INNOVATION IN HYBRID MASS TIMBER CONSTRUCTION

BROCK COMMONS TALLWOOD HOUSE

DESIGN MODELLING

KK Law

INTRODUCTION

Located on a large forested peninsula on the west side of Vancouver, the University of British Columbia is at the forefront of the global movement to revitalize mass timber construction and be innovative in the use of engineered wood products in tall buildings. Among the large wood buildings already on campus are the Centre for Interactive Research on Sustainability, the Earth Sciences Building, and the Bioenergy Research and Demonstration Facility. The newest addition to the portfolio is the 54-m-high (18-storey) Brock Commons Tallwood House, featuring the first North American use of mass timber products in a residential high-rise.

Brock Commons is one of the University's five high-rise, mixed-use, residential complexes that provide housing for students while acting as academic and recreational hubs for the campus community. The hubs are all of similar programming and urban design. However, the Brock Commons Tallwood House is unique in the use of a hybrid mass timber structure. The foundation, ground floor, and stair/elevator cores are concrete, while the superstructure is composed of cross-laminated timber (CLT) panel floor assemblies supported on parallel strand lumber (PSL) or glue-laminated timber (GLT) 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 is 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. This pioneering building showcases innovations in engineered wood products and building techniques, and creates unique research and learning opportunities related to the design, construction, operation, and inhabitation of a tall wood building in a North American context.

FRONT & BACK COVER
KK Law

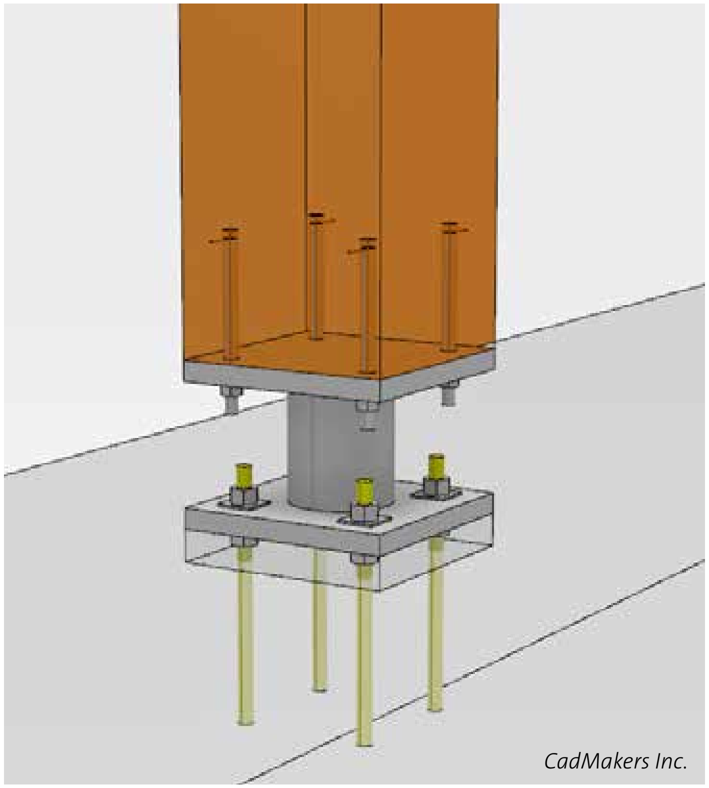
VIRTUAL DESIGN AND CONSTRUCTION MODELLING

The Brock Commons design team included a virtual design and construction (VDC) modeller, CadMakers Inc. The VDC modeller's job was to develop and maintain a comprehensive 3D virtual model of Brock Commons throughout the design phase. VDC modellers were used at different stages on past University projects, although never to the same extent as on the Brock Commons project. The VDC modeller was involved in the Brock Commons Building very early on and was tasked with collecting all relevant project information from the different team members in order to create a singular virtual model of the building with a very high level of detail.

During the design phase, the virtual model was used primarily to assist in design development and decision making. The model was also used for coordination amongst the disciplines in terms of systems layouts, construction sequencing, and preparation for fabrication of certain building elements.

Part of the rationale for including a VDC modeller on the design team was to create a single comprehensive 3D model for use throughout the project's life cycle without burdening the other design consultants with the need to produce their own comprehensive 3D models. The consultants were therefore able to focus on developing their individual designs, using their familiar modelling and drafting tools, without concern for interoperability between software or having to spend extra effort and time to develop a highly detailed model. The VDC modeller worked from the other consultants' 2D drawings and 3D design models to build and update the comprehensive virtual model. They also worked closely with the structural engineers to export detailed 2D structural CAD drawings from the 3D model.

Professional responsibility and liability were maintained with the registered coordinating design professional and with the professionals of record in each discipline. The design consultants produced the stamped documents for development and building permits. The virtual model served primarily as a design-assist tool to assess decisions and aid in coordination of system layouts. The VDC modeller also provided assistance during preconstruction, component fabrication, and assembly.



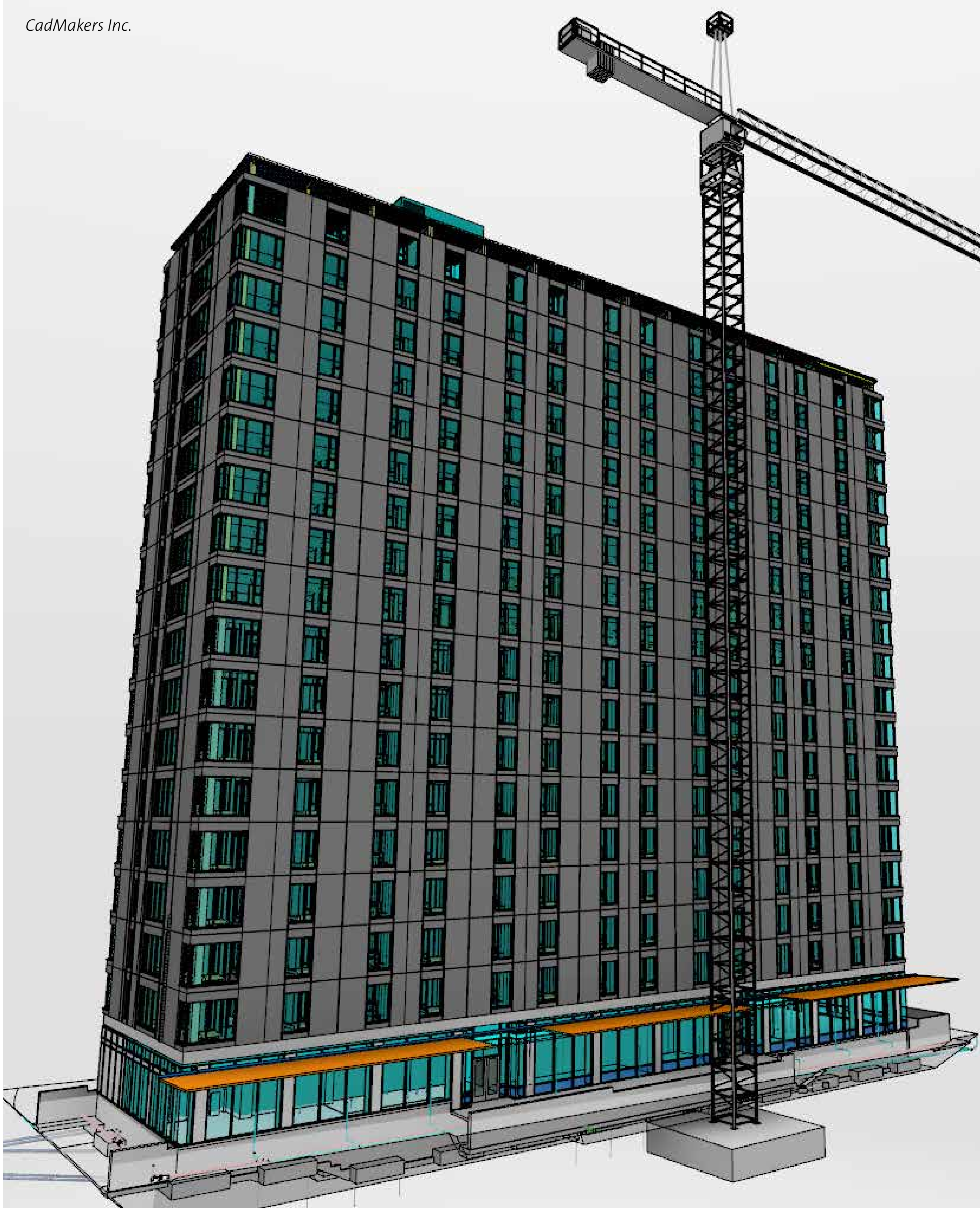
CadMakers Inc.

DESIGN PROGRAMS

- Modelling—3DEXPERIENCE (Dassault Systèmes)
- Architectural renders—SketchUp (Trimble)
- Architectural drawings—Vectorworks (Nemetschek)
- M/E/P drawings—AutoCAD (Autodesk)
- Structural drawings—CATIA and AutoCAD (Dassault Systèmes and Autodesk)

The virtual model enabled the team to simulate the construction process and proactively identify constructability issues.

CadMakers Inc.



BENEFITS OF VIRTUAL MODELLING

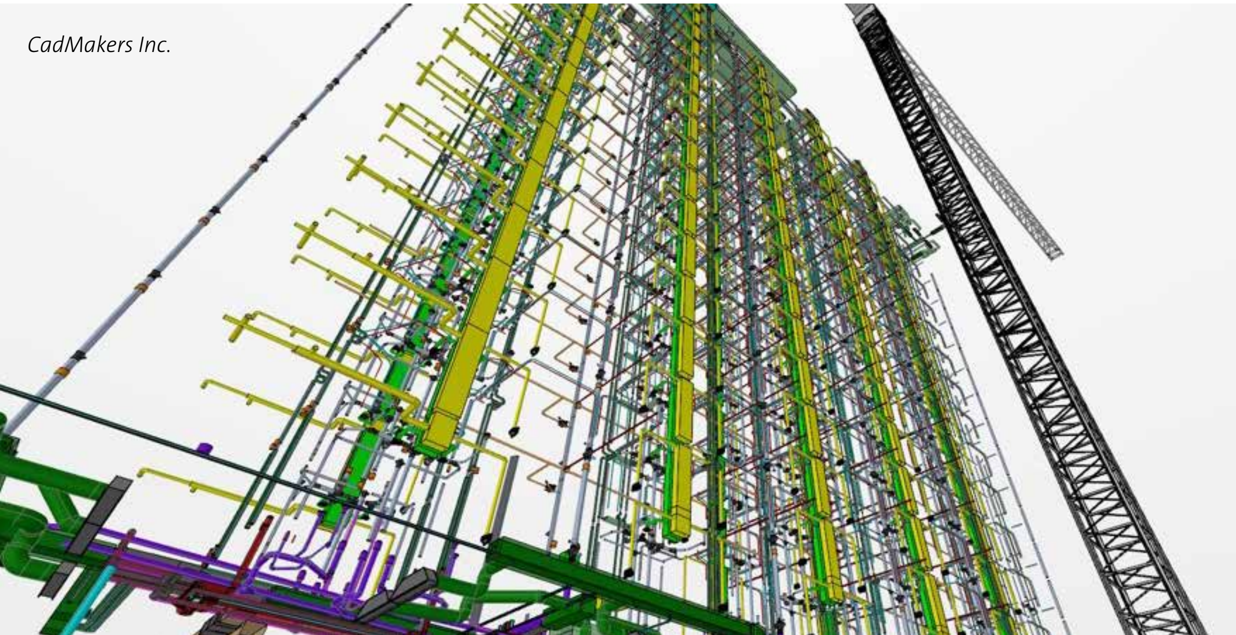
Throughout the design development, design iterations and updates were reflected in the virtual model. Any issues that were uncovered—such as identifying conflicts between different system layouts—were documented and reported back to the team as requests for information or requests for clarification. In this role, the VDC modeller acted as an external reviewer for the design and project documentation.

The VDC model enabled a higher level of coordination of building systems design. Because the CLT panels are being prefabricated ahead of installation, the routes for the utilities and services were initially defined by the design team and were further refined once the mechanical trades were brought on board. The model helped the team place and size the penetrations in each panel to accommodate the required pipes, shafts, and cabling, while ensuring that the appropriate clearances and other spatial requirements were met.

A 3-day integrated design workshop for the design team and key speciality trades was held in January 2015. The participants assessed and refined options for the structural system, and estimated costs and impacts on other engineering systems. The VDC model and the ability to update changes in real time allowed the modellers to provide rapid feedback to inform decision making during the workshop.

Due to its high degree of accuracy, the virtual model was used for quantity takeoffs of materials throughout the design and preconstruction phases. During the workshop, for example, three structural solutions were modelled and the quantities of timber were extracted to help inform the selection process.

A 4D simulation of the installation sequence that was developed from the 3D virtual model provided an overview of the assembly of building elements. This assisted the project team in visualizing the construction process and it helped the team pre-emptively resolve some of the constructability issues that would otherwise have caused on-site delays. A more detailed 4D analysis was performed during construction.



CadMakers Inc.

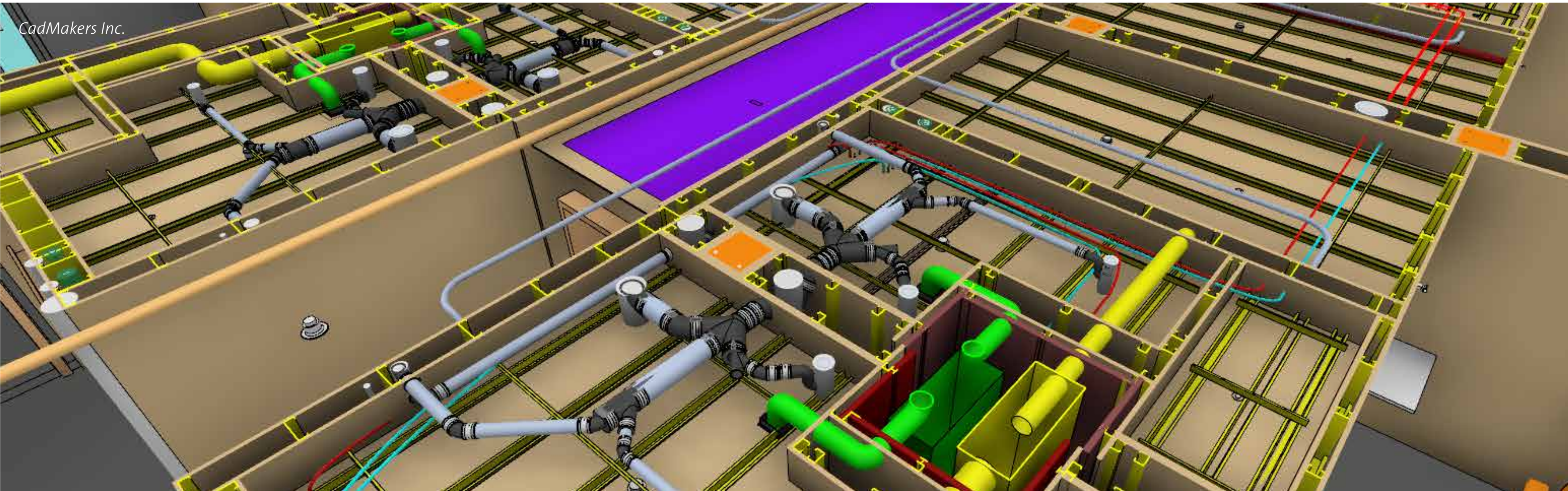
Due to its completeness and degree of accuracy, the virtual model was also used for quantity takeoffs.

The 3D virtual model and 4D simulation were shown to the construction trades prior to tender to:

- help the trades understand the scope of their work relative to the project as a whole
- show the trades that while the project is innovative in the use of mass timber products, it is not highly complex or risky
- generate more accurate bids by reducing the amount of contingency and risk allocation costs that the trades might include

The accuracy and detail of the virtual model also allow it to be used for the digital fabrication of certain building elements, specifically the CLT panels, the GLT and PSL columns, and the steel assemblies. The VDC modeller worked with the design team to locate and coordinate all penetrations and connections in the elements, and subsequently worked with the mass timber supplier (involved in a design-assist role) to develop the approval and fabrication processes for the shop drawings. The intention was to transfer the design model directly to the fabricator, to be used during the construction phase to fabricate the structural elements. A full-scale mock-up of a portion of the building was developed during the design phase, in part to allow the VDC modeller and the fabricator to practice this information transfer.

The virtual model included detailed building system elements that allowed the team to ensure accurate placement and sizing of systems and wall and floor penetrations.


CadMakers Inc.

CHALLENGES OF VIRTUAL MODELLING

The incorporation of the VDC modeller into the design team created new communication and coordination requirements among the consultants. Generally, the model was developed simultaneously with the design, with the modeller adding more information as design decisions were made. However, occasional holdups occurred due to delays inherent in the feedback loops. Whenever issues or conflicts were revealed in the model, they were communicated back to the consultants, changes were incorporated in the design, and then revisions were directed back to the modellers. During that time, other design decisions may have been made that rendered the conflict obsolete. Conversely, sometimes the modellers worked ahead of the consultants and required information that was not yet determined, or the modellers later had to revise the model when the actual design shifted from the assumptions.

Professional responsibility and liability also had to be clearly addressed across the project team. Although highly detailed, the model serves only as a supporting and informational tool. The contract documents are the 2D drawings and the specifications produced by architects and engineers. Liability is maintained through contracts with the registered professionals, not with the VDC modeller. Although the intention is to use the virtual model for product fabrication during construction, delegation of responsibility and liability had to be determined, along with processes for approvals, sign-offs, and confirmation of design and production accuracy.

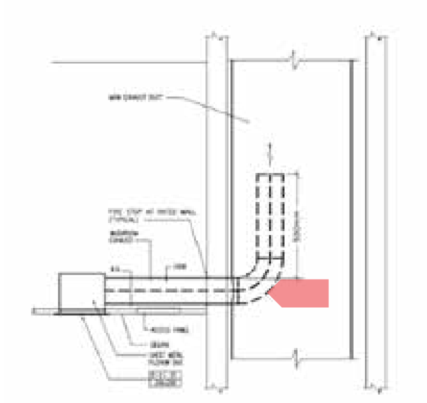
Ensuring that the model is an accurate and detailed representation of the project required that the modellers not only read and interpret the design drawings, but also understand how the systems are to be installed. To address this, the design-assist trades worked with the modellers to provide instruction on construction processes and sequencing as well as about constructability considerations. Representatives of the mechanical and electrical trades, however, were not brought on in a design-assist role, and therefore did not have input into the model. This could potentially lead to some aspects being re-worked during the construction phase.

Throughout the design phase, issues identified by the VDC modellers were documented and reported back to the design team as requests for information or requests for clarification. This allowed the team to pre-emptively identify and reconcile clashes and constructability issues, thus achieving a high degree of design coordination.

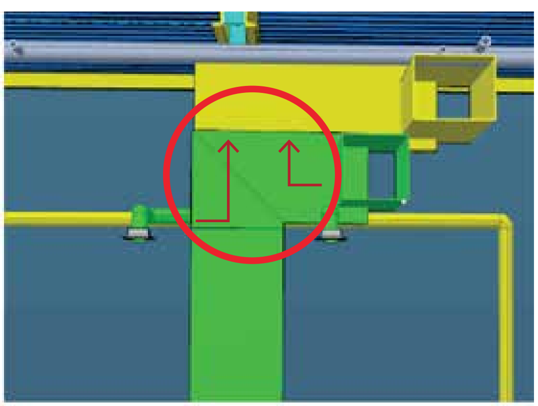
QUESTION

On M3.01, detail 2 shows the washroom exhaust connection going 500 mm up into the main exhaust duct. At level 18, the E/A duct elbows to connect to the main corridor duct. If the washroom exhaust duct runs 500 mm vertical on LVL 18 it will discharge directly into the top of the duct.

ARCHITECTURAL DRAWING



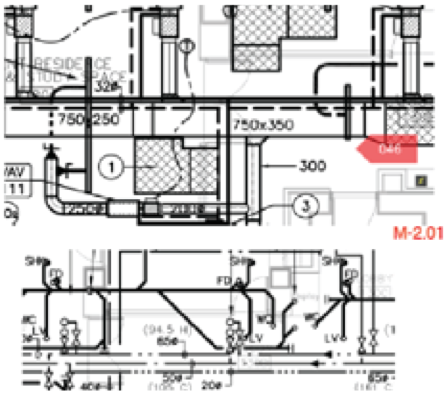
VIRTUAL MODEL



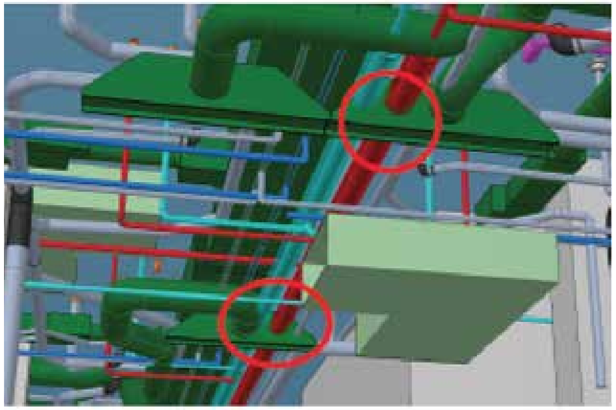
QUESTION

The diffusers in the level 1 corridor and domestic water pipes clash between grids B'-C' and 2'-3'.

ARCHITECTURAL DRAWING



VIRTUAL MODEL



FULL-SCALE MOCK-UP

As part of design development, the project team created a full-size mock-up of a portion of the building. This was built by the construction management and design-assist trades, using the virtual model as a template.

The mock-up is composed of a section of the ground and second floors, spanning 3 bays by 3 bays (approximately 12×12 m). It includes the primary elements and connections that are in the final building (with the exception of the roof assembly): i.e., the cast-in-place concrete core wall and concrete ground floor, the CLT panel floor assembly, the PSL and GLT columns, the building envelope panel, and all the relevant connections. All of the engineered wood products were digitally fabricated using the VDC model.

"Imagine having a professional sports team who never practices. [In the construction industry] we ask 700 people to play a game and never practice. Because we've never built like this before, we just need to practice."

OWNER'S REPRESENTATIVE

Fast + Epp


Research Team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The project team used the mock-up to test and validate the viability of the design decisions and to assess the constructability of the hybrid structural system components and connections between the columns and floor assembles, between the CLT panels and concrete cores, and between the CLT panels and exterior envelope panels. The virtual design models and physical mock-ups were analyzed in advance of production to improve the accuracy of fabrication and of the coordination of components and assemblies.

The mock-up also provided an opportunity to test different finishes and cladding in real conditions, including the type of concrete topping and the wood sealer to be used to protect any exposed wood during construction. After viewing the panels at real scale, the University decided to change the exterior panel cladding from an originally specified metal cladding to the wood-fibre laminate cladding.

A full-scale mock-up of a portion of the ground and second floors was built to test and validate the design's viability and constructability.

Research Team

LESSONS LEARNED

The VDC modeller played an important role on the project team by facilitating the interactive use of a 3D virtual model in the design and preconstruction phase.

- The VDC modeller helped the team find optimal solutions by analyzing and comparing the costs and impacts of different proposed designs.
- The VDC modelling allowed the design professionals to focus primarily on the building and system designs, and freed them from having to devote time and resources to modelling.
- Design and constructability problems can be anticipated when the VDC modelling includes information about connection details and identifies design and system clashes and inconsistencies.

In order to contribute effectively, the VDC modeller must have knowledge and experience of relevant construction processes and methods, or have the relevant information communicated to them by the construction manager and building trades.

Due to the innovative nature of the Brock Commons Building, understanding how the building will be constructed—including prefabrication of components, trade sequencing, and required equipment—is critical to developing a realistic plan for delivering the project on time and on budget.

- The process of virtually and physically modelling the building helped the design team understand the constructability of their approach, and it helped the team to design the components and connections accordingly.
- The process of practicing through the construction of a full-scale mock-up provided a test of design and planning assumptions in the real world, and validated material choices.

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CASE STUDY

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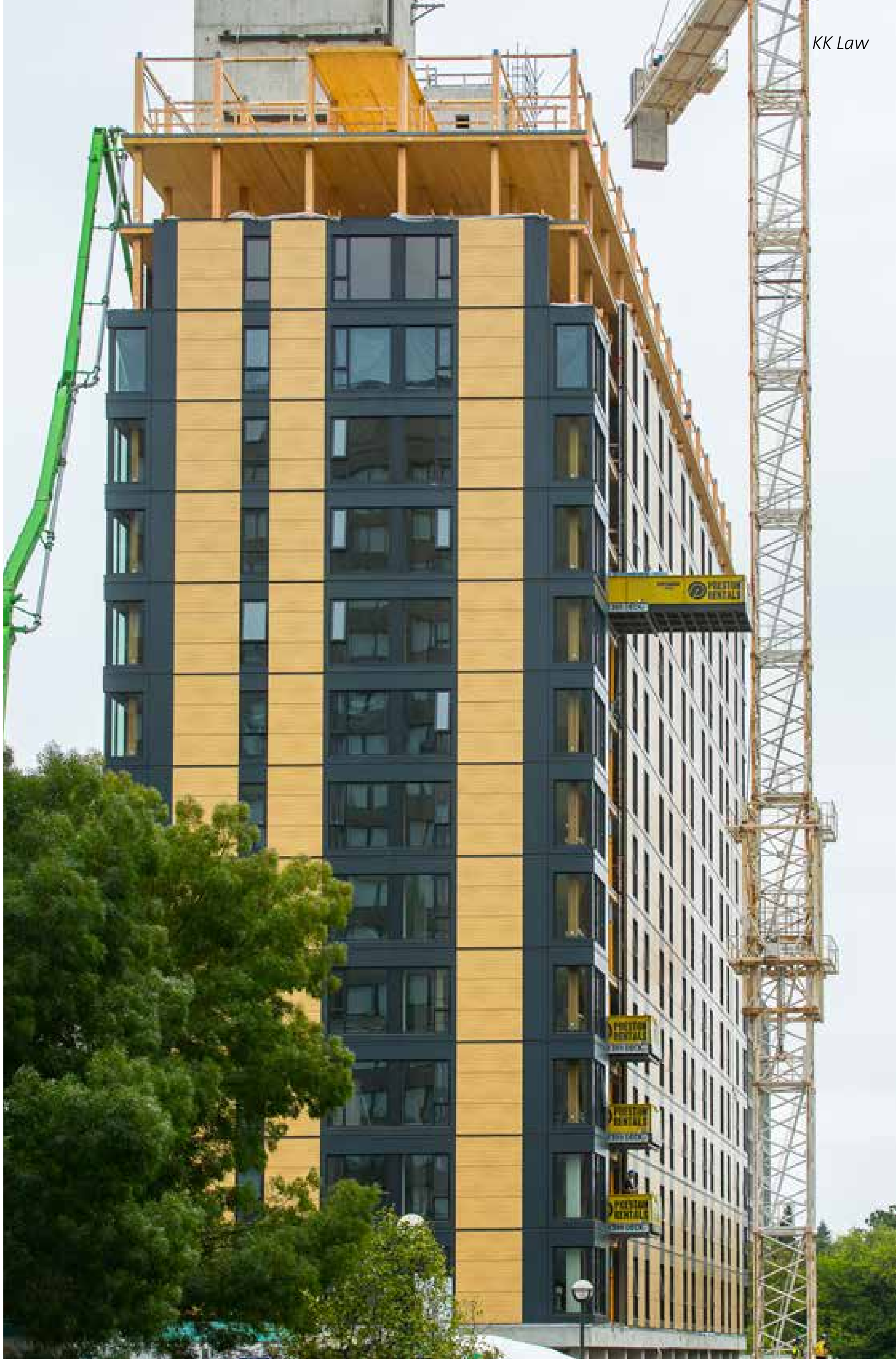
OTHER CASE STUDY RESOURCES (WWW.NATURALLYWOOD.COM)

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