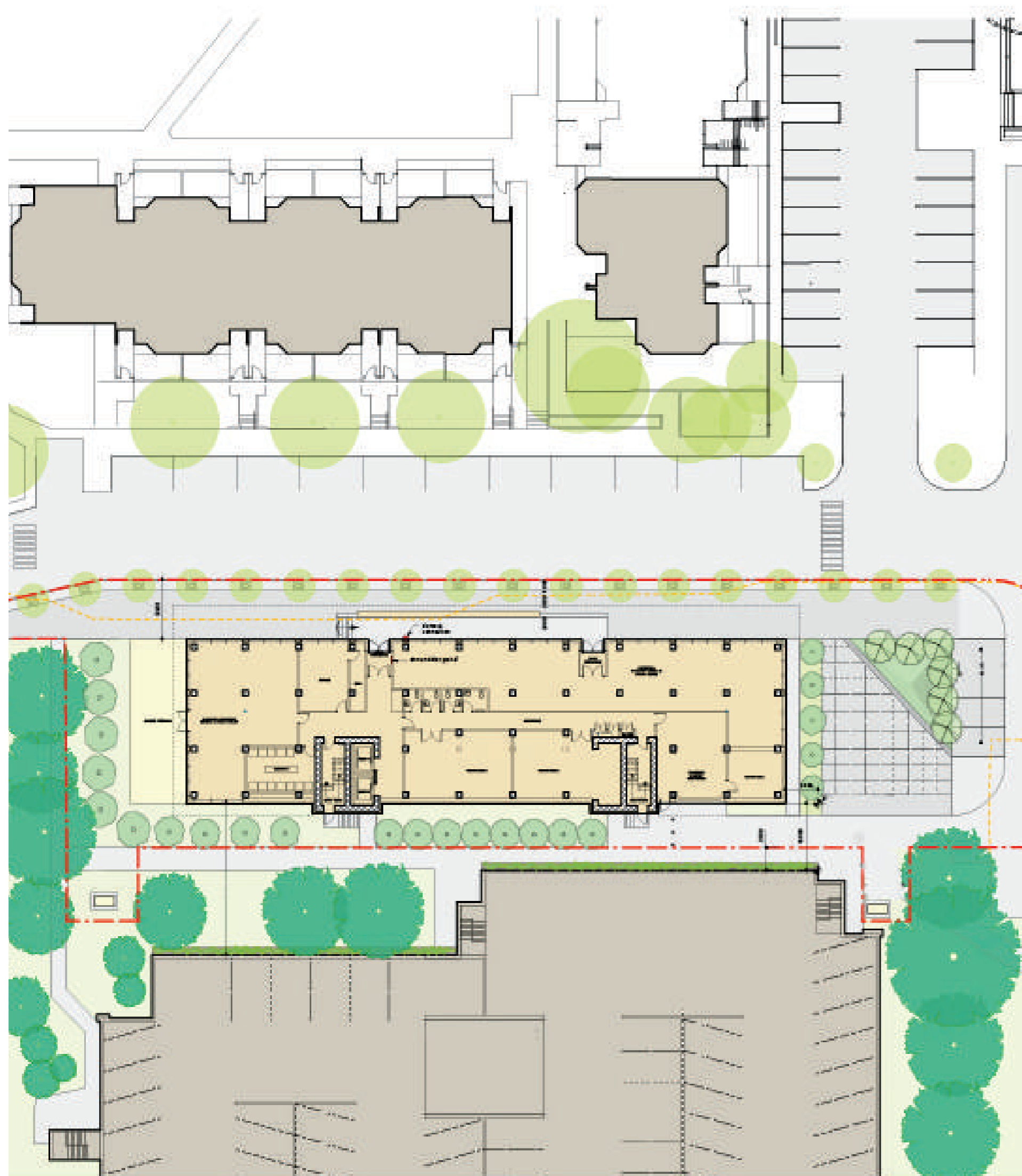
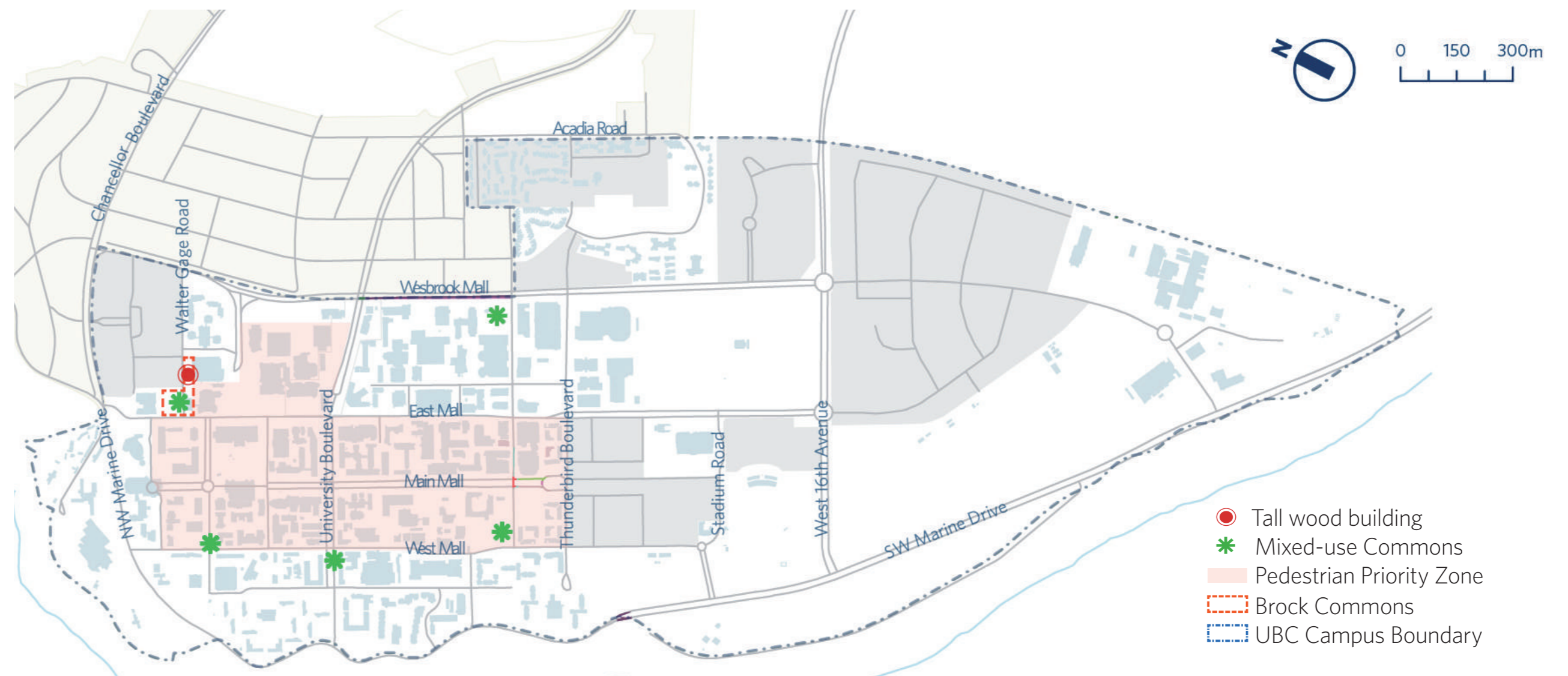
The University of British Columbia has been at the forefront of the revitalization of mass timber construction and the innovative use of engineered wood products at its academic and operational buildings. The newest addition to this portfolio is the first mass hybrid timber residential high-rise building in North America: the 18-storey, 53 m tall Brock Commons Phase 1 building.

Brock Commons is one of five housing complexes planned for the Vancouver campus (it is the third to be constructed after Ponderosa Commons and Orchard Commons). These complexes provide housing for students while acting as academic and recreational hubs for the campus community. The hubs are all of a similar programming and urban design, but Brock Commons is unique in the use of mass hybrid timber structure: 16 storeys of mass timber over a concrete podium with concrete stair cores.

### BROCK COMMONS BUILDING STATS

- Site area: 2,315 m<sup>2</sup>
- Gross area: 15,120 m<sup>2</sup>
- FSR: 6.53
- Bldg footprint: 840 m<sup>2</sup>
- 404 student beds
- 2,233 m<sup>3</sup> of timber used
- 1,753 t of stored CO<sub>2</sub>
- 679 t of avoided CO<sub>2</sub>e emissions
- 2,432 t of CO<sub>2</sub> benefit

Brock Commons is one of two tall wood demonstration projects supported by the 2013 National Resources Canada competition to advance the design and production of wood products in Canada. This pioneering building will showcase innovations in engineered wood products and building techniques, and create a unique research and learning opportunity around the design, construction, operation and inhabitation of a tall wood building in a North American context.



### PROJECT TEAM

**OWNER**  
University of British Columbia, Student Housing and Hospitality Services

**OWNER'S REPRESENTATIVE**  
UBC Infrastructure Development

**PROJECT MANAGER**  
UBC Properties Trust

**ARCHITECT**  
Acton Ostry Architects Inc.

**TALL WOOD ADVISOR**  
Architekten Hermann Kaufmann ZT GmbH

**STRUCTURAL ENGINEER**  
Fast + Epp

**MECH., ELECTRICAL, FIRE PROTECTION ENGINEER & LEED CONSULTANT**  
Stantec Ltd.

**BUILDING CODE & FIRE ENGINEERING**  
GHL Consultants Ltd.

**ACOUSTICAL ENGINEER**  
RWDI AIR Inc.

**BUILDING ENVELOPE & BUILDING SCIENCES**  
RDH Building Science Inc.

**CIVIL ENGINEER**  
Kamps Engineering Ltd.

**LANDSCAPE ARCHITECT**  
Hapa Collaborative

**BUILDING ENERGY MODELLING**  
EnerSys Analytics Inc.

**VIRTUAL DESIGN & CONSTRUCTION INTEGRATORS**  
CadMakers Inc.

**CONSTRUCTION MANAGER**  
Urban One Builders

**COMMISSIONING CONSULTANT**  
Zenith Commissioning

### CONSTRUCTION TEAM

**FORMWORK**  
Whitewater Concrete Ltd.

**REINFORCING**  
LMS Reinforcing Steel Group

**CONCRETE SUPPLY**  
Lafarge Canada Inc.

**MISC STEEL**  
BarNone Metalworks Inc.

**ENGINEERED WOOD**  
Structurlam Products LP

**WOOD STRUCTURE ERECTION**  
Seagate Structures

**PANELIZED ENVELOPE SYSTEM**  
Centura Building Systems Ltd.

**PANELS FOR ENVELOPE SYSTEM**  
Trespa & Bobrick

**DOORS, FRAMES AND HARDWARE**  
McGregor Thompson Hardware Ltd.

**STEEL STUD DRYWALL**  
Power Drywall

**ELEVATORS**  
Richmond Elevator Maintenance Ltd.

**HVAC, PLUMBING AND SPRINKLERS**  
Trotter & Morton Group of Companies

**ELECTRICAL**  
Protect Installations Group

**EXCAVATION BACKFILL**  
Hall Constructors

Images courtesy of Acton Ostry Architects Inc. and Hover Collective



# BROCK COMMONS TALL WOOD BUILDING

## BUILDING ENVELOPE

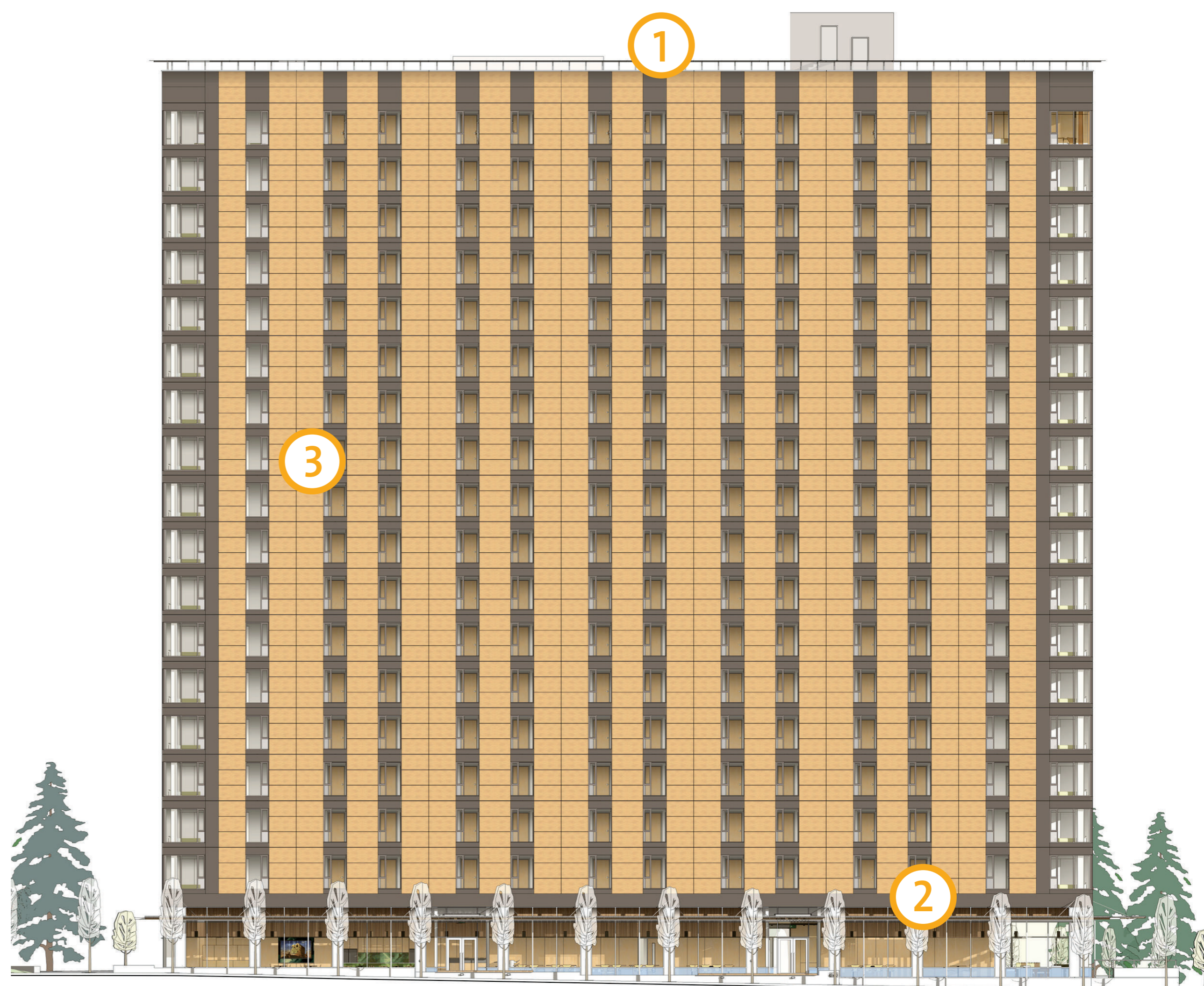
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The envelope of the Brock Commons building is a combination of a curtain wall system (ground level) and prefabricated panel system (levels 2 through 18), with a conventional built-up roof. The rationale behind a prefabricated envelope system is to allow each level to be rapidly enclosed as the wood structure is erected, thus providing protection from rain as well as reducing risk of damages. Energy performance is another consideration: the envelope has a minimum R-16 thermal resistance. The exterior colour palette and aesthetics are similar in style to the other student residence hubs on campus.

Four different envelope options were explored, as versions of design-build packages and meeting standard specification for insulation value, as well as materials and finishes:

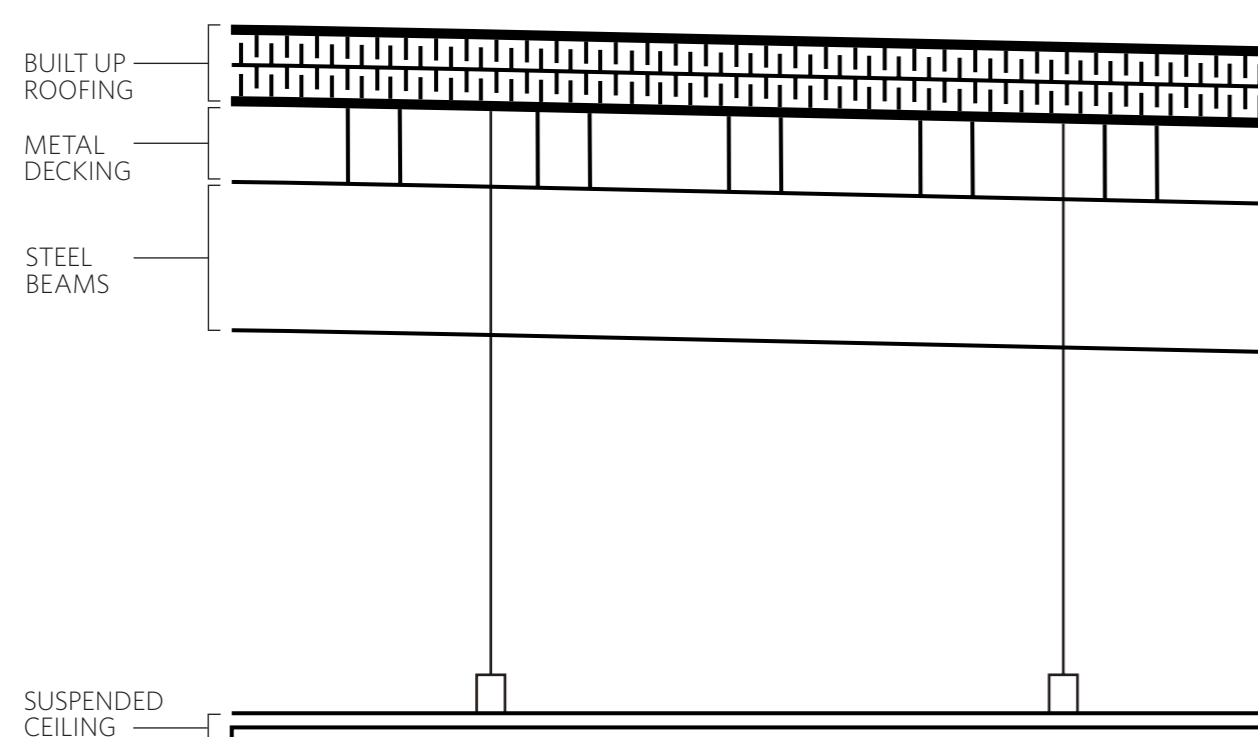
1. Curtain wall system with large insulated spandrel pieces and glazing;
2. Pre-cast carbon fibre reinforced concrete insulated sandwich panel with pre-installed windows;
3. Wood frame stud systems with pre-installed windows; and
4. Structural steel stud system with pre-installed windows (the selected option).

The decision came down to cost, weight, ease of installation and overall performance, including non-combustible construction.



### 1 ROOF

- The roof assembly is a traditional built up roofing system on metal decking supported by steel beams.



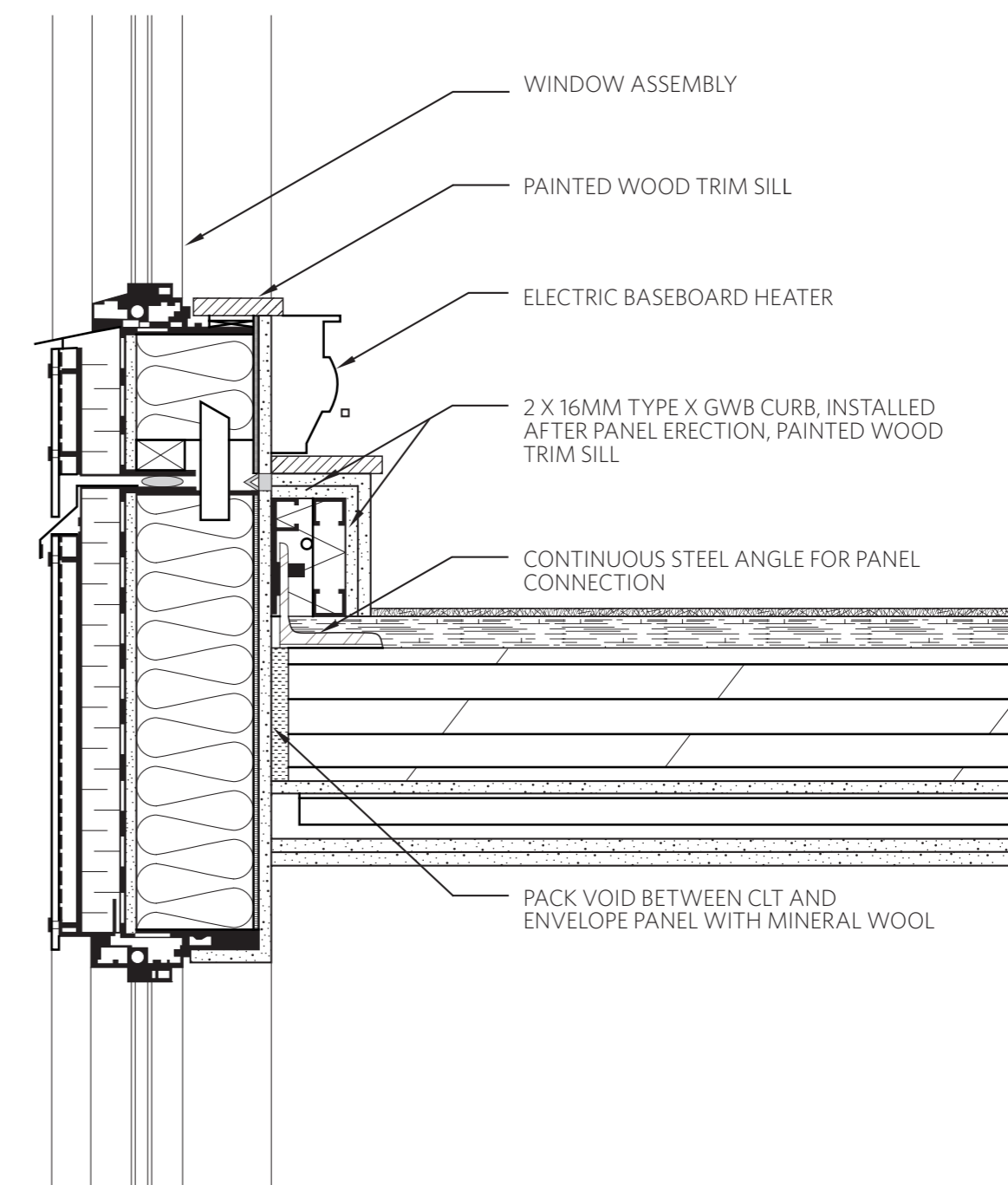
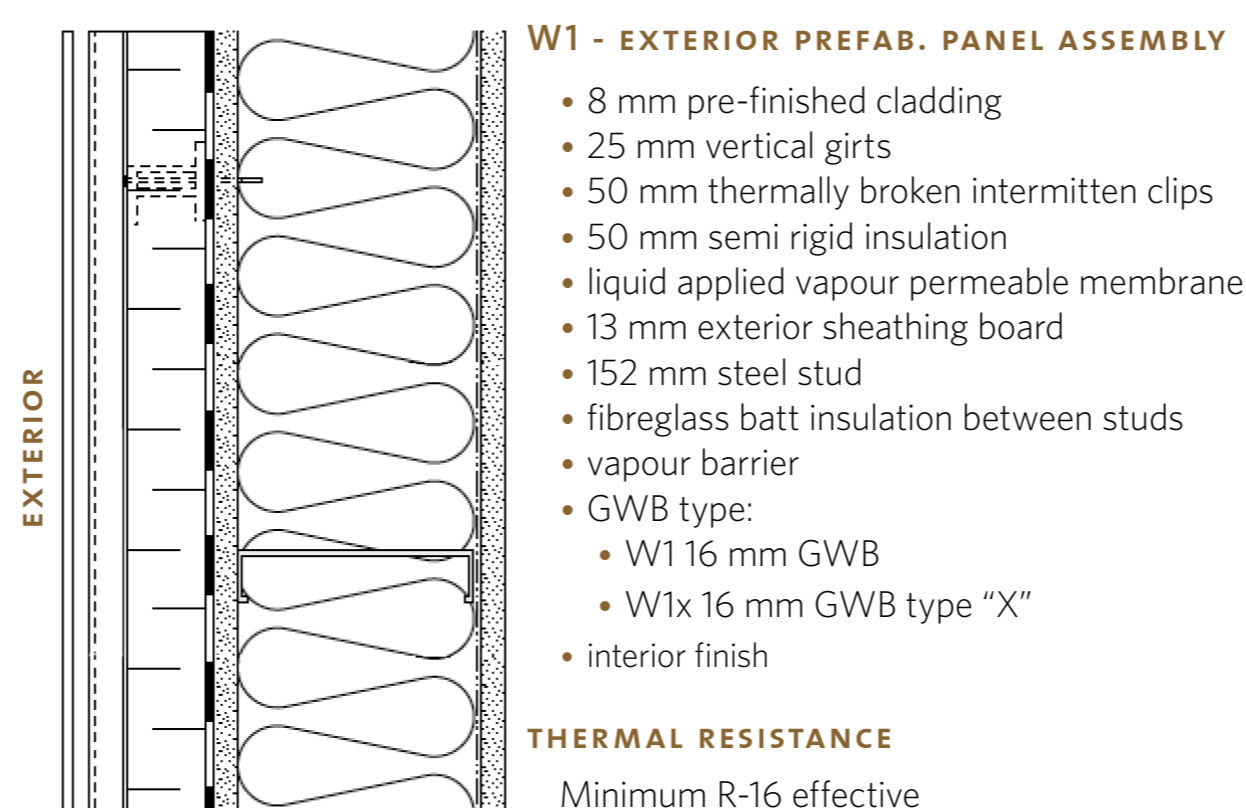
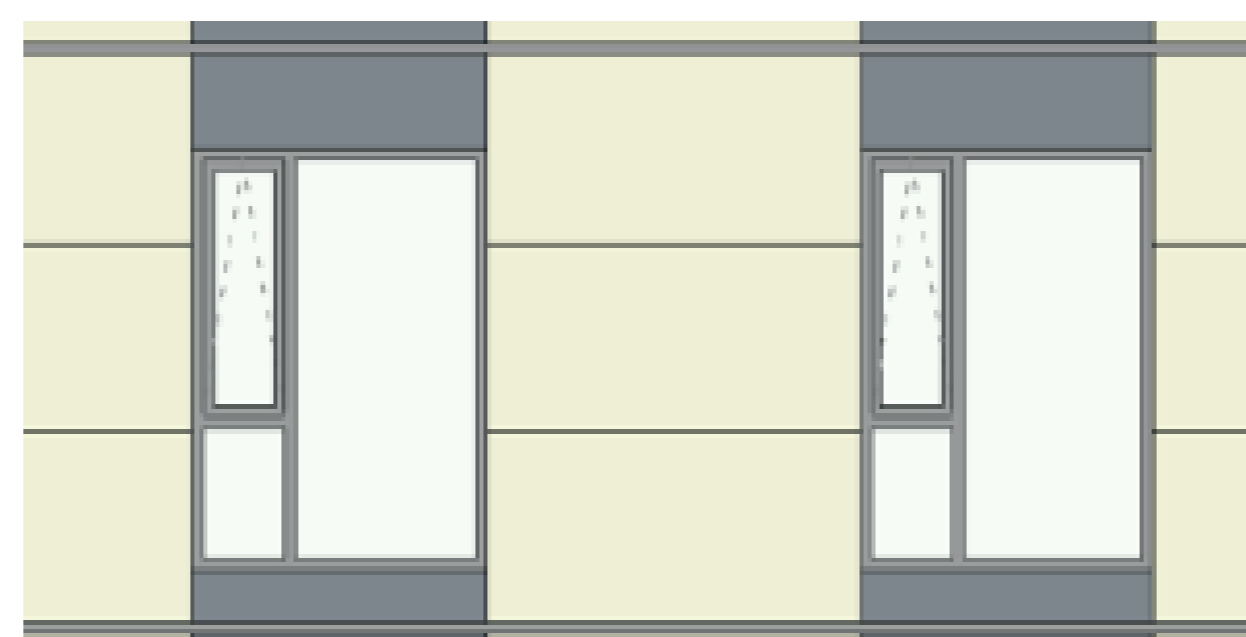
### 2 PODIUM ENVELOPE

- The ground floor of the building will be enclosed with a glazed curtain wall system
- A three layered CLT panel canopy with double folded standing seam metal roof provides rain coverage for pedestrians.



### 3 PRE-FABRICATED ENVELOPE PANEL

- The primary envelope is a prefabricated exterior panel system, supported on a steel angle (L127x127x13) mounted at each floor level.
- Panels are 8 m long by 2.81 m high (corresponding to two structural bays and one storey, plus special corner panels).
- Panels are composed of a steel stud and fiberglass batt insulation assembly, with rainscreen wood fibre laminate cladding system and pre-installed window assemblies.
- The structural, window and rainscreen components are prefabricated while the vapour barrier, batt insulation and the interior finishes are applied on site.



Images courtesy of Acton Ostry Architects Inc. and UBC Research Team



# BROCK COMMONS TALL WOOD BUILDING BUILDING SYSTEM AND SERVICES

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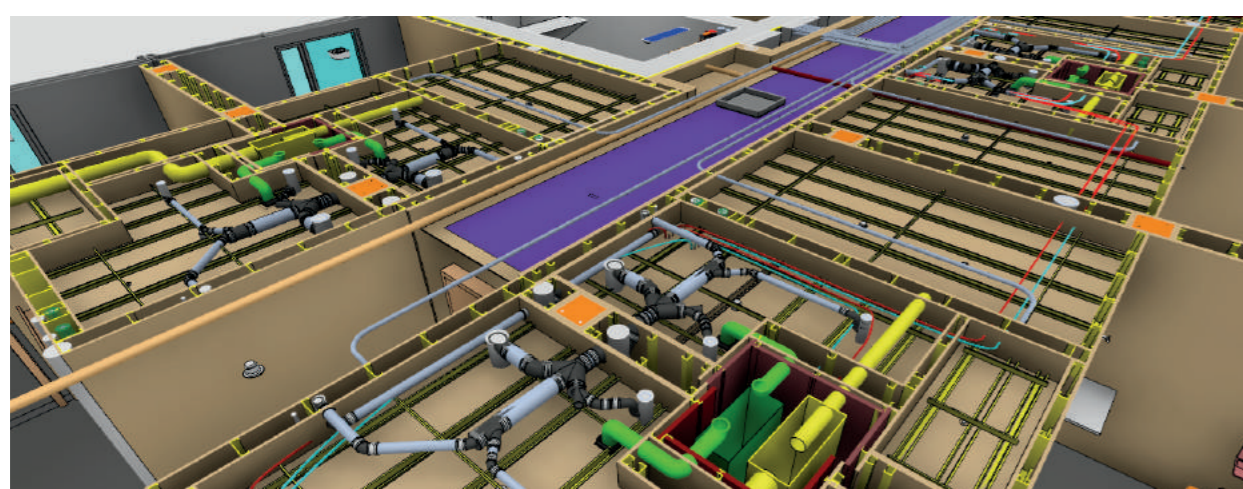
The building services include the conveyance systems, plumbing services, electrical systems, heating, ventilation and air conditioning (HVAC) systems, and fire protection systems.

The systems are relatively conventional and typical of what would be found in any residential high-rise. Design considerations for the application in a building with a wood structure include:

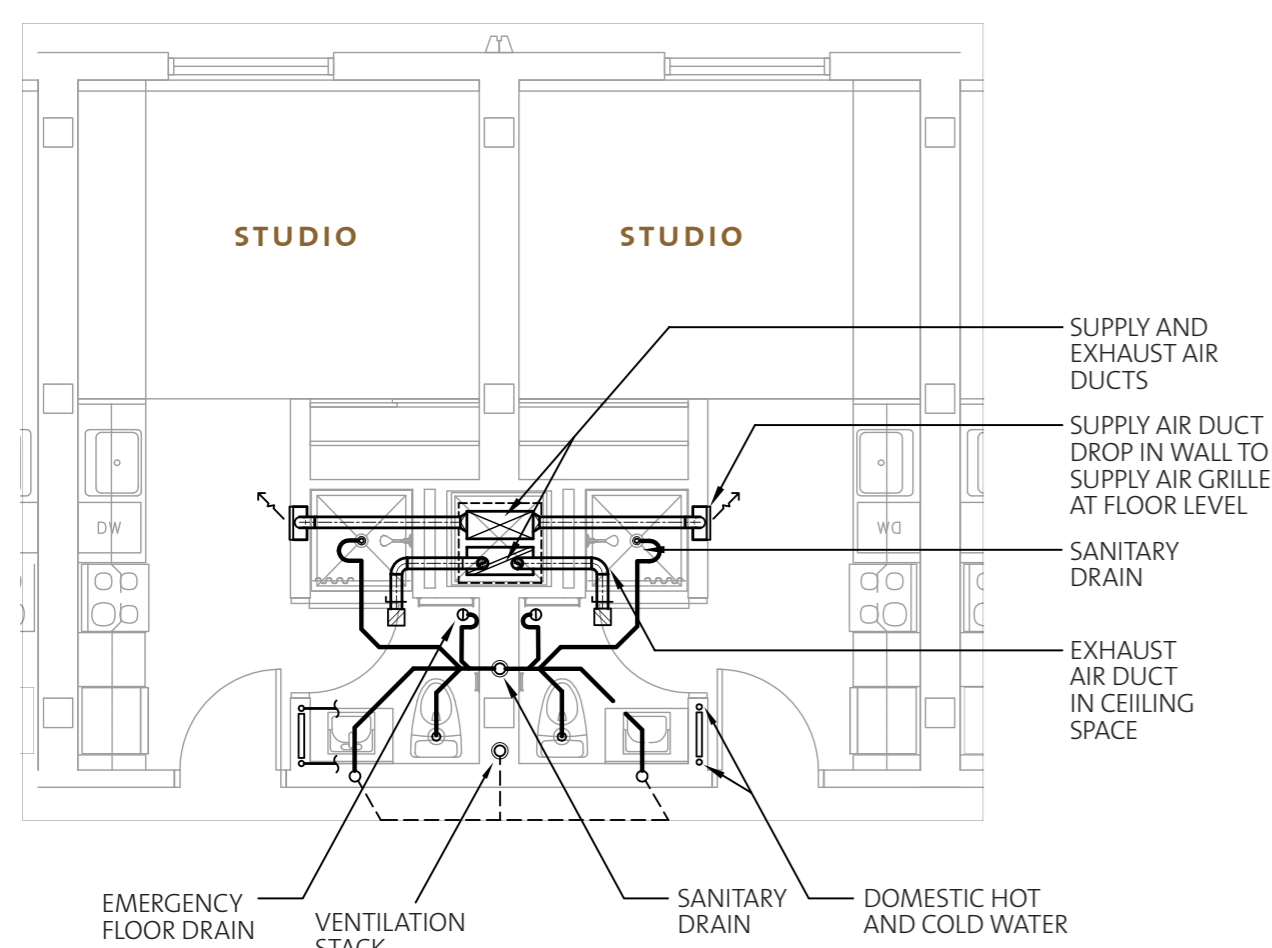
- Consolidation of building systems in centralized locations and highly coordinated distribution pathways to reduce penetrations in CLT panels.
- Pre-design of all systems distribution pathways to coordinate the headroom and clearances of surface-mounted horizontal distributions and the penetrations in prefabrication components.
- Design of flexible building systems and expansion joints to accommodate differential settlement and potential movement between the concrete cores and the wood structure.
- Prevention and mitigation measure to reduce water accumulation within units or interior assemblies in case of leaks.

## 1 HVAC

- HVAC systems includes supply and exhaust air, and stair pressurization (a life-safety measure).
- Horizontal distribution for both supply and exhaust ducts occurs at the 18th floor, immediately below the roof, and branch to vertical mechanical shafts located between units to service all levels.
- Flex ducts are used to mitigate impacts from settlement of the wood structure.
- UBC's District Energy System provides hot water for space heating and domestic hot water.
- Within units, electrical baseboard heaters provide space heating and operable windows allow for space cooling and natural ventilation.
- Kitchen exhaust uses charcoal filters to clean and recirculate air, eliminating horizontal duct run penetrations through the envelope.



Ceiling Space On Third Level

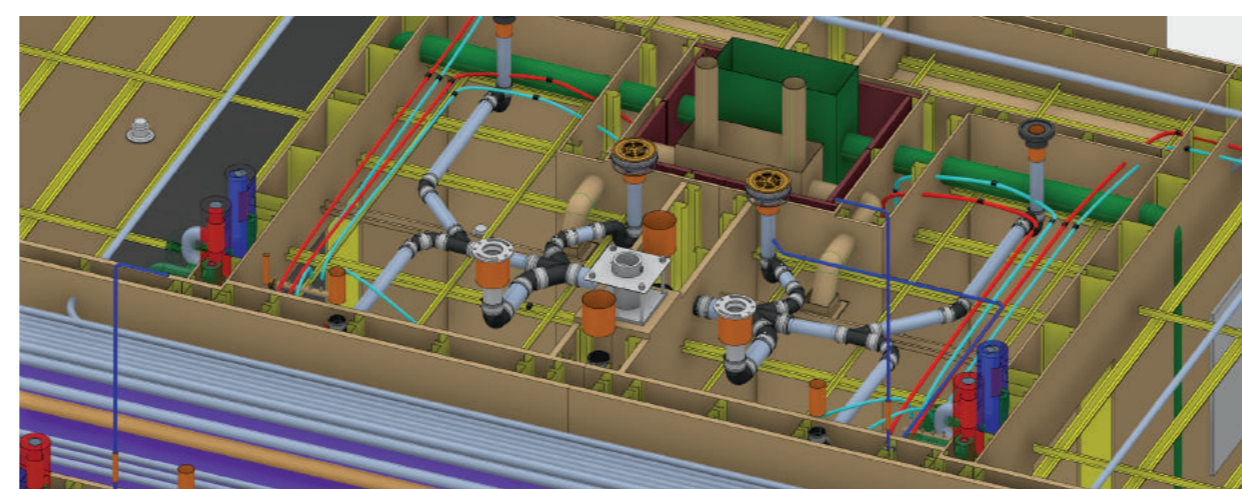


Typical Layout For Single Occupancy Ensuite

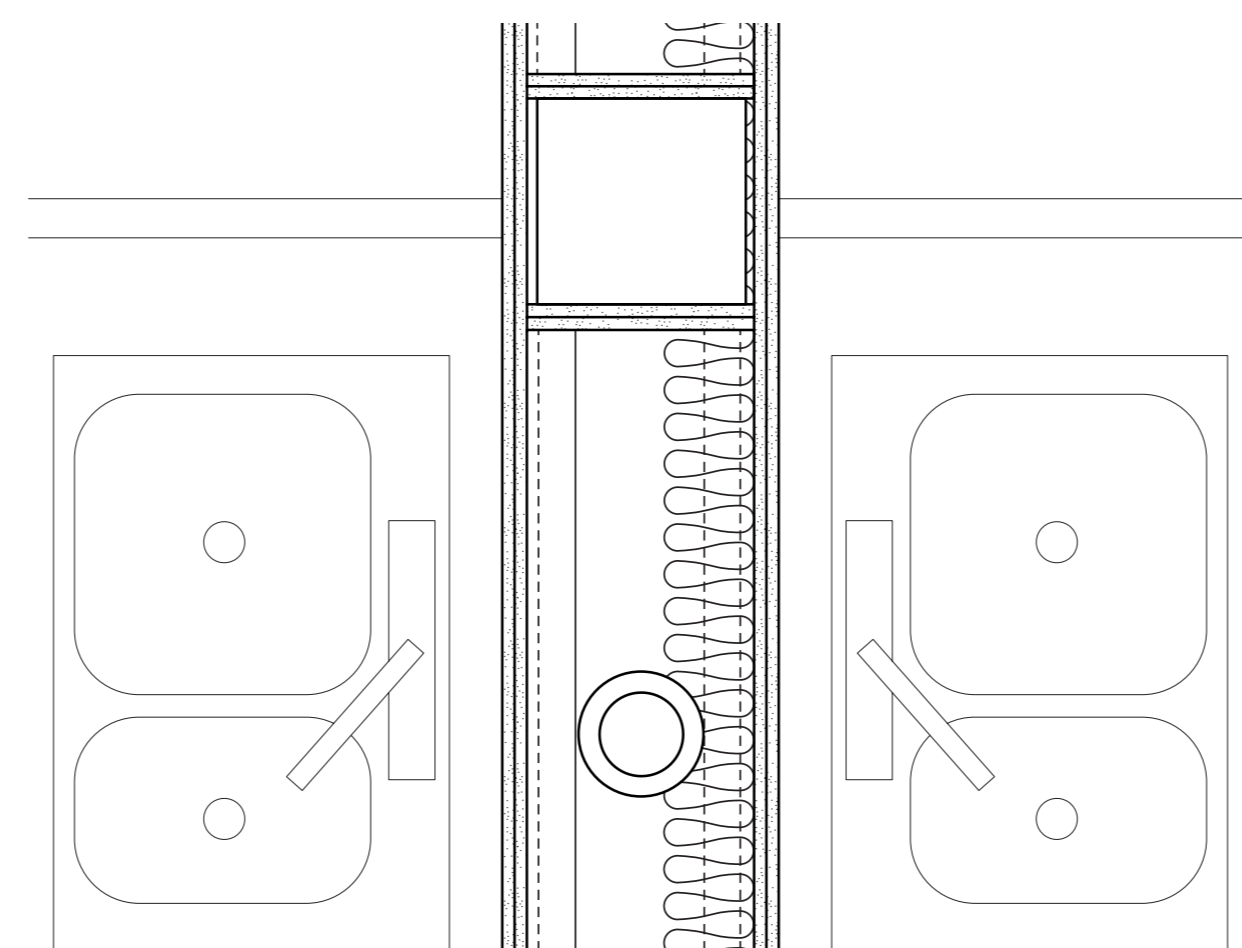


## 2 PLUMBING

- The plumbing systems include a domestic water supply, as well as sanitary and storm systems.
- Express risers in the cores serve all floor levels where horizontal piping is surface mounted below the CLT panels and services the floor above through coordinated penetrations.
- To mitigate impact of settlement, braided stainless steel connections, expansion compensators, expansion joints, and flexible pipe connectors are located at each level; the domestic water system uses PEX piping instead of copper, and the sanitary and storm stacks are suspended at every 4th floor.
- To mitigate water damage, additional floor drains are placed within units, as well as a highly visible shut-off panel for students to access in case of pipe breakage.



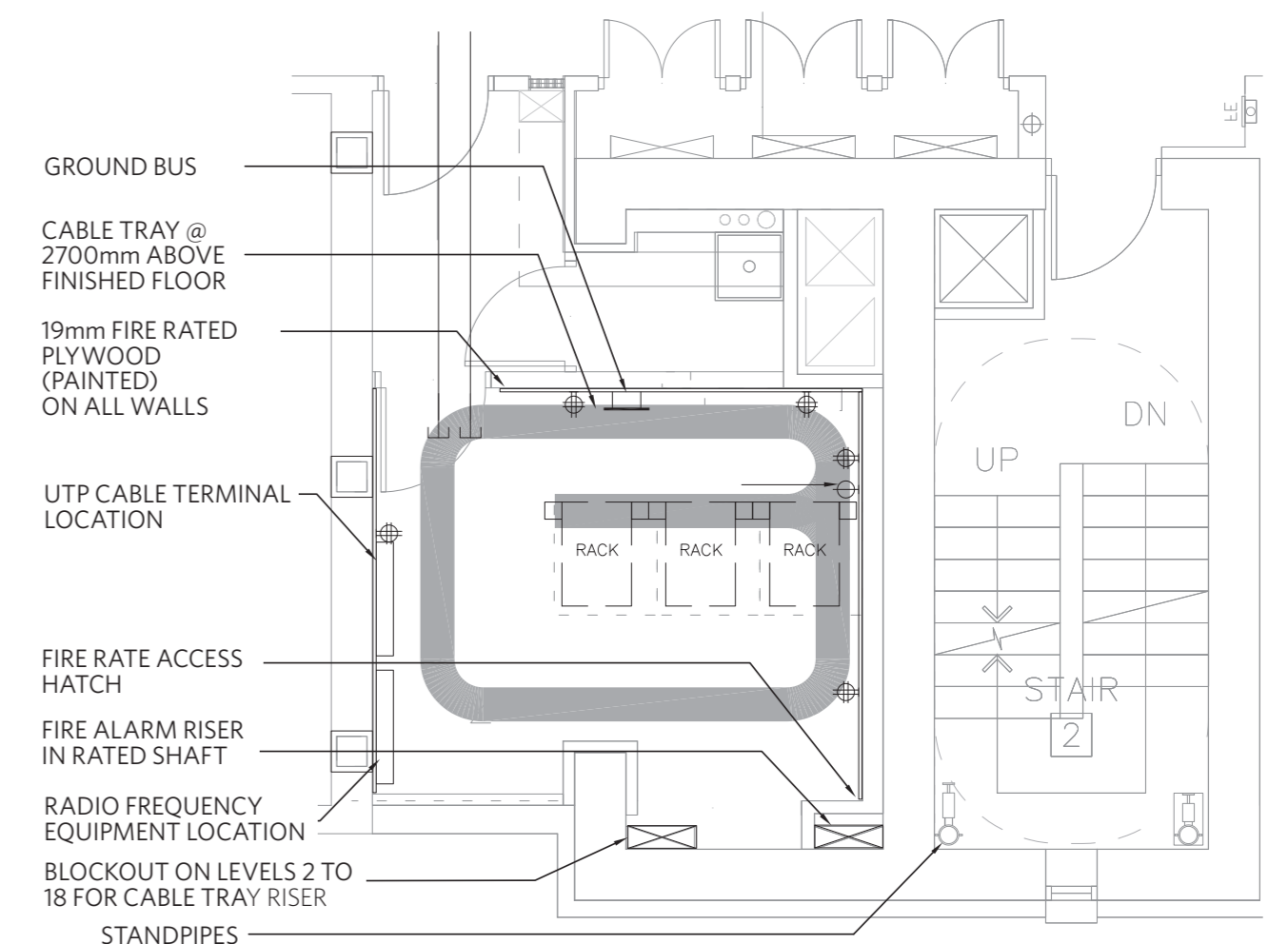
Electrical And Plumbing Layout



Typical Demising Wall At Kitchen

## 3 ELECTRICAL

- Electrical systems include electrical distribution and power, communications network, data network, fire detection and alarm, lighting, and emergency power.
- One parking stall with a charger for an electric car.
- Electrical and communications distribution branches from centralized rooms to closets and panels on each floor, which then horizontally feed the units.
- Emergency power is provided via an external emergency generator to multiple emergency panels that serve elevators, lighting, fire alarm and suppression, and life-safety systems.
- Fire alarm is single stage and addressable, which entails a CACF/ annunciator panel at the main entrance, and includes heat detection, smoke detection, manual pull stations, and audible and visual signal devices, as well as transponders and relays to the Fire Department.



Main Communications Room Plan

## 4 CONVEYANCE

- The building has two elevators housed in a concrete core, a typical arrangement for high-rise buildings.
- One elevator runs on emergency power, as a designated fire fighter elevator.



Construction of concrete cores (June 2016)

Images courtesy of Stantec Ltd., Acton Ostry Architects Inc., and CadMakers Inc.

# BROCK COMMONS TALL WOOD BUILDING CONSTRUCTION PROGRESS



June 2016

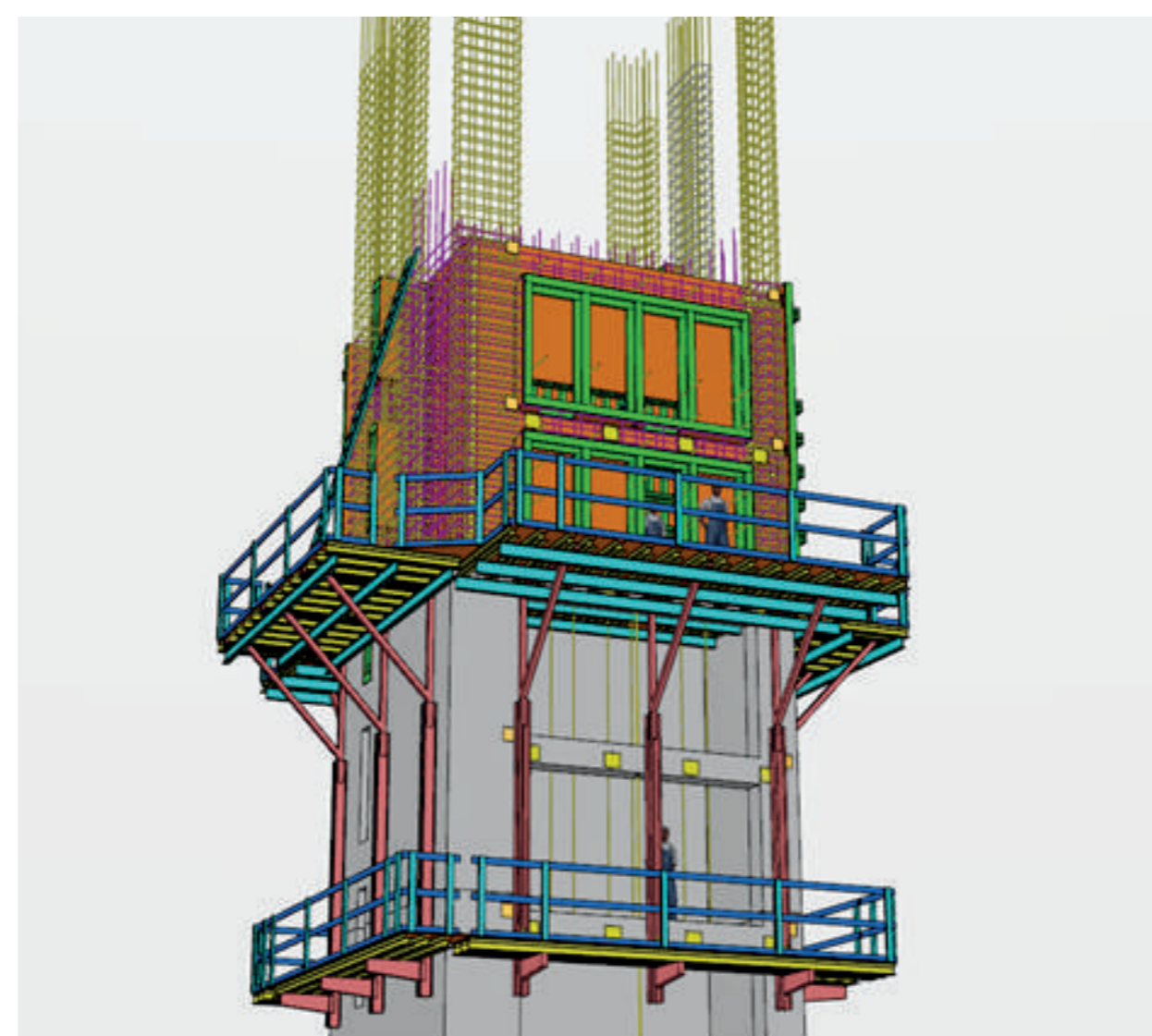
## CONSTRUCTION ACTIVITIES TO DATE



## PRECONSTRUCTION PLANNING

Considerable planning was undertaken during preconstruction in order to facilitate the construction process and address some of the challenges of building a high-rise with a mass timber hybrid structure. Construction organization and planning was aided by virtual 3D modelling.

The key strategies to address three primary challenges included:



Virtual 3D model of concrete core used to plan construction



Actual concrete core under construction

### 1 CONSTRUCTION SCHEDULING

- Construction schedule input and buy-in from major trade contractors
- Proactive procurement process of major materials, systems, and equipment; tracked for availability in advance of construction timing requirements
- Prefabrication and off-site storage of wood structure components and building envelope panels
- Computerized design models and physical mock-ups analyzed in advance of mass production to ensure correctness and approval
- Scheduling of wood structure erection for spring and summer to reduce weather-related stoppages
- Coordination of crane time for building envelope erection to keep pace with wood structure erection

### 2 FIRE EVENT

- Detail wood structure to minimize or eliminate welding
- Hot work permit required by trade contractors and firewatch personnel posted
- Temporary heat used to avoid open flame heat within the structure
- Fire standpipes installed no lower than 4 levels below construction floor and available for Fire Department with temporary siamese connections
- CLT floor structure to be encapsulated of CLT floor panels with concrete topping and layer of Type X gypsum board; no more than 4 levels of unprotected wood structure exposed at any time
- Personnel training in fire prevention and fire response
- Fire Safety Plan to be reviewed and approved by Vancouver Fire Department

### 3 WATER EVENT

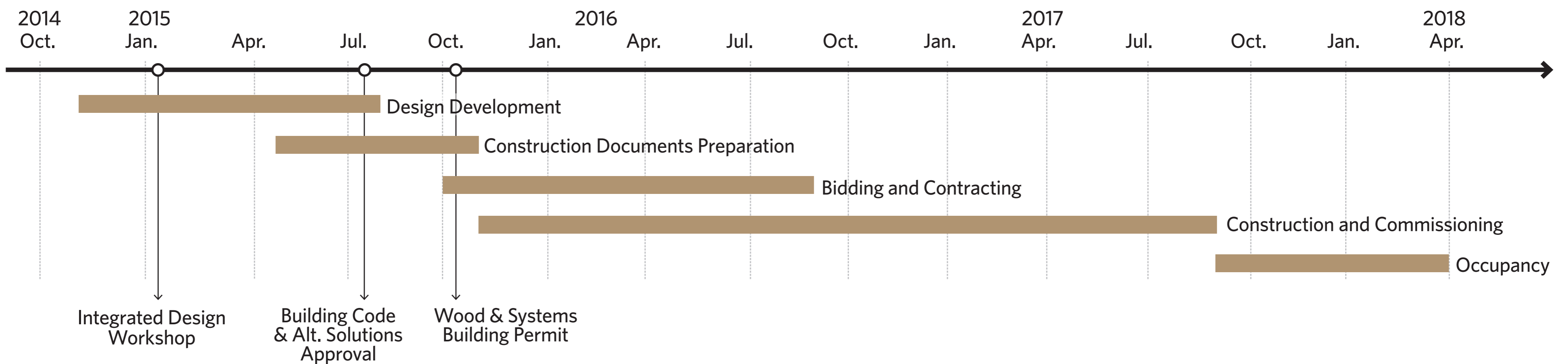
- Wood structure erection scheduled for dryer summer season
- Water resistant coatings applied to wood elements to minimize water absorption during construction
- Concrete topping covering wood slab structure sloped to direct drainage
- Assessment of wood structure moisture content prior to encapsulation
- Prefabricated temporary rain protection to be erected during wet weather
- Prefabricated building envelope installed approximately 1 level behind erection of structure
- Water flow alarms activated and main water shut-off after hours
- Personnel training regarding water damage prevention and mitigation

Images courtesy of CadMakers Inc. and UBC Research Team



# BROCK COMMONS TALL WOOD BUILDING DESIGN PROCESS

June 2016



## 1 DESIGN PHASE

The design process from Brock Commons officially began in November 2014 and was completed in October 2015: 4.5 months of schematic design, 3 months of design development and 5 months of construction documentation (with overlaps).

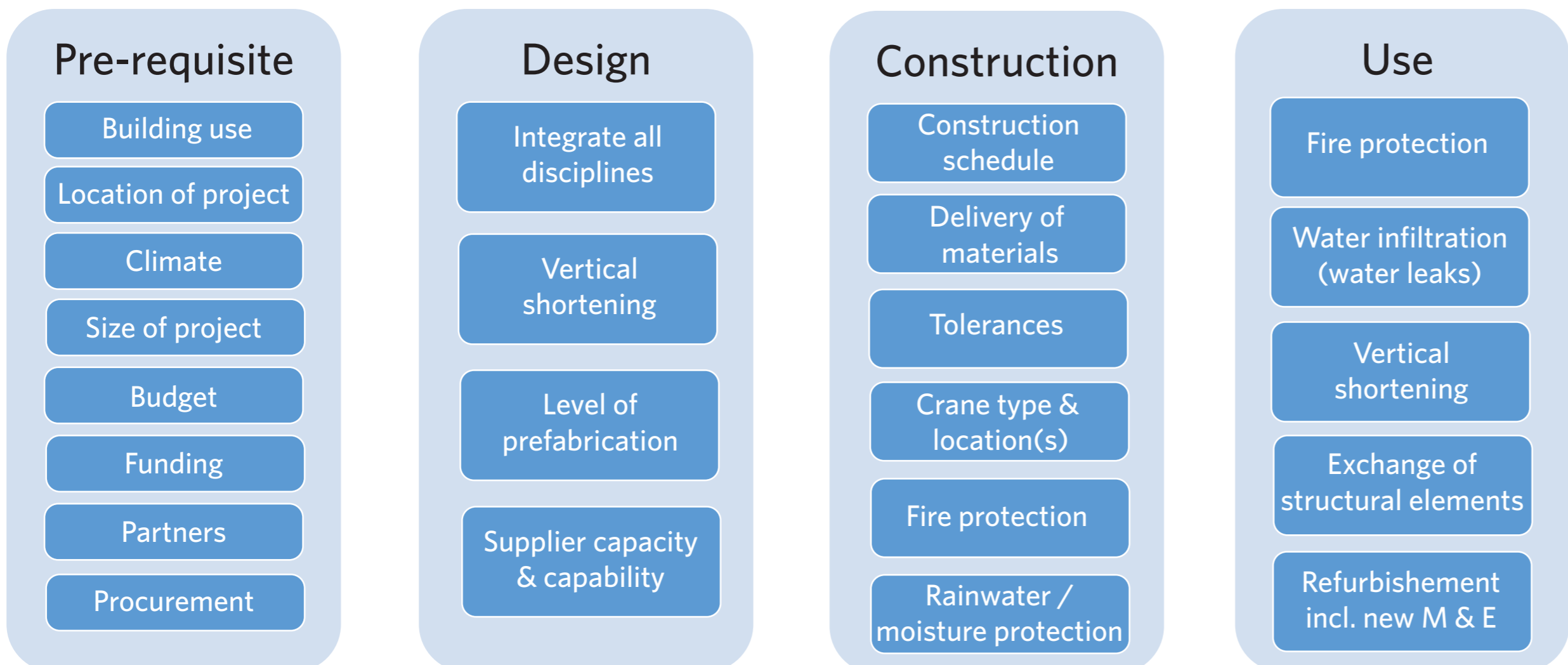
Key design strategies were utilized to address the challenges of developing a new building type for British Columbia:

- Using completed student residence, Ponderosa Commons Phase II, as a precedent project.
- Setting well-defined project parameters and guidelines for design decisions.
- Holding an integrated design workshop focused on analyzing multiple structural approaches in terms of cost, constructability and engineering system impact.
- Utilizing the virtual model for detailed visualization, decision making, planning & constructability review.
- Building a full-scale mockup to test and validate viability and constructability of key building elements and materials.
- Involving building code authorities and construction expertise throughout the design process.

## 2 DESIGN PARAMETERS AND GUIDELINES

Project design parameters included previously designed optimal suite layouts, compact site, available building area, height restrictions, and proximity to the parkade.

A set of practical guiding principles and performance requirements were used by the project team to frame the development of solutions for the mass timber hybrid structure.



Design Criteria And Guiding Principles

## 3 REGULATIONS

Building projects at UBC are governed by a number of overlapping policies, codes, standards, and regulations that are established at the local, provincial, and national levels. The primary regulation is the British Columbia Building Code 2012 (BCBC):

- BCBC classifies Brock Commons as a residential occupancy (Grp C) with Assembly Spaces (Grp A-2).
- BCBC Article 3.2.2.47 states that buildings above six storeys with residential and assembly occupancy must be of non-combustible construction, sprinklered throughout, have floor assemblies with a fire resistance rating (FRR) no less than 2HR and loadbearing elements that have a FRR no less than the supported assembly.

The project team and UBC Chief Building Official worked with the provincial Building and Safety Standards Branch (BSSB) to draft a site specific building regulation, the UBC Tall Wood Building Regulation. The regulation:

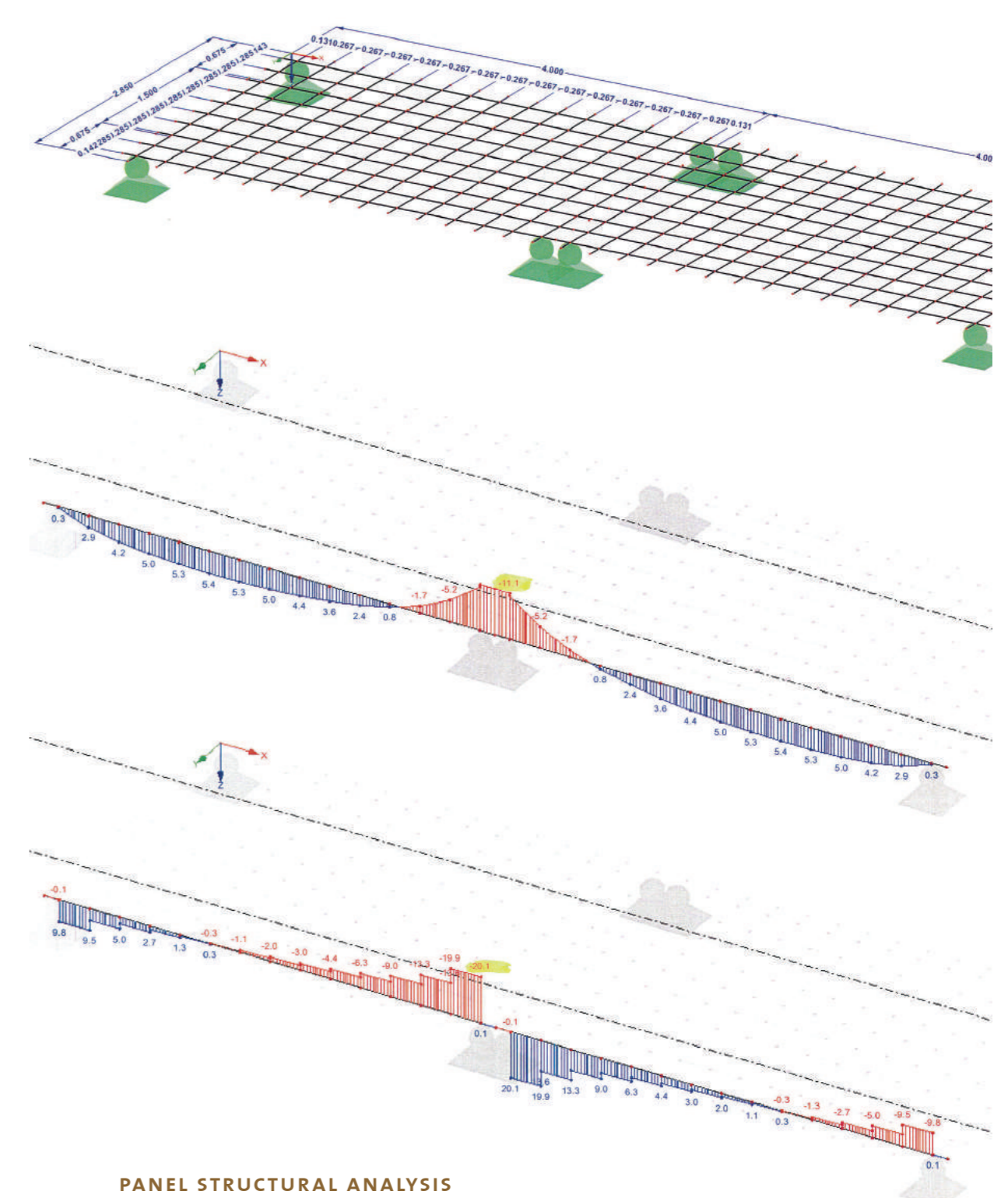
- Exempts the project from some parts of the BCBC, such as the size limitation on combustible construction;
- Substitutes specific technical requirements that apply exclusively to this building; and
- Ensures occupant health and safety protection is equal to or better than that provided in the Code for non-combustible construction of this size.
- Other regulations:
  - National Building Code of Canada 2015
  - British Columbia Fire Code 2012
  - UBC Policy No. 92, Land Use and Permitting
  - LEED Gold Certification requirements
  - ASHRAE 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings

## 4 UBC SITE-SPECIFIC REGULATION REVIEW

The development of a site specific regulation is a rigorous review process which results in a building regulation that is only applicable to the site of a specific project. For Brock Commons the process included:

- Concept design and proposals for mitigation strategies for key areas of technical risk by the project team.
- Peer reviews of the structural design and mass timber products by two independent third party engineering firms, one local and one international.
- Structural performance and fire safety design reviews by two expert panels, composed of design building professionals, building officials, advanced wood construction organizations, and qualified researchers.
- Collaborative problem solving involving the BSSB, UBC's Chief Building Official and the project team.
- Consultation and advising by an experienced code consulting company with expertise in combustible construction.

Feedback from the reviews incorporated into the building design. The purpose of the review process was to confirm that all areas of uncertainty were identified and adequately addressed in the regulation.



Structural analysis including reaction at bearings, longitudinal bending forces and longitudinal shear forces performed as part of the third party structural peer reviews process by Merz Kley Partner AG.

Images courtesy of Acton Ostry Architects Inc. and Fast + Epp

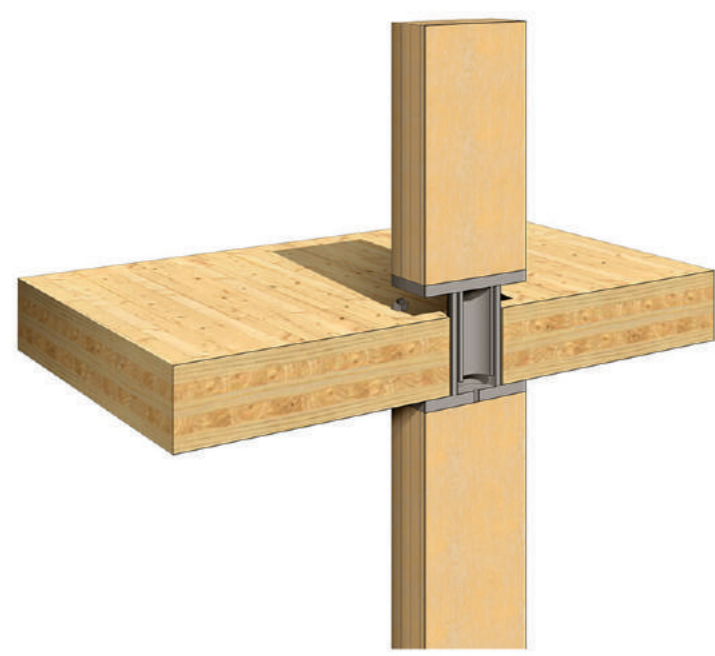
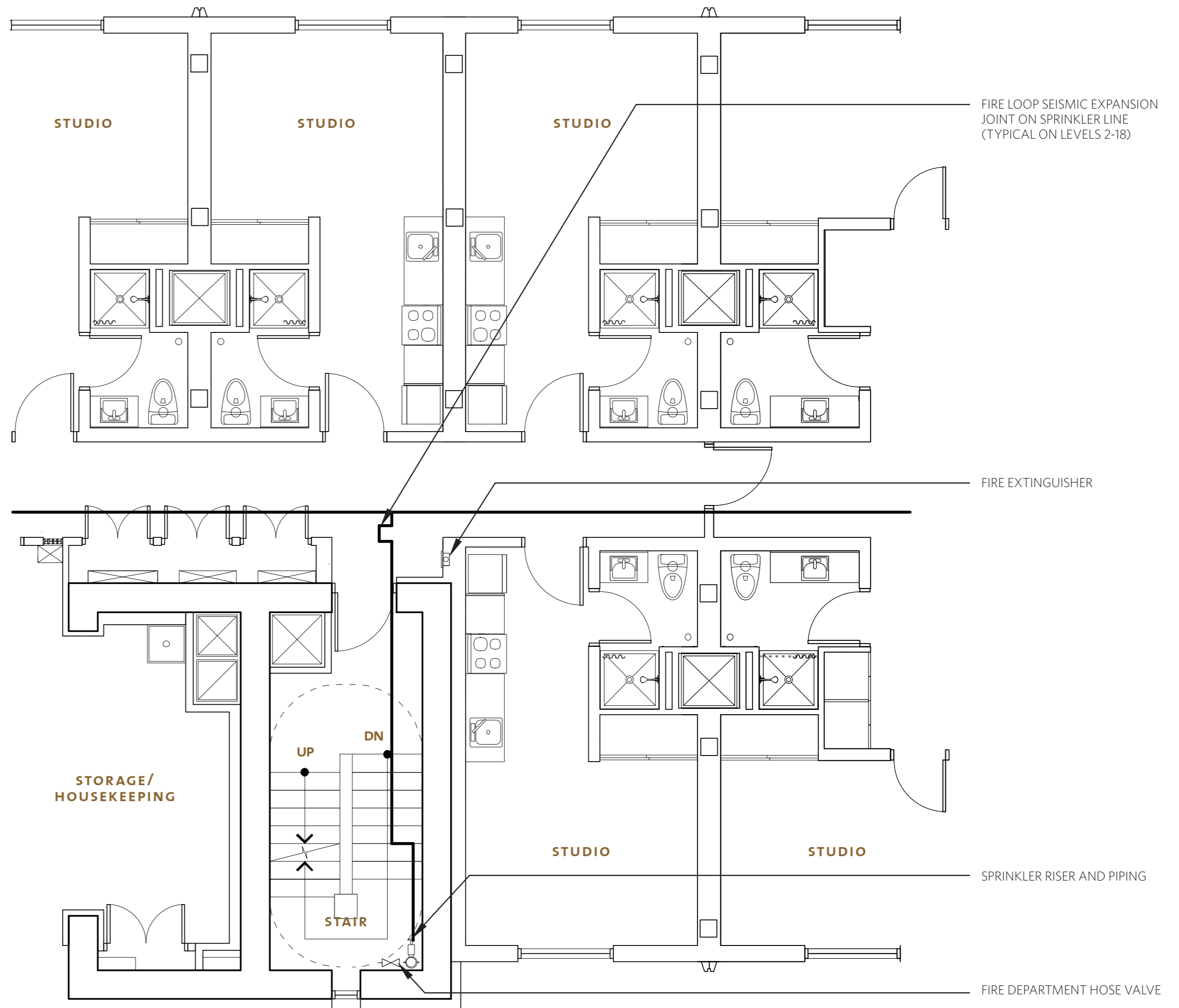


# BROCK COMMONS TALL WOOD BUILDING FIRE PROTECTION

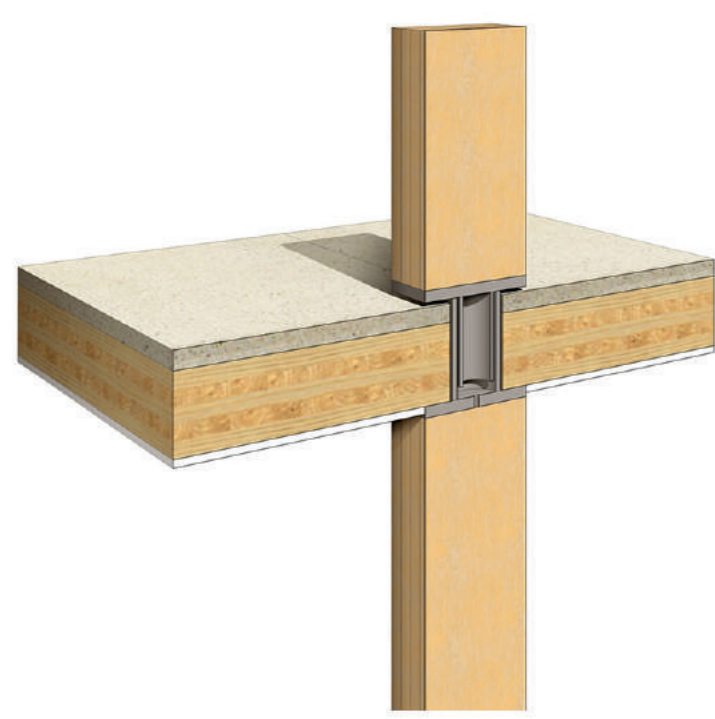
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Fire protection was a key consideration in the design of Brock Commons. One of the main focuses of the UBC Tall Wood Building Regulation (the site specific regulation for this project) is to ensure that the level of occupant health and safety protection is equal to or better than what is required by the BC Building Code for a non-combustible (i.e. concrete) building of this size. To achieve this the design utilizes passive fire protection, active fire detection and suppression techniques, as well as measures to protect the building during construction.

Most of these techniques are common for residential high-rise buildings in BC, including the fire resistance rating (FRR) separation. FRR separations serve to limit the probability that structural elements, floors and loadbearing walls exposed to fire will prematurely fail or collapse, preventing occupants from exiting and first responders from entering, as well as lead to the spread of fire between storeys. The ratings ensure that the structural system has an acceptable level of endurance during a fully developed fire in the event that the sprinkler system fails.



CLT floor slabs with glulam columns and steel connectors



Partial encapsulation during construction



Completed construction

## 1 FIRE PROTECTION STRATEGIES DURING CONSTRUCTION

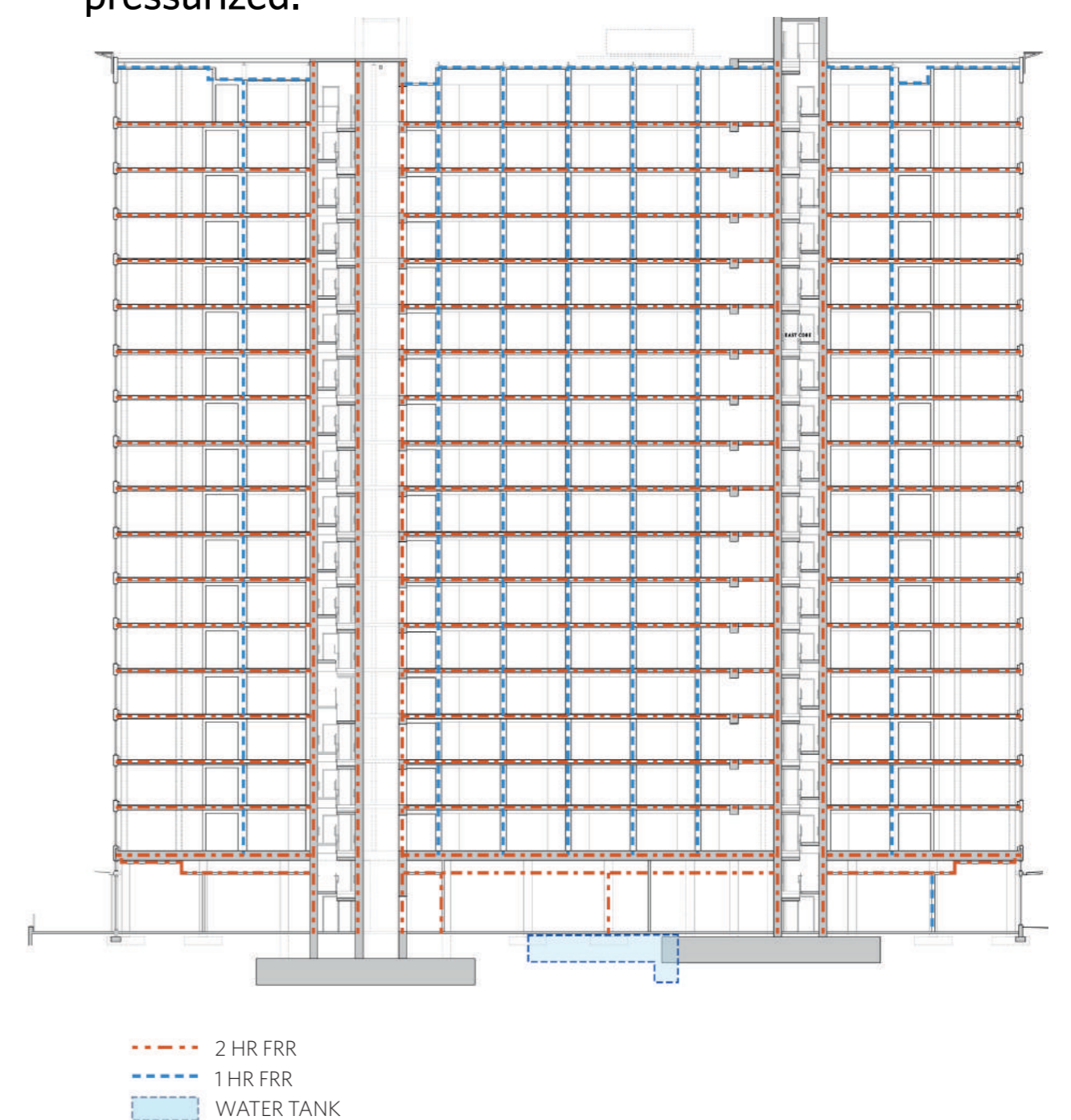
- Less than four levels of unprotected wood during construction.
- Protection of wood structural elements by installing a layer of Type X gypsum board and concrete topping as structure is built.
- Functional standpipe in concrete cores.
- On-site security and fire watch.

## 3 ACTIVE FIRE PROTECTION STRATEGIES

- Single stage and addressable fire alarm system, with audible and visual signal devices.
- An automatic sprinkler system and a standpipe system, connected to the municipal water system, and backed-up by a 20,000 litre on-site water tank and fire pump (both running on emergency power). The tank provides 30 minutes of water supply, and close to 100 percent system reliability.
- Fully sprinklered residential units, with recessed sprinkler heads to limit potential accidental damage. Fire extinguishers are also provided on each level.
- A dry sprinkler system (to limit water freezing and pipe damage) installed under the exterior CLT canopy.
- A water curtain for areas where 100% unprotected openings are required, specifically the ground level public spaces adjacent to the parkade.
- Monitored and electrically supervised alarm and sprinkler systems with signals to the Vancouver Fire Department.
- Expansion joints where the sprinkler riser exits the concrete core on each level.

## 2 PASSIVE FIRE PROTECTION STRATEGIES

- Non-combustible ground level and stair/elevator cores, which serve as the exits for the upper levels.
- Full encapsulation of the wood structure (with the exception of the 18th floor lounge, which is fully sprinklered) in multiple layers of Type X gypsum board to provide a 2HR fire resistance rating (FRR) for all the structural assemblies.
- A 2HR FRR between each floor level and for all vertical shafts, and no interconnected floor space.
- An enhanced 2HR FRR between the residential units (only 1HR FRR is required by code) and 1HR FRR between the units and the corridor, which is pressurized.



Images courtesy of Acton Ostry Architects Inc. and Stantec Ltd.



# BROCK COMMONS TALL WOOD BUILDING INTERIOR DESIGN AND LAYOUT

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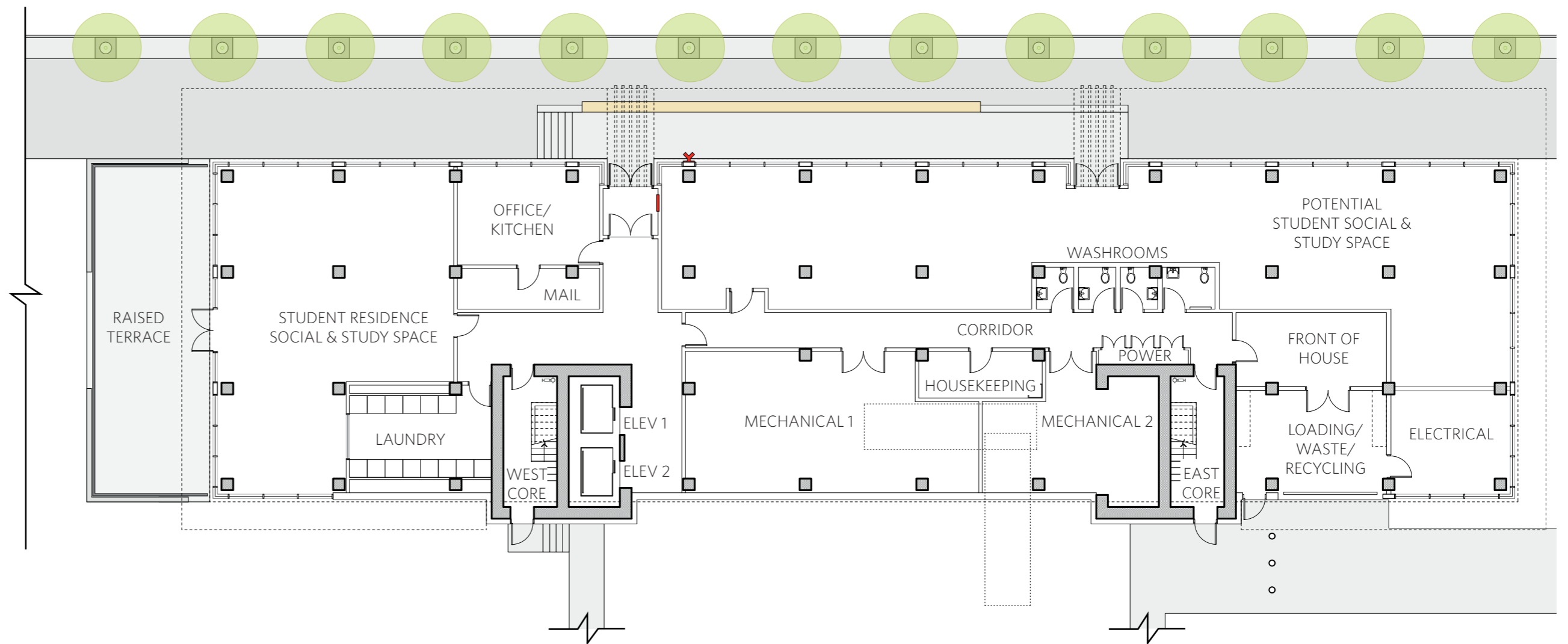
## INTERIOR LAYOUTS

The program and interior suite layout for Brock Commons was based on precedents developed by Student Hospitality and Housing Services for other student residence hubs.

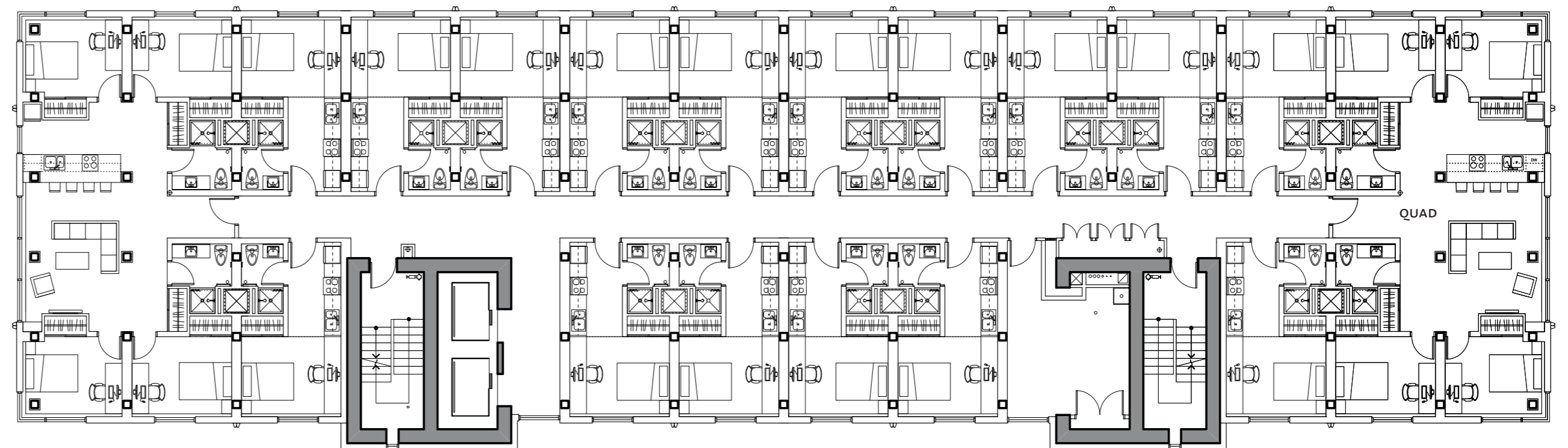
- The ground level houses public amenities for students such as social gathering and study spaces. Administration, laundry facilities, storage spaces, mechanical, electrical and other service rooms are also located on the ground floor.
- Each residential floor has 16 single units and 2 quad units (with the exception of the 18th floor which has a quad and a lounge).
- Considerations for the wood structure included minimizing penetrations through the CLT panels and plywood splines by concentrating services, positioning bathrooms and kitchens back-to-back in the center of the room, and eliminating piping in the demising walls.



Interior View - Lounge



Ground Floor Plan



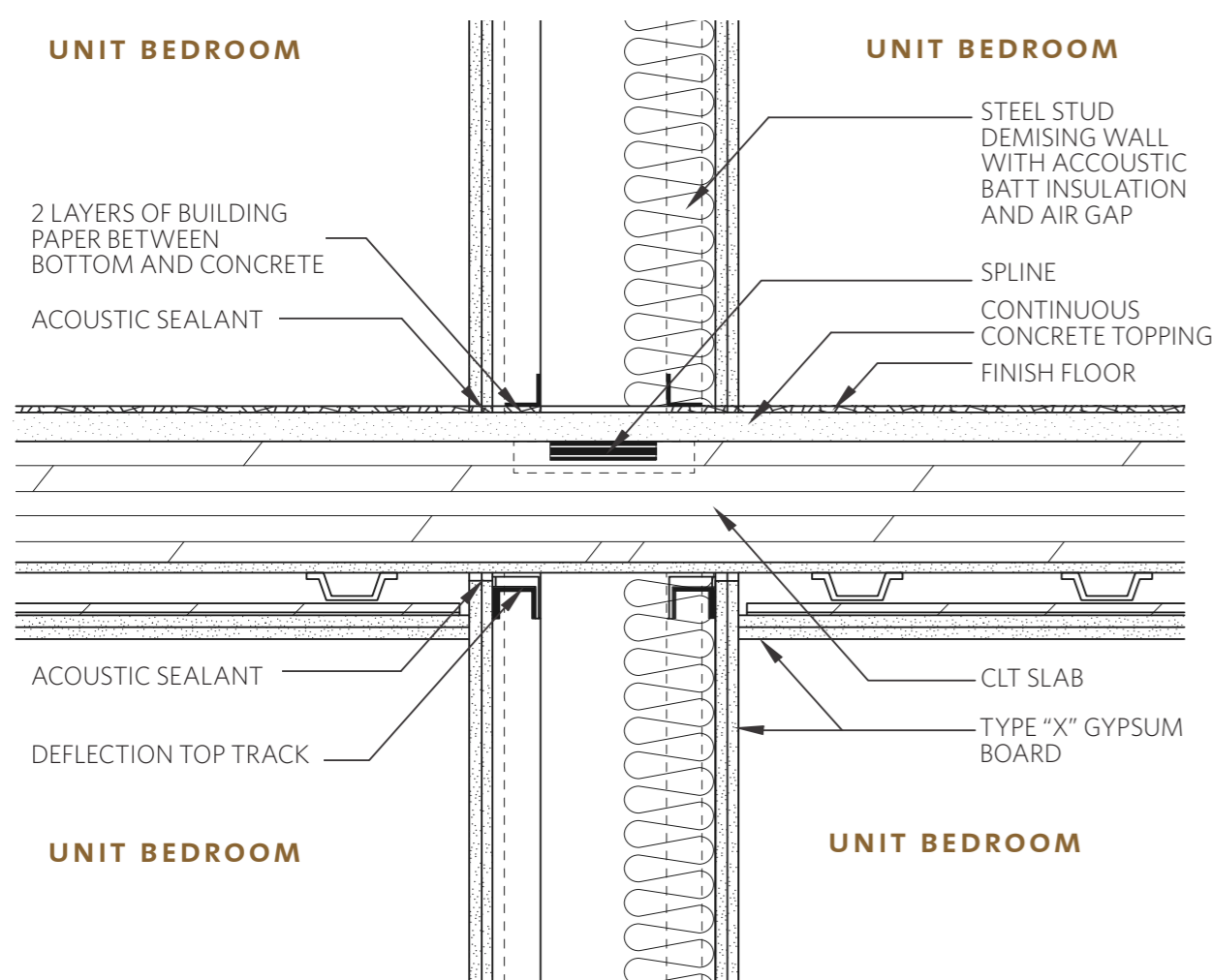
Typical Floor Plan

## ACOUSTICS

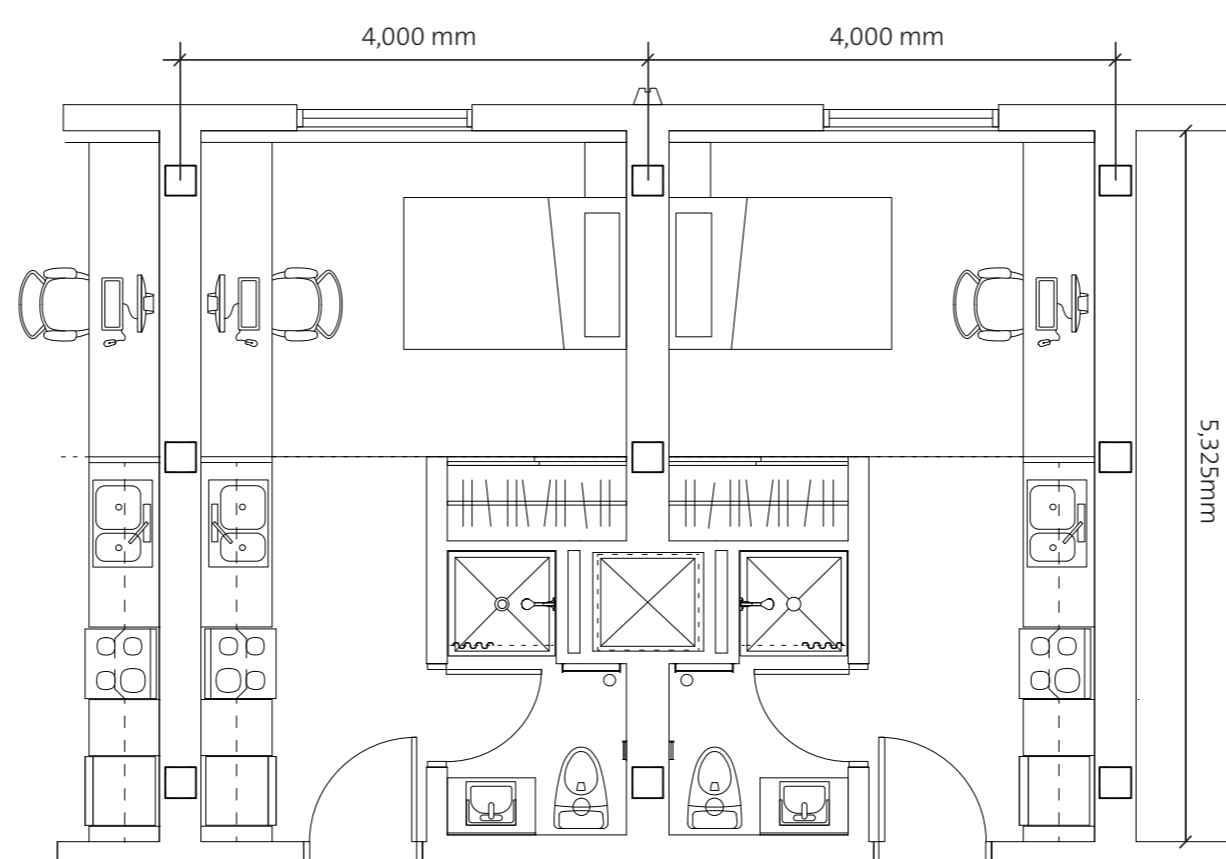
Key performance considerations of the interior design are mitigating disruptive vibrations and sound transmissions. Design factors that address these include:

- Increasing the weight and stiffness of the CLT floors with a 40 mm concrete topping.
- Reducing floor surface hardness by installing carpet tile and resilient flooring in the units.
- Providing an air space between the CLT panels and interior ceilings, by suspending the gypsum board from resilient bars and hat tracks.
- Providing sound absorption through layering, air spaces and insulating materials in interior partitions.

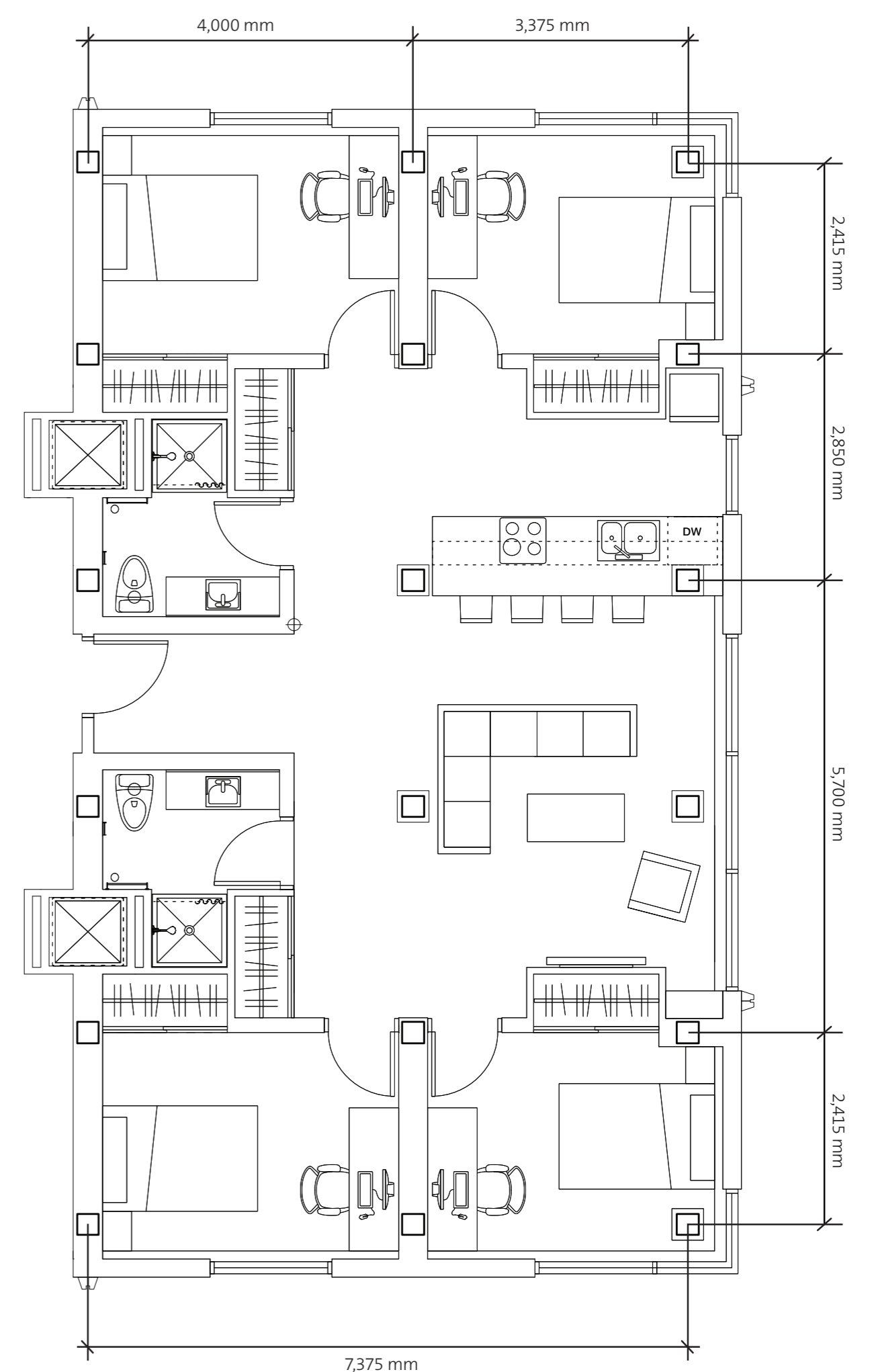
Acoustical insulation is designed to provide between 52 and 54 STC (Sound Transmission Class) for floor assemblies and between 50 and 62 STC for wall assemblies.



Typical demising wall showing sound resistance between floor and ceiling  
CLT Panel Interface



Typical Single Occupancy Unit



Typical Quad Occupancy Unit

Images courtesy of Acton Ostry Architects Inc.

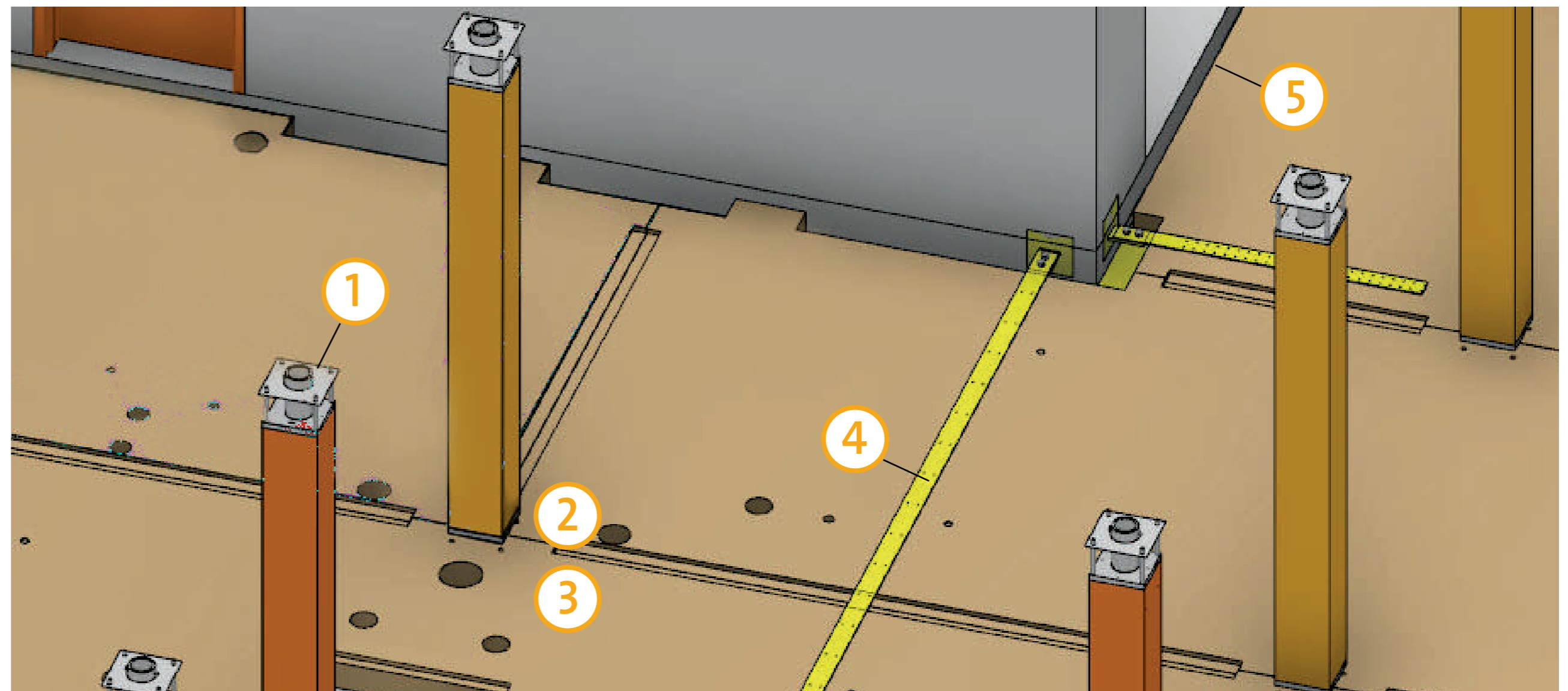


# BROCK COMMONS TALL WOOD BUILDING STRUCTURAL CONNECTIONS

The hybrid structure of Brock Commons includes multiple connection types: between the mass timber structure and the concrete podium and cores, within the mass timber structure, and between the mass timber structure and the roof.

Considerations for the connections include:

- Effective transfer of vertical (gravity) loads as well as panel shear loads.
- Function of floor panels as diaphragms and transfer lateral loads to the cores.
- Minimizing transmission of vibrations throughout the building.
- Accounting for building settlement as well as movement between the wood and concrete elements.
- Settlement and shrinkage of the wood elements due to moisture content and loading.
- Tolerance for fabrication and installation, and variances of the wood products.
- Constructability of assemblies, and ease and speed of installation.
- Mitigation of water infiltration as well as any potential damage.
- Long-term monitoring of connection performance.



## FLOOR TO COLUMN CONNECTION



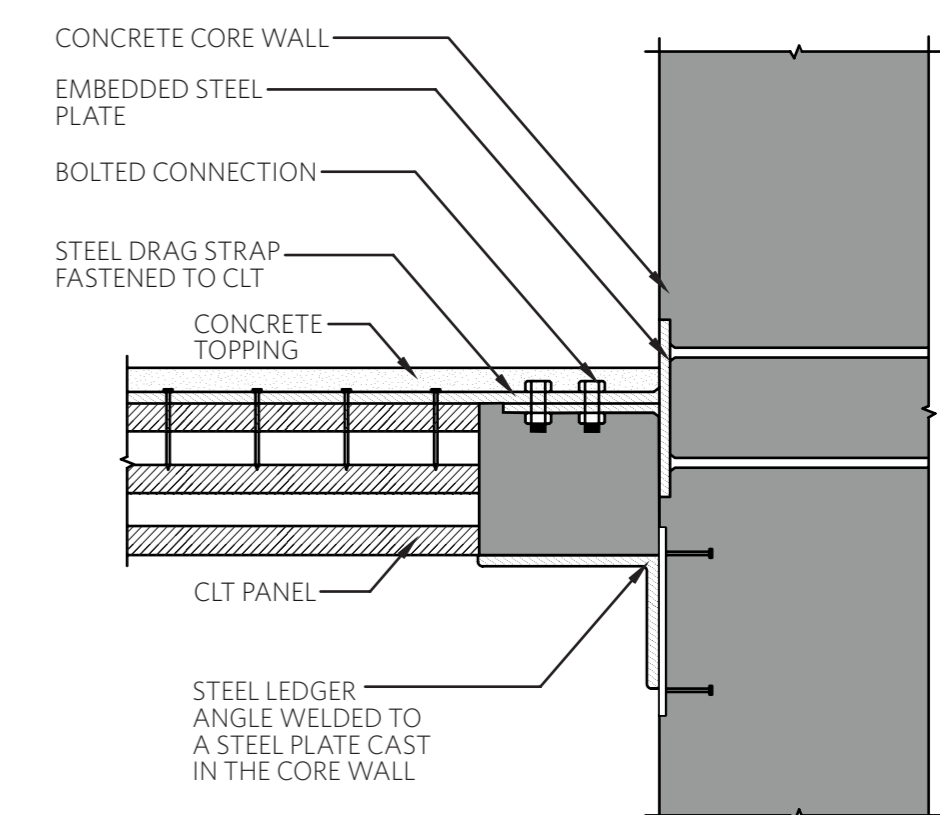
## CORE TO SLAB CONNECTION

### 4 DRAG STRAPS

- The drag straps are steel plates (100 mm wide) screwed to the tops of the CLT panels and bolted to steel tabs which are welded to embed plates on the cores.
- The drag straps transfer lateral loads from the floors to the core.
- Strap length, thickness and spacing varies depending on position within the structure to accommodate different loads (larger and closer spacing on higher levels).

### 5 STEEL LEDGERS

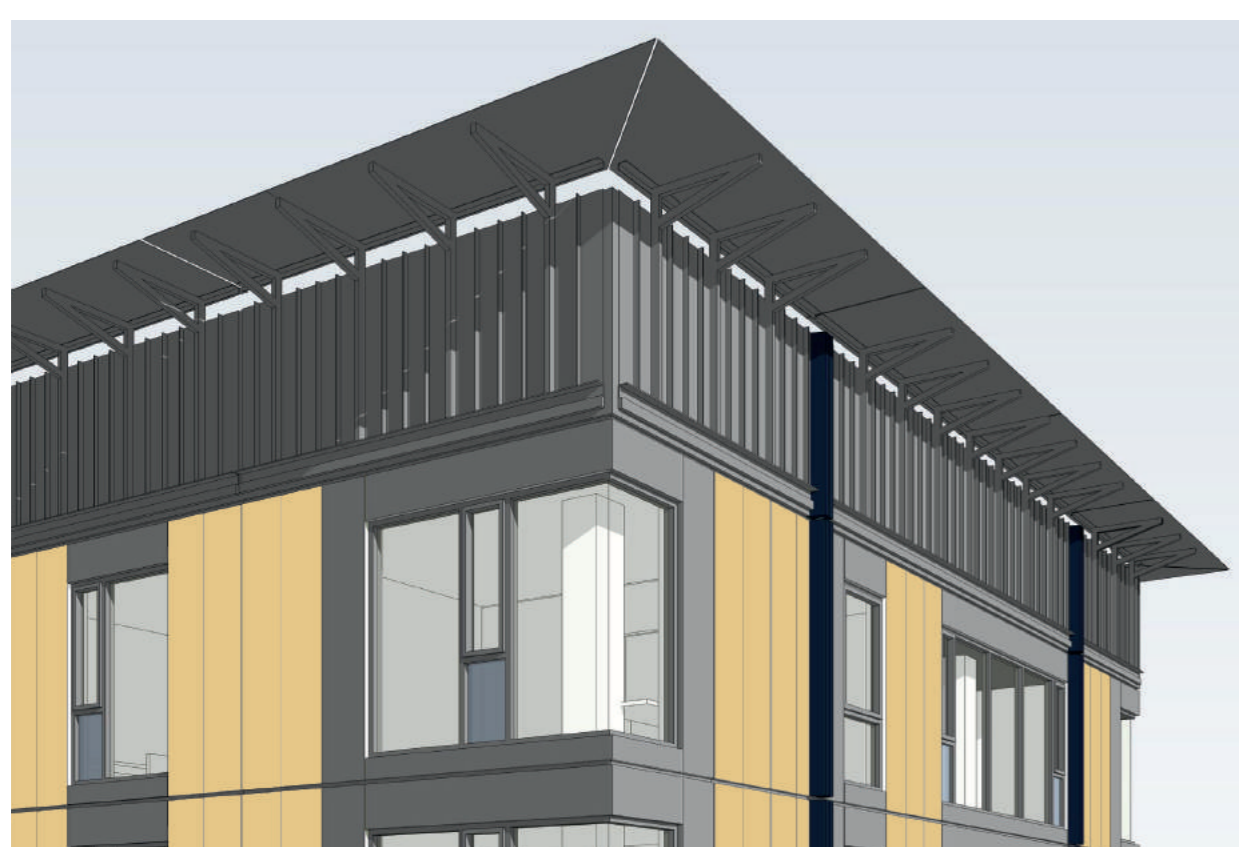
- CLT is supported at the concrete core by steel ledger angle (L203 x 152 x 13 thick LLH) welded to an embedded plate (300 mm wide) cast into the core walls.
- Connection accommodates vertical and horizontal shear transfer at the connection point.



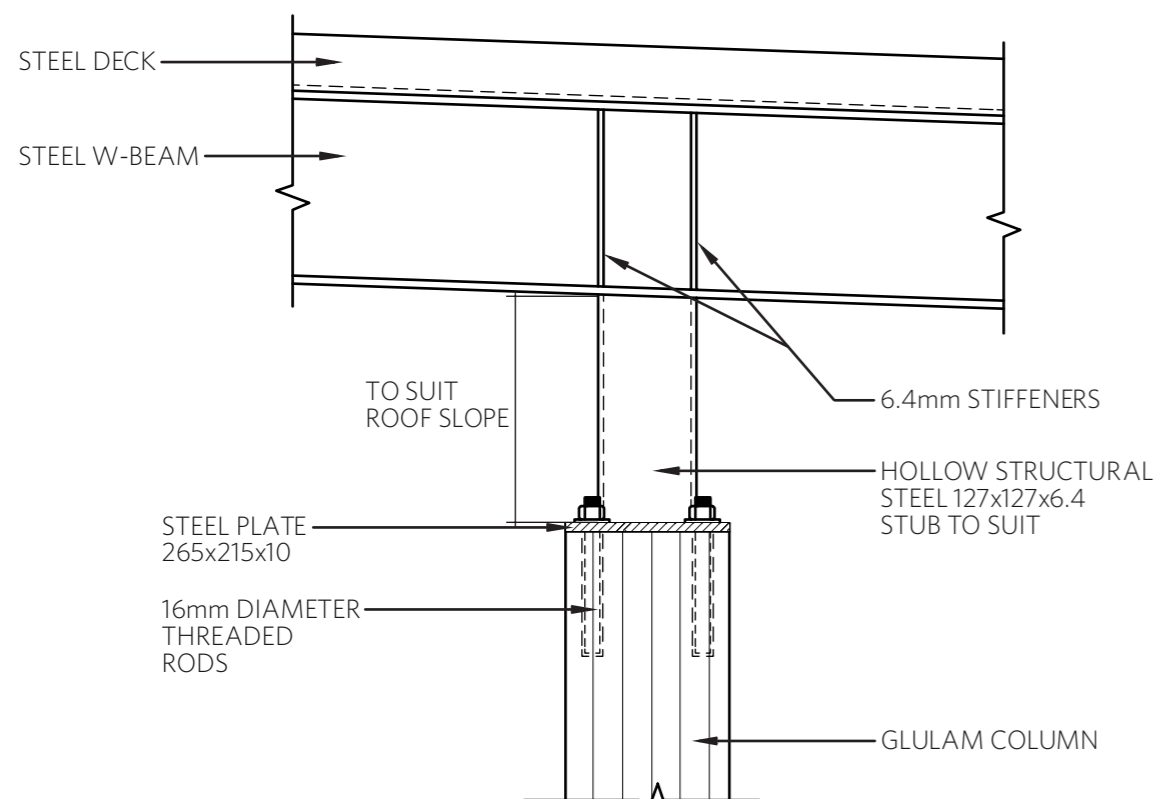
## COLUMN TO ROOF CONNECTION

### 1 COLUMN TO STEEL ROOF

- The column to roof structure connection is similar to the column to column connection, roof beams will be supported on a welded steel assembly that will be bolted to the top of the glulam columns.
- The assembly will be adjusted for the sloping of the steel roof structure.

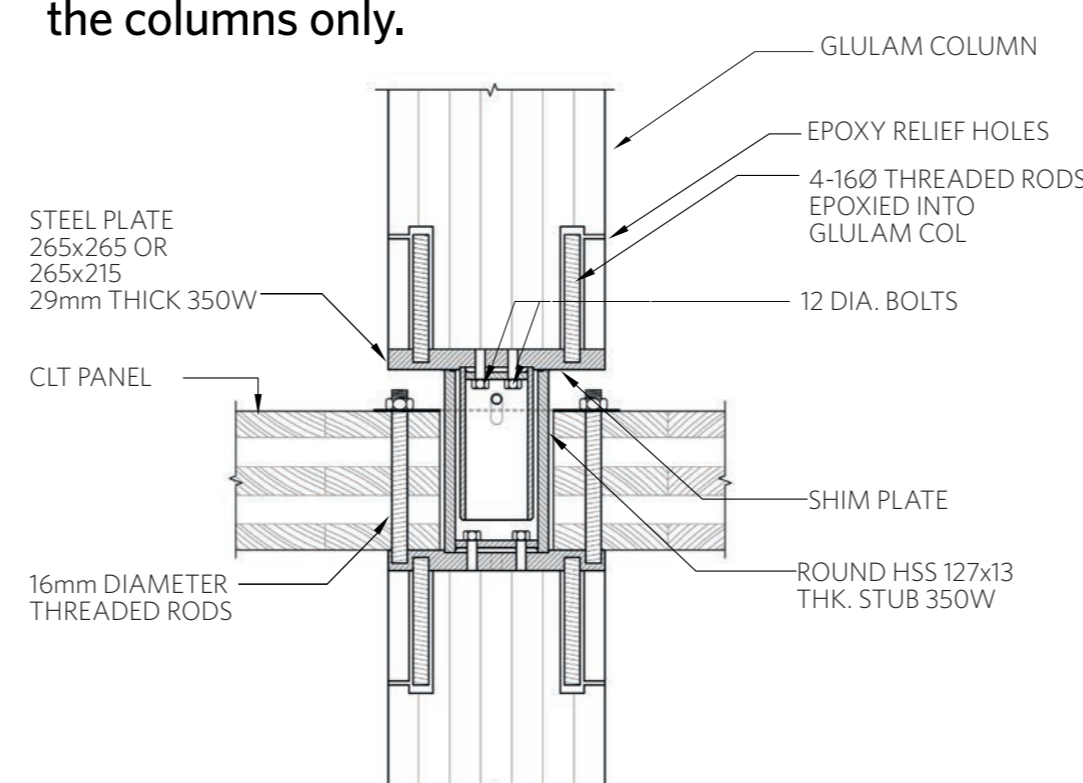


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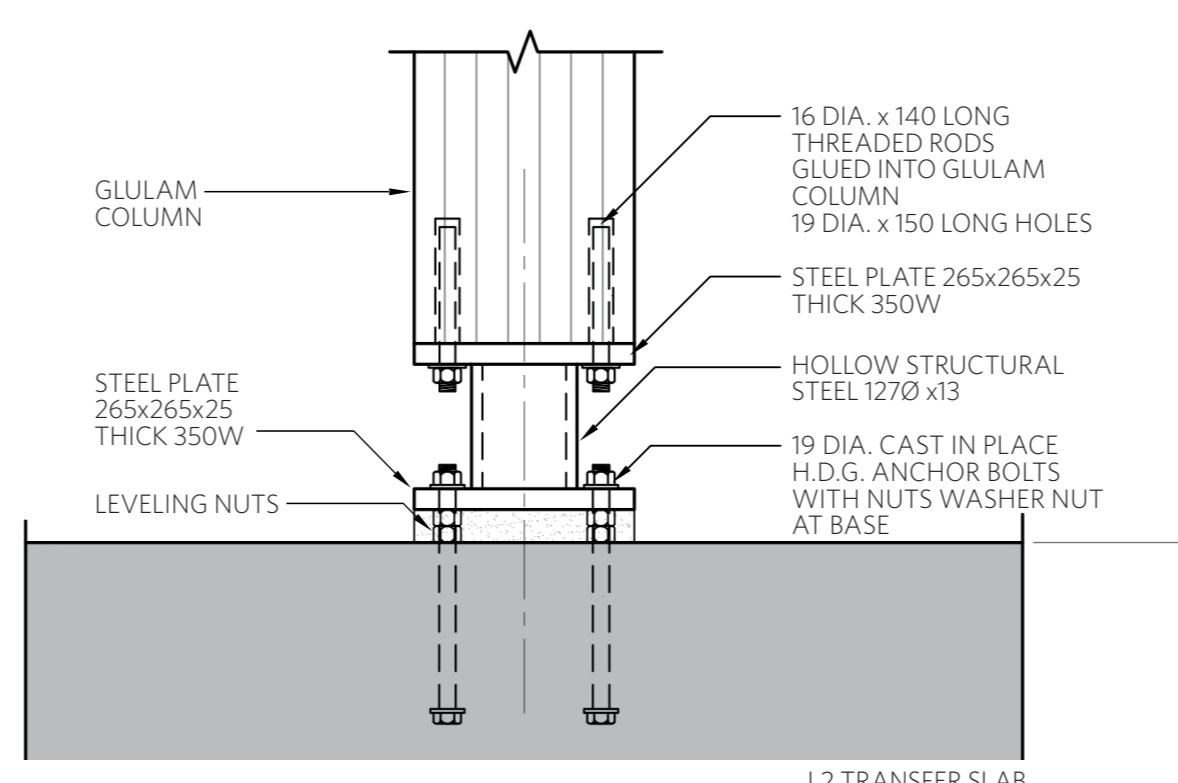
### 2 COLUMN TO CLT PANEL

- The column to column/CLT panel connection consists of round steel hollow structural sections (HSS) fastened to steel plates connected at the top and the bottom of each column using threaded rods epoxied into the column.
- The smaller HSS at the column base fits into the larger one at the top of the column below.
- The CLT panels are supported on top of the lower columns, and are bolted to the steel plates by four threaded rods.
- The connections transfer vertical loads directly through the columns only.



### 3 COLUMN TO CONCRETE SLAB

- The concrete slab to column connection is similar to the column to column connection except that the bottom plate is bolted to the concrete transfer slab.



Images courtesy of Acton Ostry Architects Inc., CadMakers Inc., and UBC Research Team



# BROCK COMMONS TALL WOOD BUILDING STRUCTURAL SYSTEM



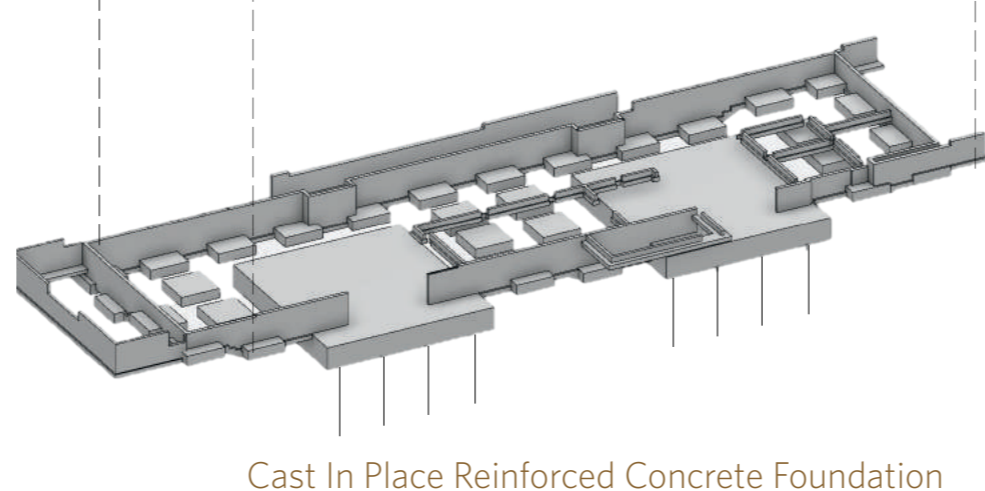
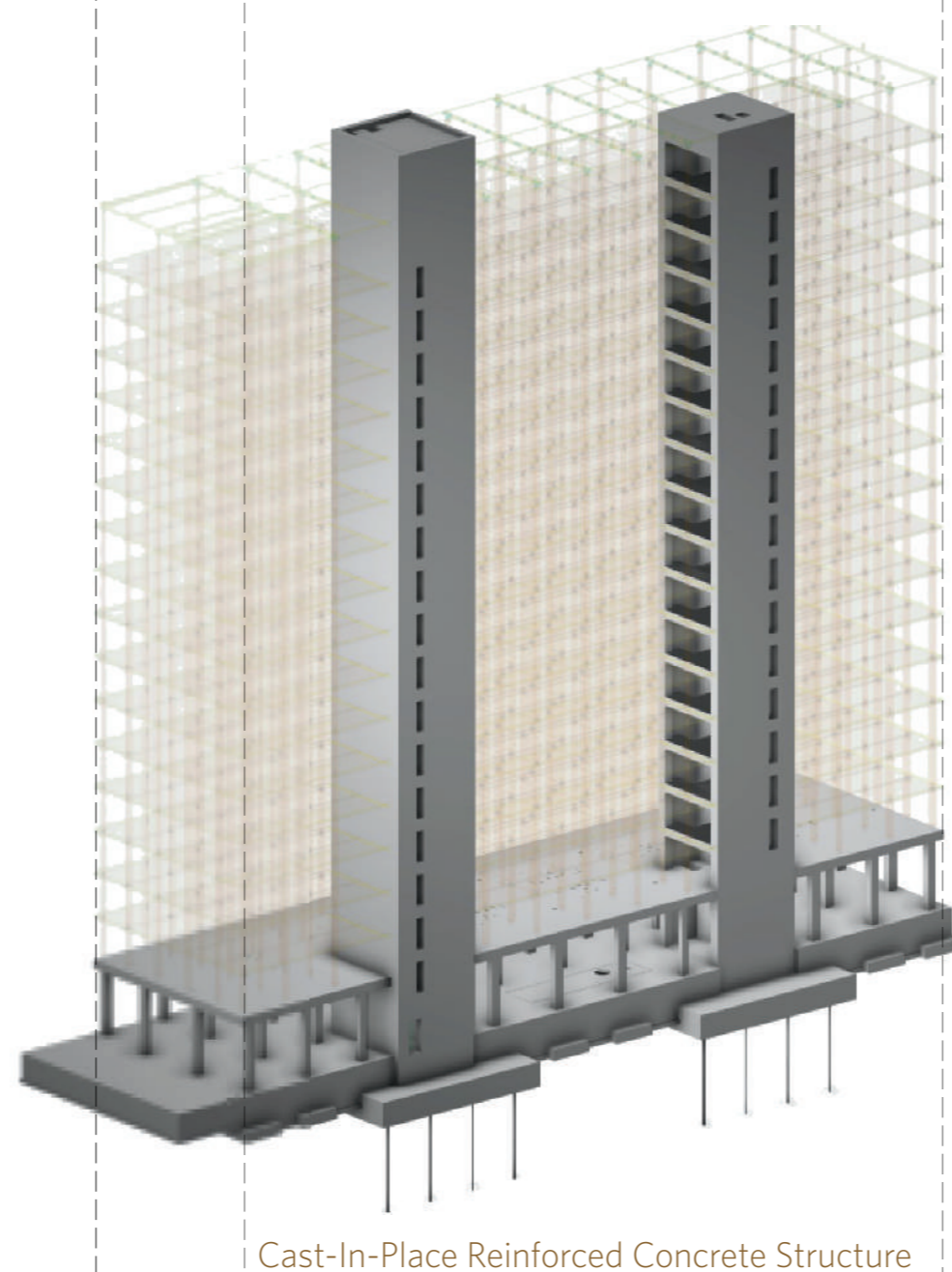
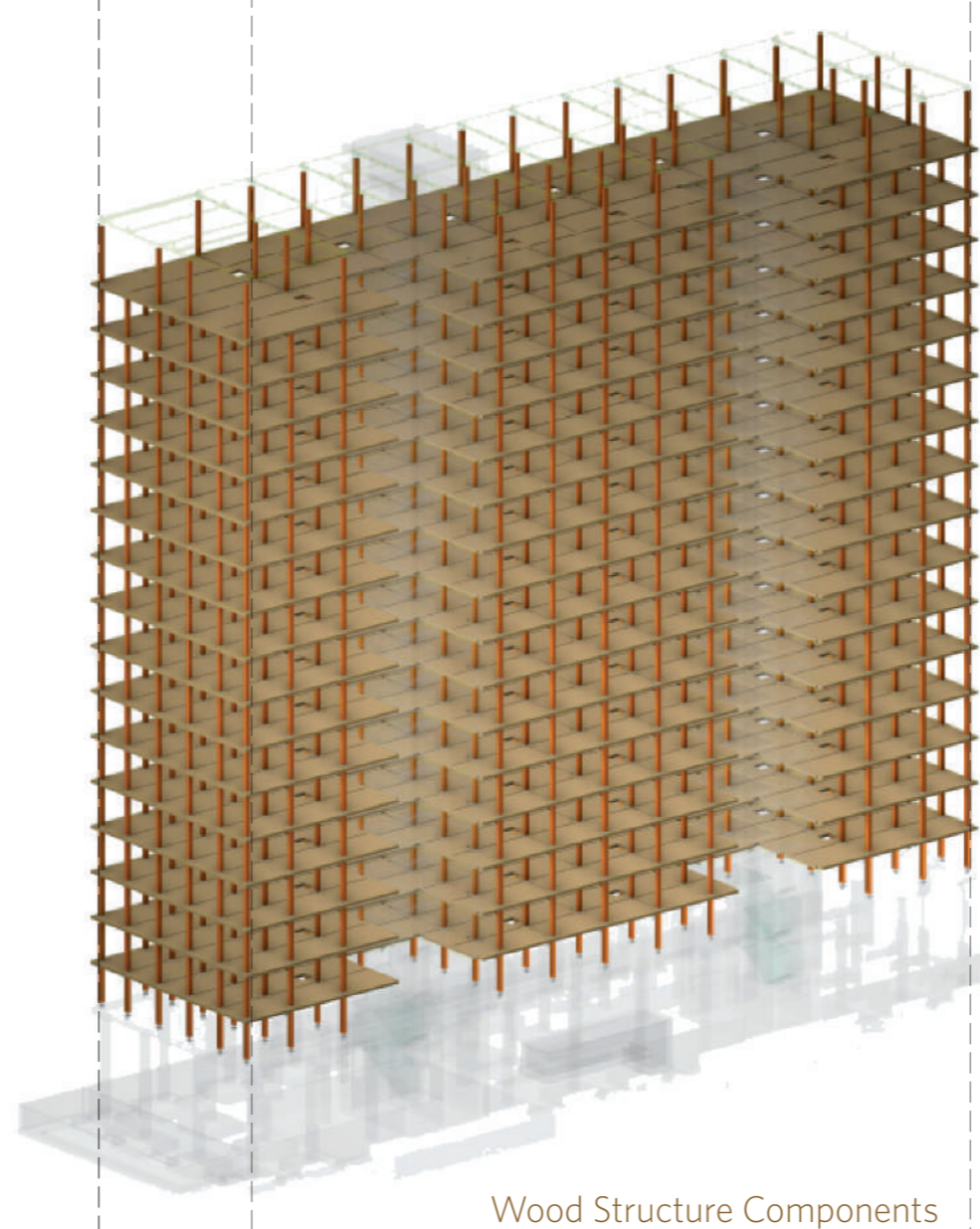
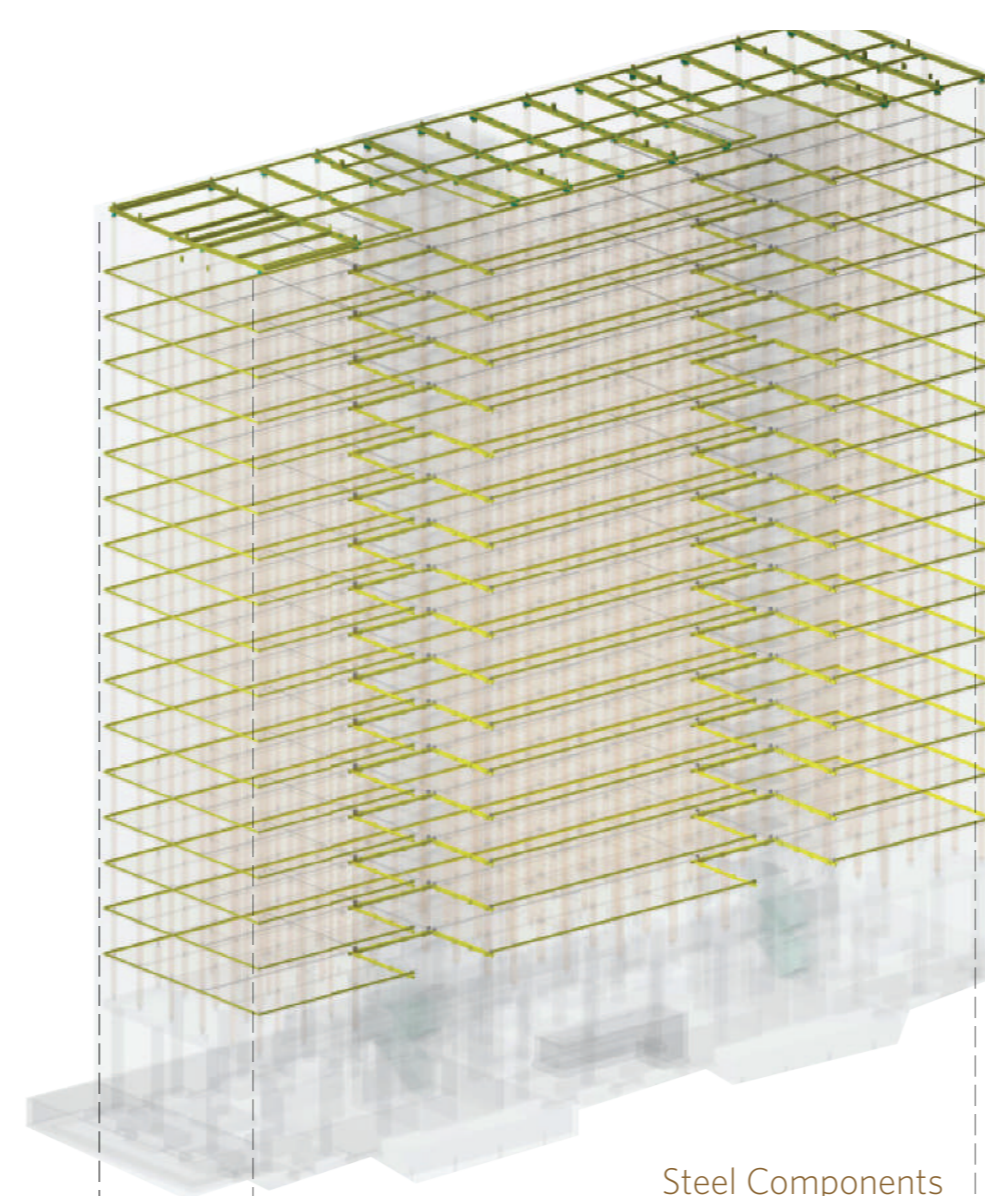
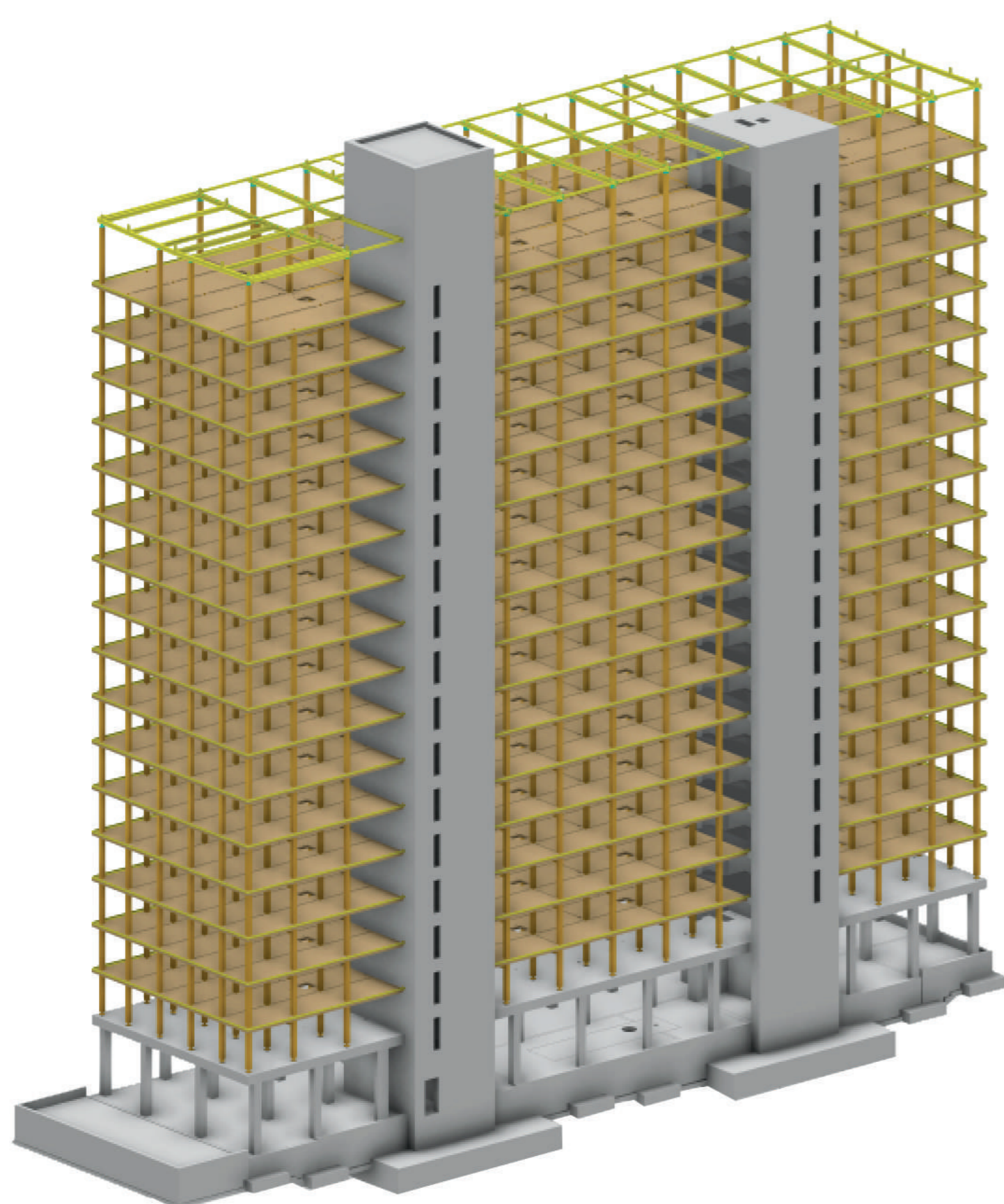
June 2016

The structural system for Brock Commons is designed as a hybrid configuration. The foundations and ground floor as well as the cores (which house stairwells, elevators and service risers) are cast-in-place concrete. The structure on Levels 3 through 18 is composed of mass timber columns and floor panels. Connections and specific elements, like the roof structure, are steel.

Specific design considerations for the hybrid structure were:

- Structural capacity
- Volume of lumber
- Constructability
- Cost
- Availability and sourcing of products
- Building services routes
- Settlement and shrinkage
- Fabrication and construction tolerances

The choice of a mass timber superstructure is estimated to result in a building that is significantly lighter than its concrete equivalent.



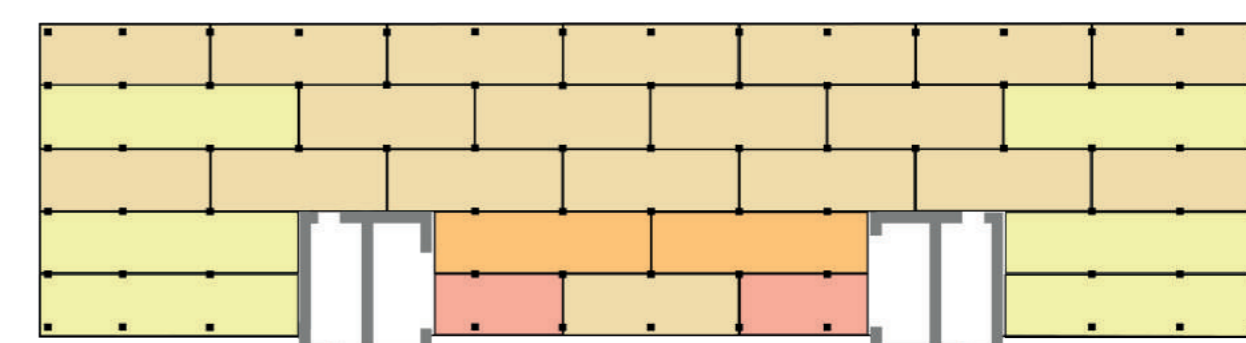
## ROOF STRUCTURE

The roof will be built with steel decking and steel beams supported on the glulam columns. The choice of a steel roof was made to mitigate potential issues in the event of moisture infiltration.

## COLUMNS

The floors and roof are supported by GLT and PSL columns, arranged in a grid measuring 4x2.85 m. Larger columns (265x265 mm) on the lower levels, and slightly smaller ones (265x215 mm) on the upper levels. PSL columns are utilized at points with higher loads in the middle of the floor plates between levels 2 and 5.

## FLOOR SLAB DESIGN



The floor slabs are composed of CLT panels, oriented on the building's long axis and installed in a staggered configuration and secured with plywood splines to create a diaphragm. Panels are 169 mm thick, one bay wide (2.85 m) and of four different lengths to a maximum of three bays (12 m long). There are 29 panels per level and most are unique due to the configurations of pre-cut mechanical, plumbing and electrical openings.

## CONCRETE CORES

The two cores house stairs, elevator shafts and mechanical services. Made of cast-in-place reinforced concrete (450 mm thick), they provide structural rigidity to resist lateral wind or seismic forces along the full height of the building.

## PODIUM

The concrete podium houses the ground level amenity and service spaces, and supports the wood structure on the second level transfer slab (600 mm thick). The decision to build a concrete podium was driven by a need for large spans independent from the wood column grid, resistance to impacts and to house mechanical and electrical services in non-combustible spaces.

## FOUNDATIONS

The foundation is reinforced concrete spread footings (2.8x2.8 x0.7 m) with a concrete wall and strip footing (600 x 300 mm) at the perimeter. Each core is supported by a raft slab (1.6 m thick) with four soil anchors at 1250 kilonewton tension force capacity.

Images courtesy of Acton Ostry Architects Inc. and CadMakers Inc.



# BROCK COMMONS TALL WOOD BUILDING VIRTUAL DESIGN AND CONSTRUCTION

A comprehensive 3D virtual model of Brock Commons was developed and updated through the design phase by a virtual design and construction (VDC) modeller, CadMakers, working as a member of the design team. The VDC modeller collected design information from the other consultants to create a single highly detailed and accurate model of the building, including all components and building systems.

Throughout the design phase of the project, virtual design and construction (VDC) model was used for the following:

1. Visualization
2. Multi-disciplinary coordination
3. Clash detection
4. Quantity takeoffs
5. 4D planning and sequencing
6. Constructability review
7. Digital fabrication

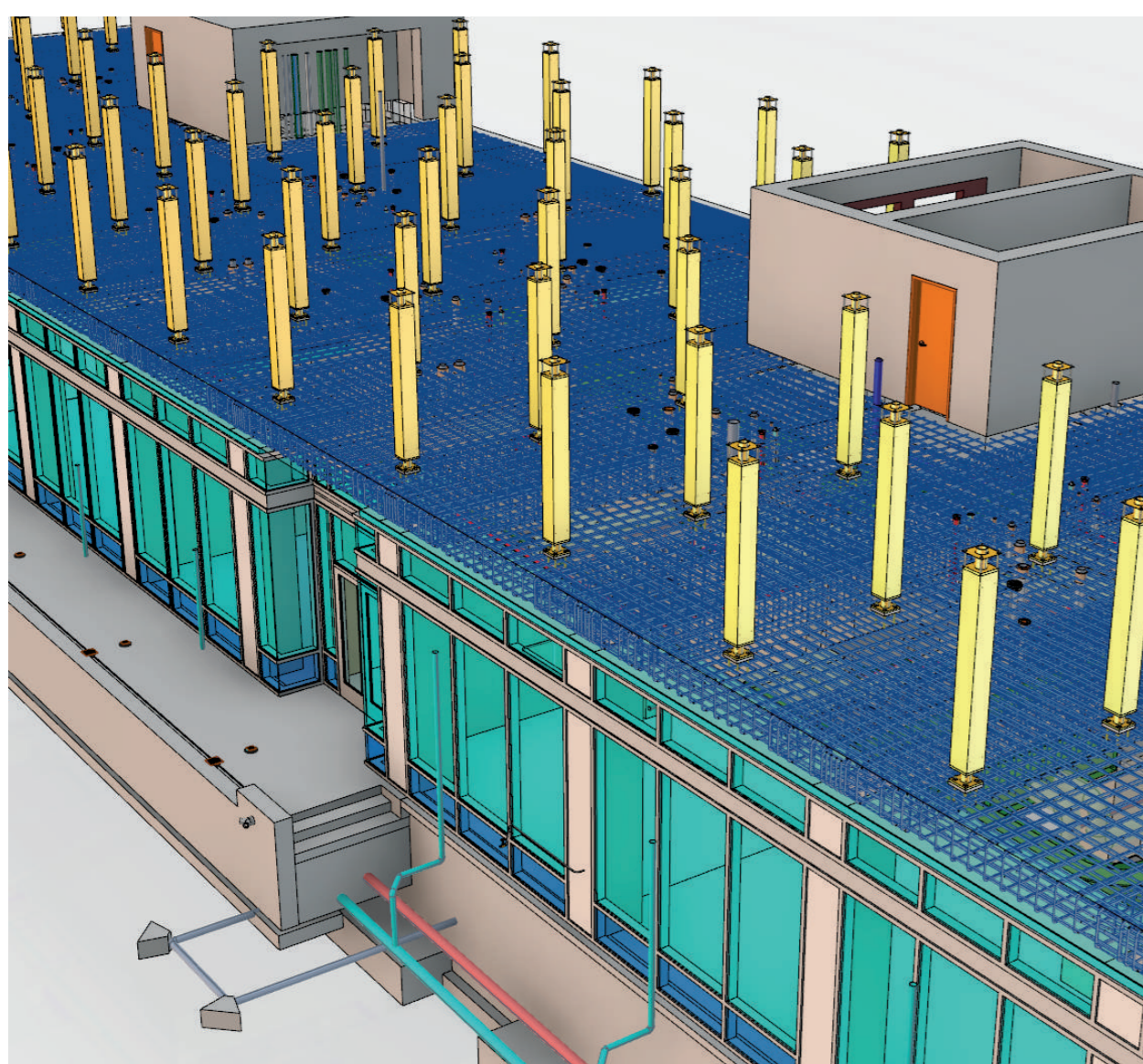
Part of the rationale for including a VDC modeller on the design team was removing from the design consultants the responsibility to produce a 3D model that could be used throughout the project's lifecycle. Each consultant was able to focus on their scope of work, using familiar modelling and drafting tools, without concern for software interoperability.

Design Programs:

- Modelling software: 3D Experience by Dassault Systemes (includes CATIA, ENOVIA and Design Review)
- Architectural renders: Trimble sketchup
- Architectural drawings: Nemestchek Vectorworks
- M/E/P drawings: Autodesk Autocad
- Structural drawings: CATIA/Autodesk Autocad

## 1 VISUALIZATION

- The model was used primarily to create visualizations of different options to assist design development and decision making.
- During the integrated design workshop, the model was updated in real-time to provide rapid feedback as the team assessed different structural systems.



Images courtesy of CadMakers Inc.

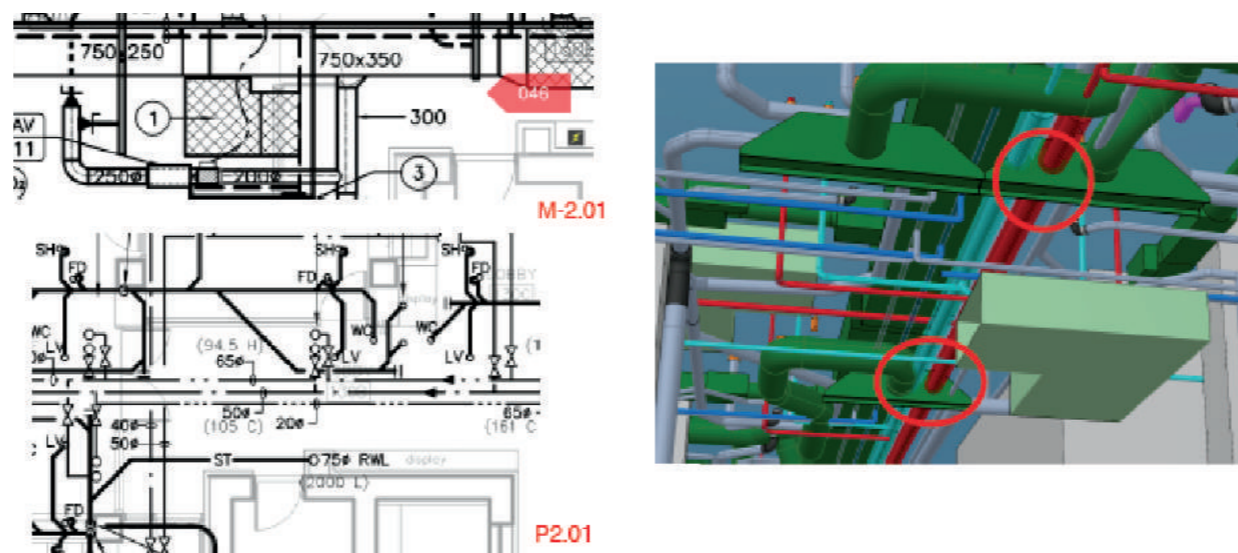


## 2 MULTI-DISCIPLINARY COORDINATION

- The VDC modeller worked from the consultants 2D drawings and 3D models to create the model.
- Design changes were updated in the model and any issues were documented and reported back to the team as requests for information or clarification. In this role, the VDC modeller acted as an external reviewer for the design and project documents.

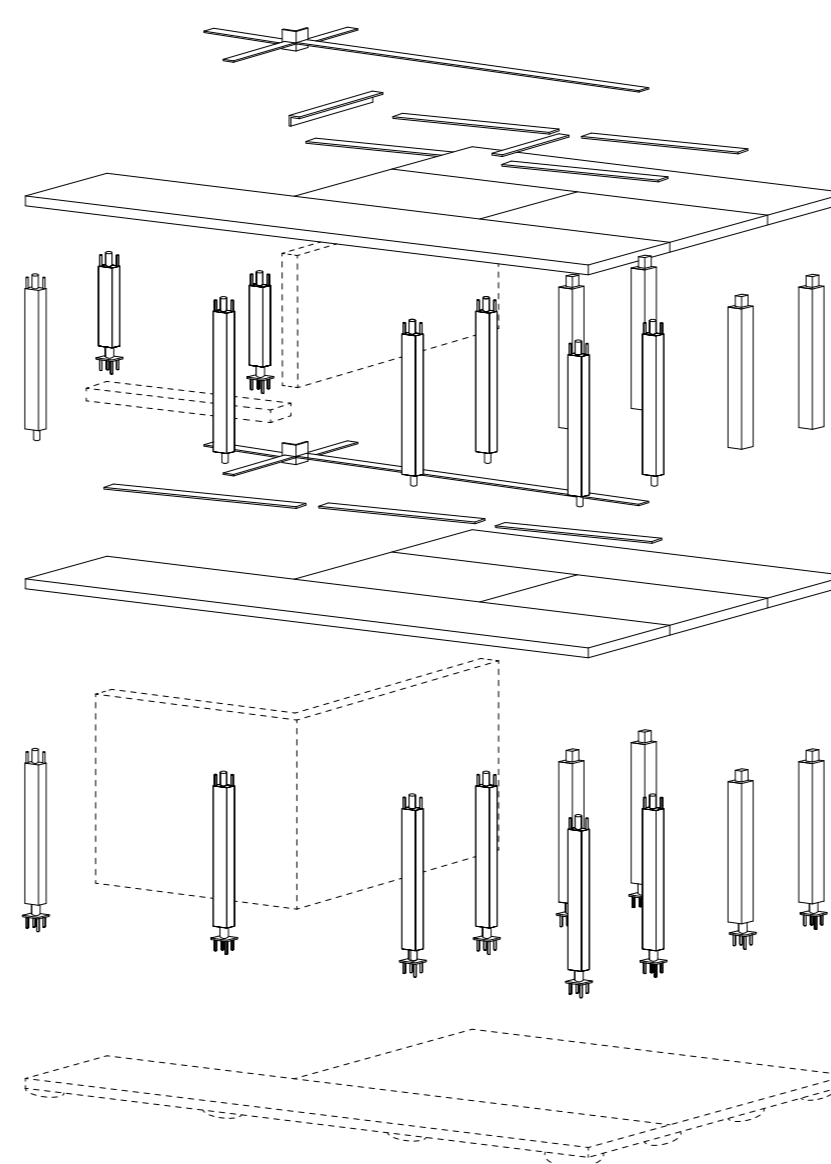
## 3 CLASH DETECTION

- Due to the prefabrication of significant building elements, the routes for building systems and the associated penetrations had to be planned during design.
- The 3D model was used to position pipes and conduits, size penetrations and shafts, ensure appropriate clearances and other spatial requirements were met, and resolve major clashes between system routes.



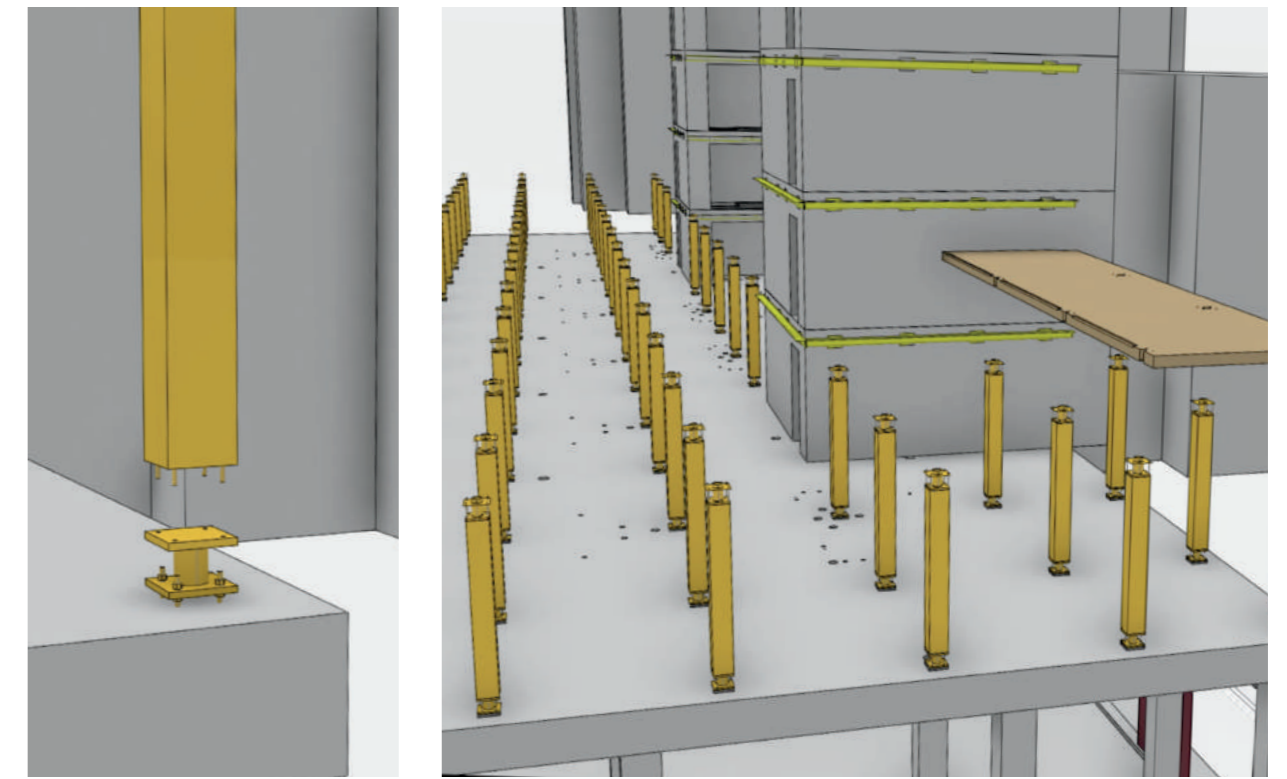
## 4 QUANTITY TAKEOFFS

- Quantity takeoffs of material were extracted from the VDC model for decision making, cost estimates and construction planning.
- During the workshop, the structural design options were modelled and the quantities of different timber products were calculated to help inform the selection process.



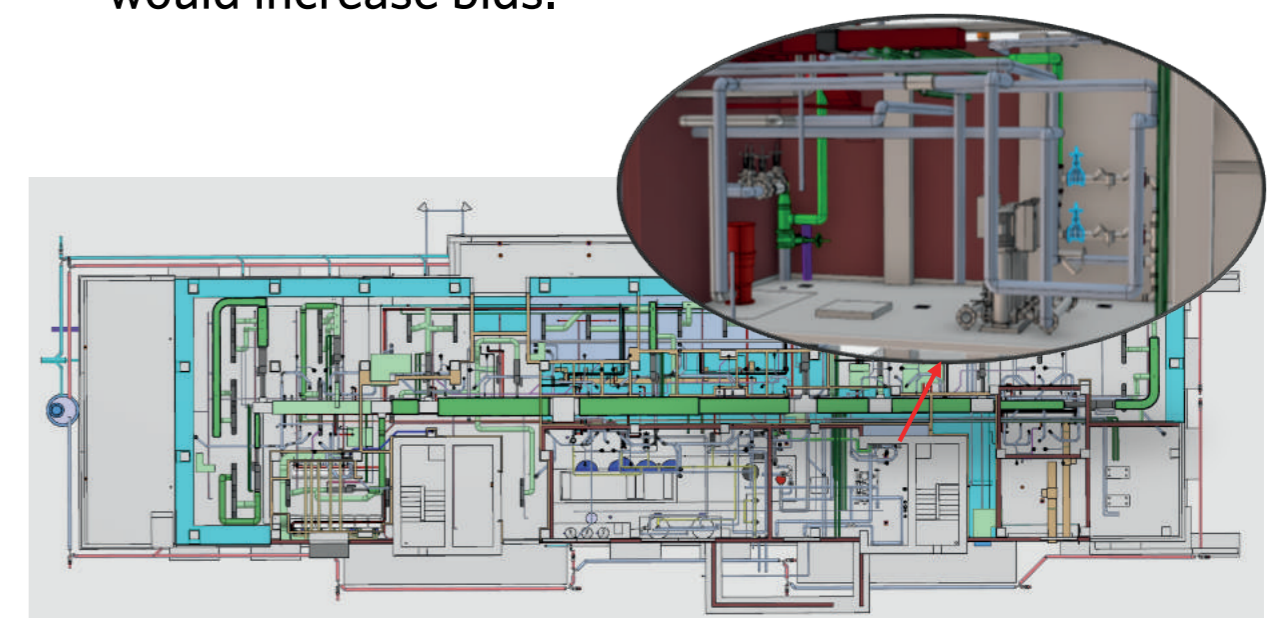
## 5 4D PLANNING AND SEQUENCING

- In designing both the virtual and the digital mock-up, the VDC modeller developed a 4D simulation of the installation sequence for analysis purposes.
- This detailed simulation of the installation sequence allowed the team to visualize the process and work out issues that could potentially delay the project.



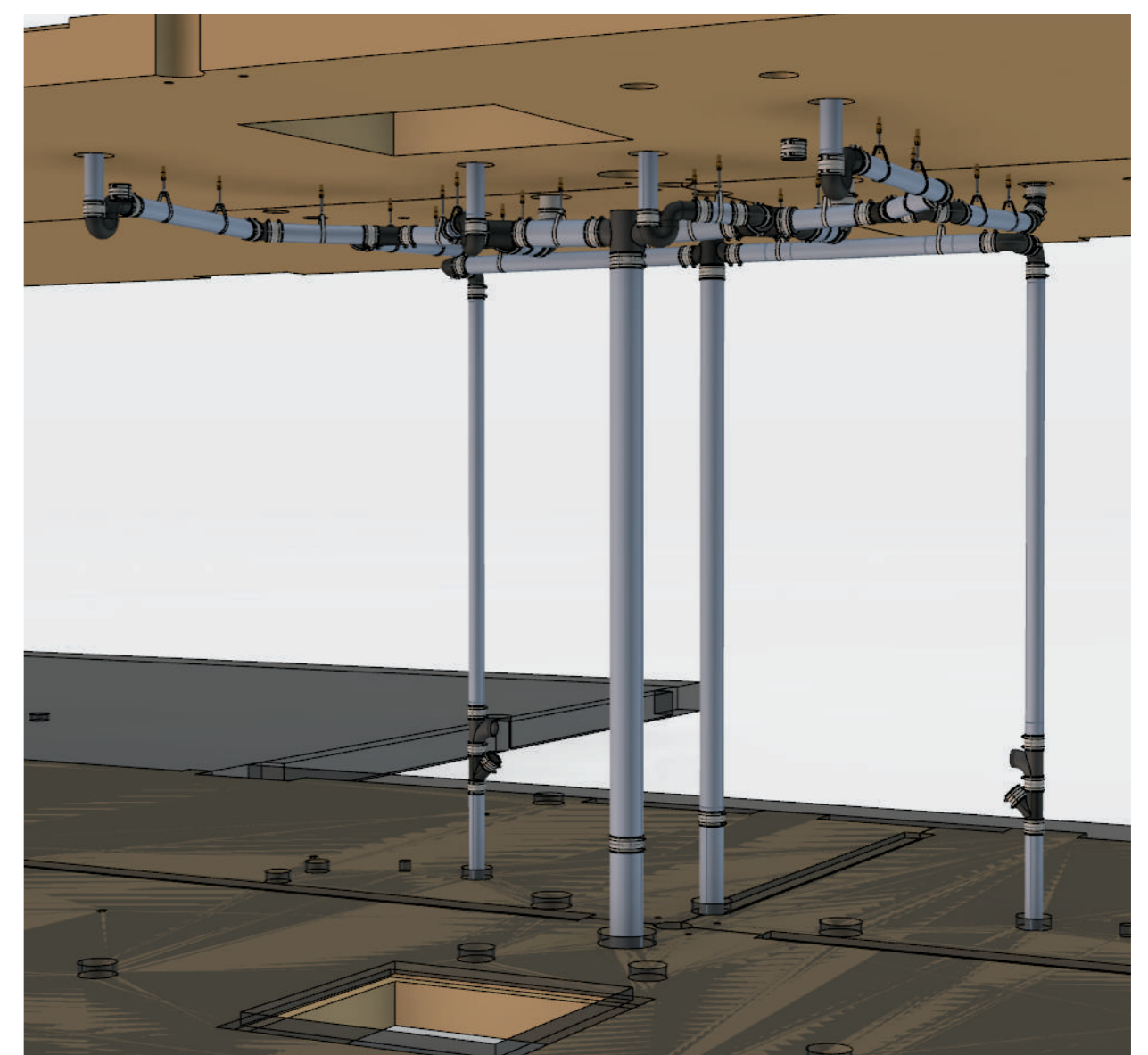
## 6 CONSTRUCTABILITY REVIEW

- The VDC 3D model and 4D simulations were used as communication tools with construction trades.
- It assisted in pre-emptively resolving some of the constructability issues that could cause on-site delays.
- It helped to ensure potential trades had a good understanding of the project prior to tender in order to reduce the uncertainties and risk allocations that would increase bids.



## 7 DIGITAL FABRICATION

- VDC model is able to be used for digital fabrication of certain elements, namely the CLT panels, the GLT and PSL columns and the steel components.
- The VDC Modeller worked with the mass timber supplier to develop a shop drawing approval and fabrication process.



# BROCK COMMONS TALL WOOD BUILDING WOOD PRODUCTS



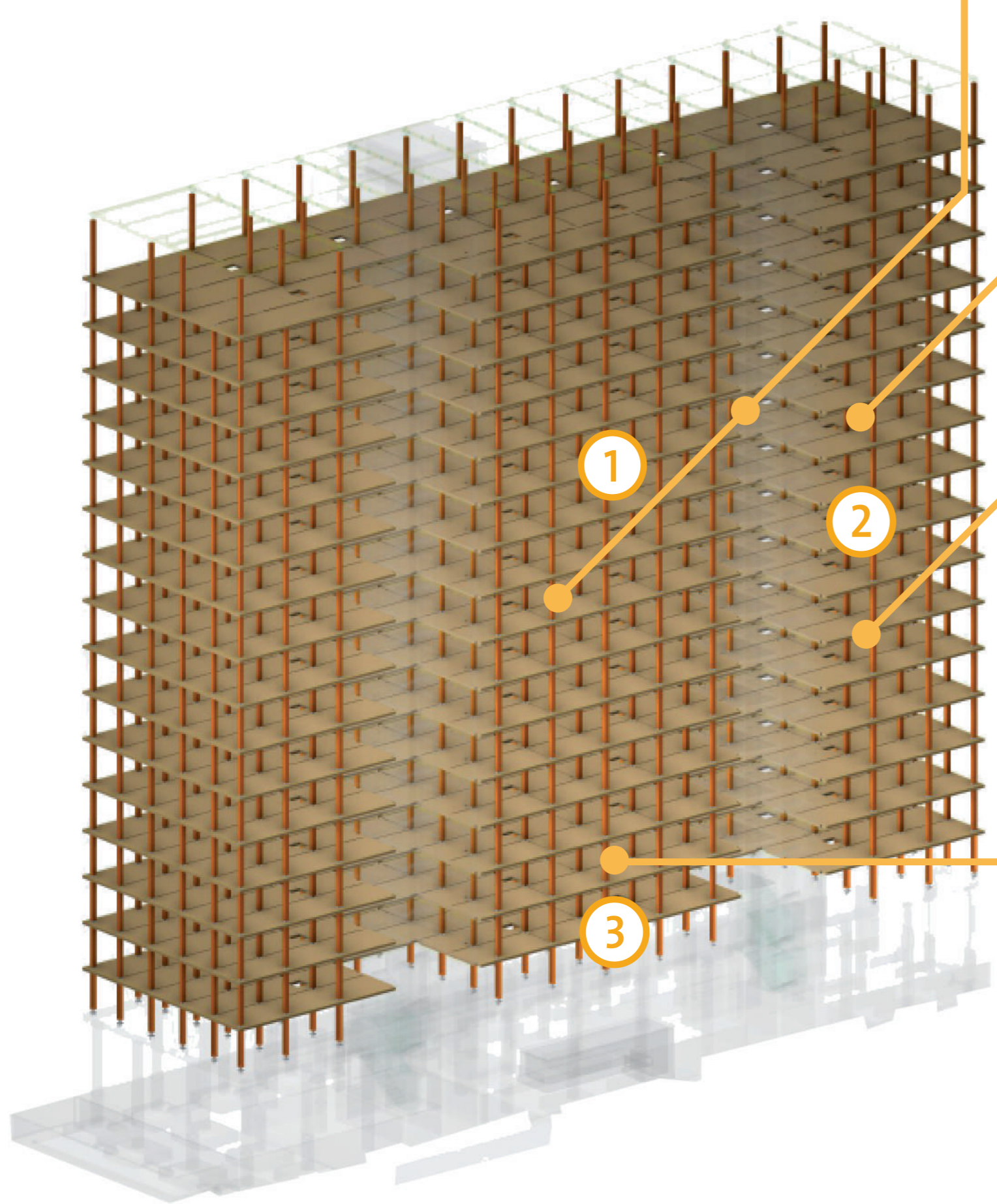
June 2016

Mass timber and structural composite lumber products are manufactured from various derivative wood products by binding strands, veneers or boards of wood with adhesives. These products include:

- Glue Laminated Timber (GLT)
- Cross Laminated Timber (CLT)
- Parallel Strand Lumber (PSL)
- Nail Laminated Timber (NLT)
- Laminated Veneer Lumber (LVL)
- Laminated Strand Lumber (LSL)
- Oriented Strand Lumber (OSL)

These products are extremely versatile and can be used in diverse building typologies and functions. They are made of a renewable resource and manufactured with a lower carbon footprint than steel or concrete. Products can be designed for specific attributes such as shape, structural capacity, aesthetic qualities and finishing treatments.

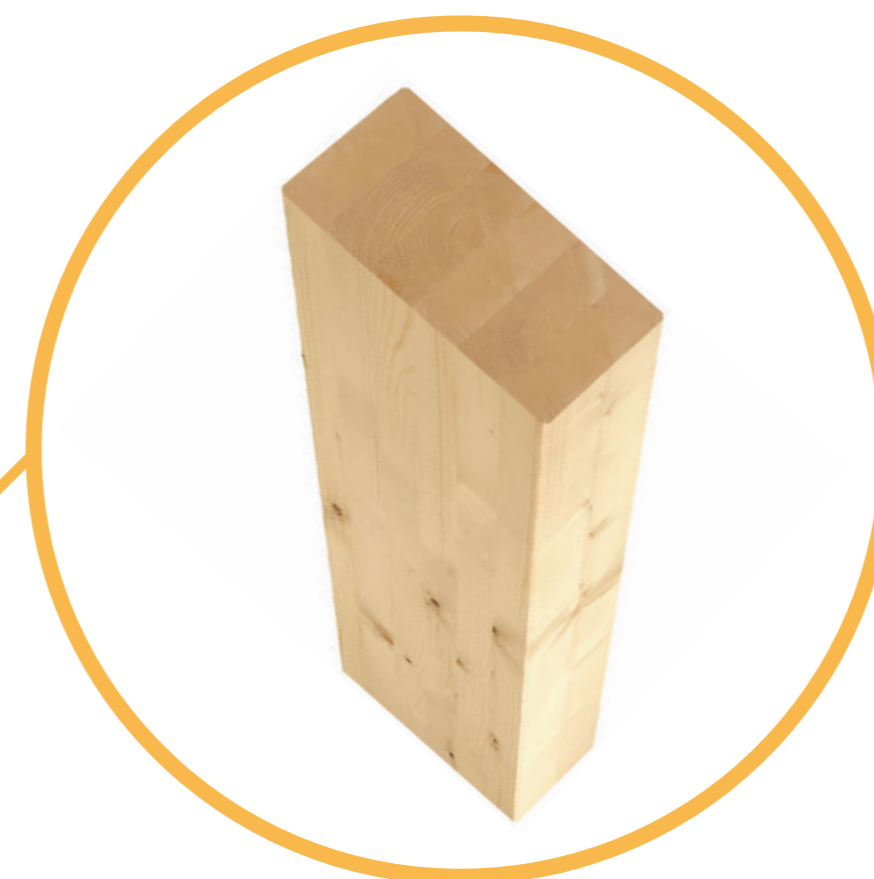
Products are fabricated in controlled factory settings and then assembled on the construction site. The lamination technique enables the production of large structural members from multiple smaller pieces selected for strength and quality. Sizes are typically driven by transportation and constructability constraints.



Wood components of the Brock Common's superstructure



CLT is used for the floor slabs between levels 3 and 18.



GLT is used for the majority of structural columns between levels 2 and 18.



PSL is used for the heavy loaded structural columns between levels 2 and 5.

## 1 CROSS-LAMINATED TIMBER

- CLT panels are manufactured by cross-laminating three to nine layers of lumber with adhesives or mechanical fasteners.
- Panel sizes typically range from 50 mm to 300 mm in thickness, from 1.2 m to 3 m in width, and 5 m to 15 m in length.
- CLT panels are used for loadbearing floors, walls and roofs and can function as diaphragms or shear walls.
- Openings within panels can be pre-cut in factory or on-site, ranging from smaller holes for pipes and ducts to openings from doors and windows.



## 2 GLUE-LAMINATED TIMBER

- Glue-laminated timber is manufactured by laminating end-jointed dimension lumber pieces in horizontal layers with glue under controlled conditions.
- GLT lumber is a special grade (lamstock) which is purchased directly from lumber mills in three species combinations: Douglas Fir & Larch, Hem & Fir, and Spruce & Pine.
- GLT is used for structural applications including headers, beams, girders, columns, and heavy trusses.
- GLT can be manufactured to an almost limitless variety of straight and curved configurations, and can meet both design complexity and structural requirements.



## 3 PARALLEL STRAND LUMBER

- PSL is a high strength structural composite lumber product manufactured by gluing strands of wood (from which growth imperfection have been removed) together under high pressure.
- PSL wood strands are sourced in Canada from Douglas fir and in the United States from Southern Pine.
- PSL is used for heavily loaded columns, and beam and header applications where high bending strength is needed.
- It is a proprietary product marketed under the trade name Parallam®.



Images courtesy of Acton Ostry Inc., UBC Research Team, iaacblog.com (CLT), eurowood.co.nz (GLT), and StructureCraft Builders (PSL)  
Information courtesy of Canadian Wood Council, cwc.ca