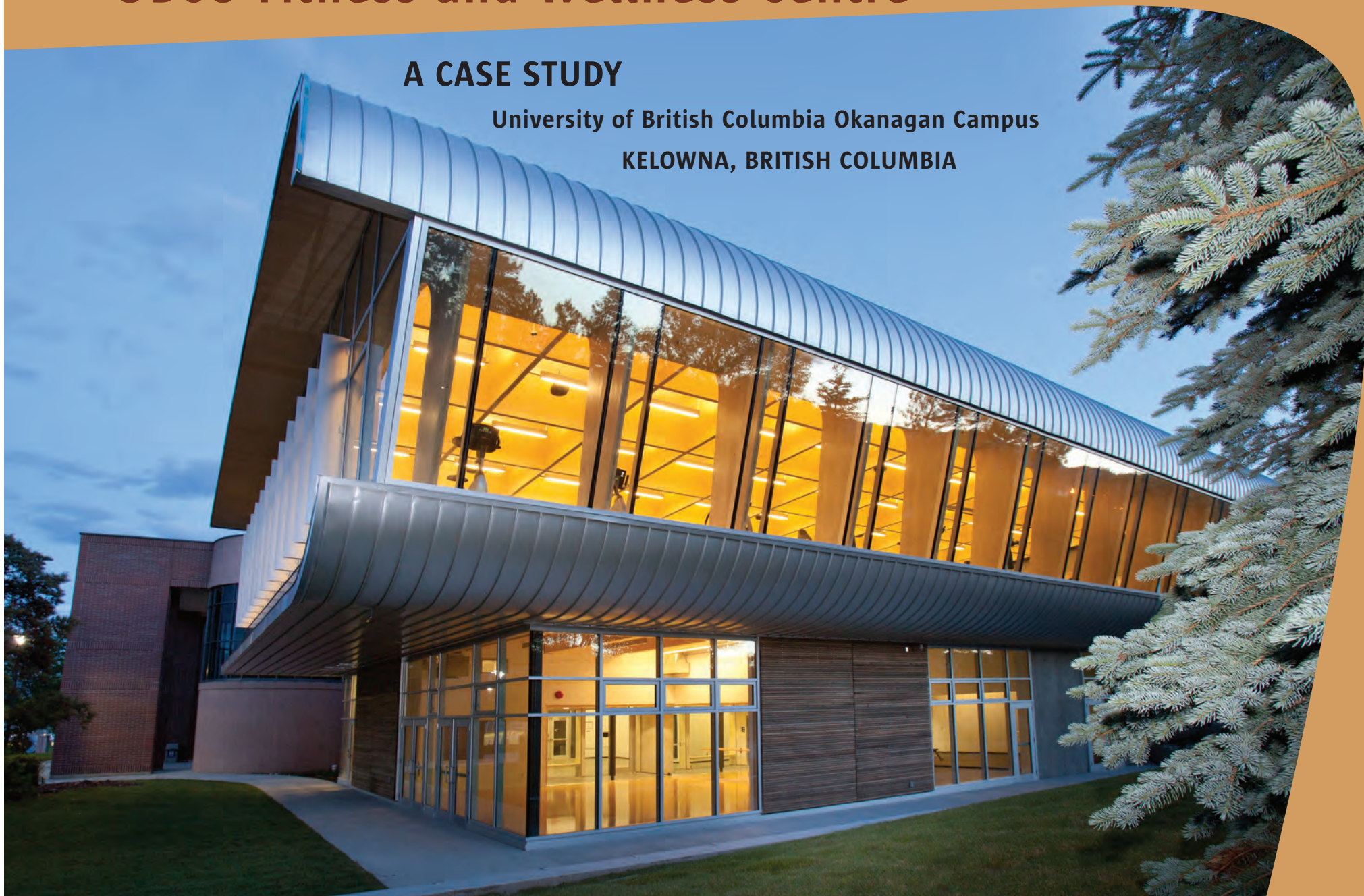


UBCO Fitness and Wellness Centre

A CASE STUDY

University of British Columbia Okanagan Campus
KELOWNA, BRITISH COLUMBIA



UBCO Fitness and Wellness Centre

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INTRODUCTION

The University of British Columbia - Okanagan (UBCO) is located in the south-central community of Kelowna in BC's interior. UBCO's student community numbers just over 8,300 undergraduate and graduate students, 20 per cent of whom currently live on campus.¹ UBCO strives to provide a vibrant campus life for its students. This is particularly important for resident students as the campus is located at a significant distance from activities in downtown Kelowna.

UBCO's Athletics and Recreation Department manages recreational needs on campus. It has been operating out of facilities initially built in 1994 to accommodate less than half of the current student population. The athletic competition venues on campus still meet a

very high standard, but fitness and recreation facilities were lacking. A storage area in the existing gymnasium complex was converted into a weight room and cardio workout area in an effort to provide added services but a permanent solution was needed for the ever increasing number of memberships to the facility.

Following the receipt of a substantial private donation for the express purpose of building a new fitness centre on the UBCO campus, UBC Properties Trust² held a design-build competition for the new building. The donor stipulated two conditions for the facility: it needed to have an aviation theme, and it had to demonstrate innovative wood construction.

¹ The percentage of resident students is poised to increase with planned additions to campus housing.

² UBC Properties Trust was created in 1988 to acquire, develop and manage real estate assets for the benefit of UBC.

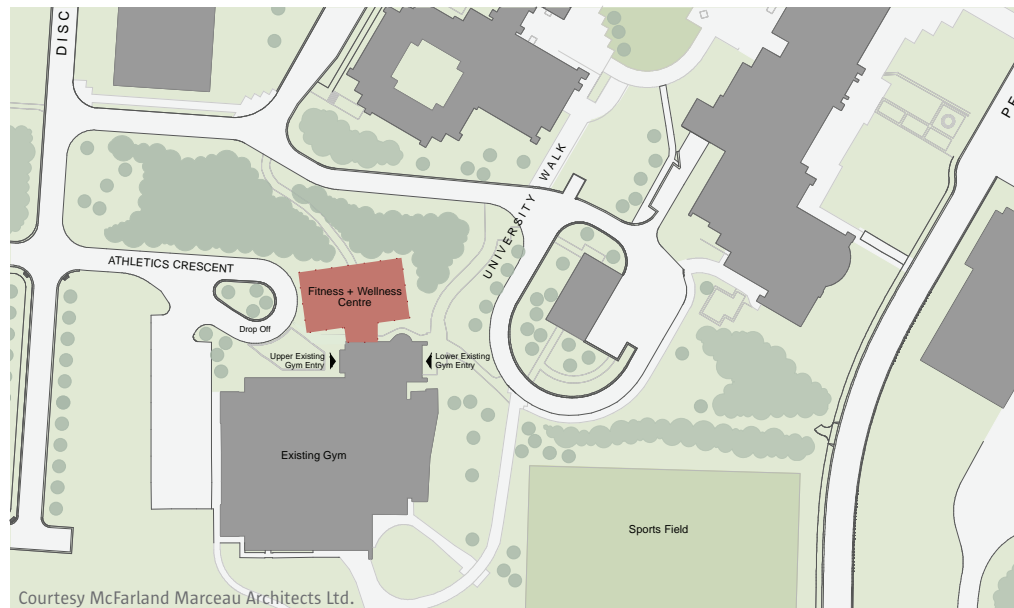


Project Description

The new UBCO Fitness and Wellness Centre (FWC) is the result of a design-build project headed by Kindred Construction in partnership with McFarland Marceau Architects. The FWC pavilion, or *The Hangar* as it has come to be known, is attached to the north side of the existing gymnasium complex via a 7.6-metre-wide link and sits at an angle to it, thereby preserving a view down University Walk, the campus' main pedestrian axis and convocation route.

The Hangar seems to float on its base, the upper floor projecting out over the landscape, poised to take flight. The glazed north and east façades create a transparency, bringing users out into the Okanagan landscape and letting the landscape in. Slender beam/column elements form what look like knee joints all along the north face where the roof meets the north wall. The light and fleet image portrayed by the building speaks of athleticism. The FWC's honeycomb roof structure and profile is a direct reference to the wing structure of the versatile WWII Mosquito Bomber. Versatility and athleticism, both appropriate expressions for a fitness and wellness centre.

The new UBCO FWC houses a cardio exercise area, a weights and strength training area, various studio spaces for yoga, combat sports, spin bikes, pilates and dancing, and will eventually accommodate an interior climbing wall. Access to the two main levels of the FWC is maintained through the existing gymnasium complex; no inter-level access is provided in The Hangar aside from a ship's ladder providing access to the mezzanine level of the mechanical room.



Guiding Principles / Objectives

UBCO's academic mission is to create a complete community on campus, one that accommodates work, school and home. In keeping with that mission, one of the main objectives in the development of the FWC was to provide a facility on campus, within close proximity to work and school, as part of UBCO's support structure for a healthy lifestyle, destined for students and faculty alike.

Not only would the program elements of the facility contribute to UBCO's support structure, its appearance

within the campus setting should foster an inviting and healthy environment as well.

As previously noted, the donor wanted to optimize the use of wood in the project while introducing references to the local aircraft industry. In addition to this requirement, UBCO has its own design guidelines regarding massing, materials and colour palette, weather protection and contextual fit. These were all considered in the design solution for the new FWC.





THE DESIGN PROCESS

The design team at McFarland Marceau Architects had to address several realities when developing their approach to the design of the FWC. One reality was the creation of a small pavilion attached to a much larger building. Another was its setting within the Okanagan landscape. Yet another was the aviation theme and the priority given to a wood construction system – all within the context of the university’s design guidelines.

Most UBCO campus buildings, including the gymnasium, are clad in dark masonry. This creates a certain opacity and weight. The desired aviation theme, on the other hand, conjures up images of lightness and curving lines. Larry McFarland, principal-in-charge at McFarland Marceau, felt that the aviation theme created an opportunity to break away from the gymnasium building, both figuratively and literally. The athletic form is a natural expansion of aviation imagery – lithe, light and strong. They would craft a transparent building out of a lightweight but strong material – wood. They would site it at an angle to the gymnasium, and create a visual connection with the landscape in which it was set, both through fenestration and through the natural colours of the materials used.

The teams at McFarland Marceau and Equilibrium Consulting had designed several buildings using the relatively new construction material, lightweight cross-laminated timber (CLT). Conveniently, one of only three CLT manufacturing facilities in the country, Structurlam, was located in Penticton, B.C., so they could take advantage of a local industry.

To date, CLT panels have typically been used as mass wood wall and deck systems. Involving the fabricator early in the design process significantly increased the combined experience of the design/build team, putting them in a position to push the envelope of what CLT was capable of accomplishing. The result would be an innovative construction system whose expression in the building would truly reflect the athleticism of its users.

“The idea of using aircraft shapes came out of my childhood pastime of building balsa wood airplanes. Replicating an airplane in the design of this project was possible since you can cut almost any shape you want from CLT. It is strong in both directions, so using it structurally made sense. We are very pleased with this beautiful structure and it also tells a nice story.”

J. Eric Karsh, Structural Engineer,
Equilibrium Consulting Ltd.

“It is not every day that an entirely new building system appears on the scene. This is essentially what CLT is for North American designers. We have been experimenting with CLT over the last few years but this project presented an opportunity to really put it through its paces. CLT is not inherently strong as a beam, but when considered like those components in nature that are not strong on their own but achieve strength in assembly, much like the cellular structure of wood, interesting possibilities emerge.”

Craig Duffield, Lead Design Architect,
McFarland Marceau Architects Ltd.



Siting and Scope

When initially constructed in 1994, the gymnasium was designed to accommodate the eventual addition of a fitness centre to the north.³ The FWC would be attached to the existing gymnasium complex at the north wall in a park-like space surrounded by trees. The two buildings would act as one, for all intents and purposes, particularly from the user's point of view. Since the two buildings would be physically linked, the existing building dictated floor to floor heights in the FWC. The primary reception area would be maintained in the gymnasium building and one would enter the new FWC through it.⁴

The existing gymnasium would house all stairways and elevators; horizontal links from the gymnasium would be provided onto each floor of the FWC portion of the complex. This would afford controlled access to the complex and only exits needed to be provided in the FWC. Plumbing requirements for the FWC would be minimal, as washrooms and showers in the existing complex would serve all users. With the reduced need for circulation areas within The Hangar, the gross area requirements for the new building could be reduced.

The gymnasium complex, aside from providing a significant aspect of UBCO campus life, performs an important yearly function as well: convocation ceremonies are held there. Activities start with a ceremonial walk from UBCO's University Centre; the procession wends through campus and down University Walk. The new FWC would be the visual anchor for the procession's terminus so it would need to play the part.

³Mechanical, plumbing and electrical installations were designed and located in the north end of the gymnasium in consideration of the future construction of a fitness centre.

⁴The Hangar has a small reception area on the upper level to oversee the main fitness room.

Code Considerations

The FWC falls under the assembly occupancy, Group A, Division 2, according to the British Columbia Building Code (BCBC).⁵ A two-hour fire separation was foreseen at the 7.6-metre junction between the existing gymnasium and the FWC using an alternative approach for BCBC compliance. The two-hour fire separation allowed a combustible construction system for the two-storey, fully-sprinklered building⁶ and a heavy timber construction system would be used.

A combination of concrete masonry units and gypsum wall board was used for the two-hour fire separation between the two buildings. In actual fact, two back-to-back one-hour fire separations were used. The one-hour separation on the existing building side is accomplished using two layers of 16-mm-thick Type X gypsum wall board. A 240-mm concrete block wall was used on the FWC side.

Five metres of the 7.6-metre connection is glazed, creating the appearance of a barrier-free transition between the two buildings. A fire-rated sprinkler system was used on either side of the glazing to maintain the required fire separation. Each pane of glass has its own sprinkler head which, if required, creates a film of water against the glass, keeping it cold. Each of these sprinkler heads has an increased water flow when compared with standard heads.

⁵BCBC Article 3.2.2.26. two-storey, sprinklered building with no basement.

⁶The sprinkler system of the FWC was designed as an addition to the existing system and the buildings share the same alarm system.



The east and west walls in the link between the two buildings are one-hour fire separations. This maintains the required limiting distances to windows in the existing building. The wood-concrete composite floor system was required to be a three-quarter-hour fire separation. A custom-engineered fire-stopping detail was required in order to maintain the integrity of the fire separation at penetrations through the composite floor. There were no fire-rating requirements for the roof assembly; wood elements for the assembly did not have to meet the minimum dimension requirements for heavy timber.

Sustainability Objectives

As with all new buildings on the Okanagan Campus, the FWC was designed to meet a LEED® Gold building rating. Energy performance is forecasted to exceed the Model National Energy Code for Buildings by at least 45 per cent.

The FWC was connected to the existing geo-exchange system which provides the heating and cooling for all campus buildings. Heating and cooling transfer within the building itself was achieved using combined hydronics (heat distribution in liquid form) and forced air. Heat pumps located in the FWC mechanical room boost the hydronic temperatures in the various air handling units which distribute the heat by forced air.

Sports facilities also have important cooling requirements. This is due to heat generation from occupant activities. The amount and orientation of glazing provided in the FWC was calculated to address such heat generation, as were the exterior vertical-fin sunshades integral to the glazing system on the east façade.

The choice of a CLT construction system would help sustainability objectives on several fronts. Since such systems are typically insulated from the exterior, thermal bridging through studs is eliminated and a tighter building envelope can be achieved. This significantly improves the efficiency of the building's heating and cooling systems, resulting in energy savings. In addition, interior finishes are not required as the CLT structure can double as the finished surface. Not only does this result in an efficient use of materials, but users will benefit from the aesthetics of this cost-saving treatment.



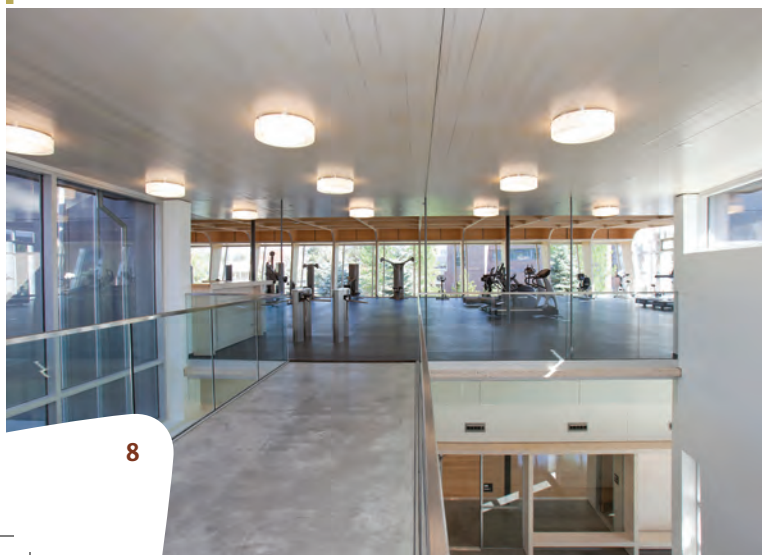
THE BUILDING

As one approaches The Hangar, the aeronautic theme is obvious. The slender silvery roof and underbelly of the upper storey seem to hover in space with only glazing to keep the two taut membranes apart. Looking closer, one can see the wooden structure within, the lines of the slender forms curving as one with the roof, from horizontal to vertical – a sprinter poised for the start of a race.

The upper level of the building cantilevers on two sides of its smaller support base. Glazing and thin horizontal strips of cedar siding on the base's exterior add to the illusion of the upper storey either taking flight, or sprinting off into the distance.

The glazed wall which separates the gymnasium from the link into The Hangar helps to create a non-confining space despite the two-hour fire separation. This open feeling pervades while crossing the catwalk into the upper level exercise room; the catwalk appears suspended in space and there is no barrier upon entering the new building. In fact, one has the impression of almost going right back out again for, seen from their edges, the slender CLT columns of the north wall nearly disappear into the landscape beyond. UBCO's new Fitness and Wellness Centre is truly state-of-the-art. Never before have structural wood elements spanning such a space been so slender.

Acoustical walls separate the lower-level studio spaces. A special sprung hardwood floor in the larger studio acts as a floor-wide shock absorber⁷, helping to enhance performance and reduce impact-related injuries. Structural CLT walls and ceilings enclose storage rooms and provide seating all along the downstairs corridor. Upstairs, CLT panels also create the entrance area, with its combination desk/ counter and dropped ceiling. The coffered roof structure is truly exemplary of the whole being greater than the sum of its parts. It is a marvel that such slender elements are actually structural.



⁷The concrete slab in the large studio is depressed by approximately 65 mm. The hardwood flooring is installed directly onto rubber pads. The system creates the give needed in high-impact exercise spaces.



Its Structure

The two-storey FWC pavilion uses a primarily wood-based hybrid construction system. At the ground floor, concrete shear walls (one which rises the full two-storey height), a few strategically-placed HSS steel columns,⁸ and two CLT box-rooms form the basics.⁹ It helps to think of the building in two sections, to either side of the single interior column gridline. This column line acts as a transfer zone for the differences in structural treatment to the north and south of it.

Glulam beams for the upper level floor system describe the main grid lines of the roof system above. They cantilever beyond the wall in the north section of the building and line up to receive the CLT roof support elements.¹⁰ A wood-concrete composite floor system is supported on the glulam structure to the north of the transfer beam and spans freely between the transfer beam and the back wall of the building to the south. The back wall support system is a combination of shear walls and glulam beams. The glulam support beam interrupts where the link meets The Hangar. At that point, three tension rods hang from the roof glulam above to support the second storey floor system, including the link's catwalk. This suspended configuration allows the link to be open at the south wall of The Hangar and helps to create the free-flowing movement between the two buildings.

The roof system did not have to meet heavy-timber requirements and slender 99-mm-thick CLT ribs were used to form what appears to be a two-way space frame. In fact, to the north of the transfer beam, the CLT system is a rigid moment frame, a system which is typically very difficult to achieve in wood. Horizontal ribs curve at the north wall, where a 45-degree split joint occurs, and the beams become columns. The CLT bridging elements, used as cross-bracing for the slender ribs, are not as deep as the ribs of the moment frame. They are installed flush with the bottom of the moment frame elements and a groove is introduced into the top edge to accommodate the sprinkler lines.

The roof deck is also CLT panels. The panels are cut into narrow strips to form the curves at the north end. Nearly all CLT used in The Hangar is three-ply, including the roof deck panels, wall, ceiling and floor panels, as well as the roof's slender-ribbed moment-frame system and its bridging elements. A 169-mm-wide CLT transfer beam at the roof level is the only five-ply CLT element in the building; the CLT roof deck for the link is seven-ply.

⁸ There are three HSS steel columns in the interior (main gridline C) at the ground floor and five in the glazed portions of the exterior walls. There are four HSS steel columns in the interior space at the upper level (main gridline C).

⁹ Three-ply CLT wall and ceiling panels form the box rooms.

¹⁰ Bearing on the north wall is a combination of a concrete shear wall and a W-section steel beam supported on HSS columns.



3-ply CLT



HBV Mesh



HSK Connector



Sherpa Connectors

Specialty Systems

Cross-laminated Timbers – CLTs

CLT panels are fabricated by stacking alternating layers or plies of structural-grade lumber at 90 degrees to each other in odd-number layups, with a minimum of three plies. These are subsequently either glued together or mechanically fixed to form large panels. Due to the nature of the manufacturing process, CLTs have improved dimensional stability with increased strength and stiffness in both directions, giving the panels a two-way action much like is found with two-way concrete slabs, only with less weight. CLT panels are available in finish and industrial finish-grades.

Connections

Various high-efficiency connections were used in the construction systems for The Hangar.

HBV Connectors

HBV shear connectors consist of perforated steel plates or mesh simultaneously embedded in adjacent materials to create a composite action between the two. In the case of a wood-concrete composite floor system, half of the HBV mesh is embedded in the wood and glued in place with a proprietary epoxy-based adhesive system. The concrete is poured over the protruding portions of the mesh using the wood substrate as formwork. A mechanical shear connection is created once the concrete is cured.

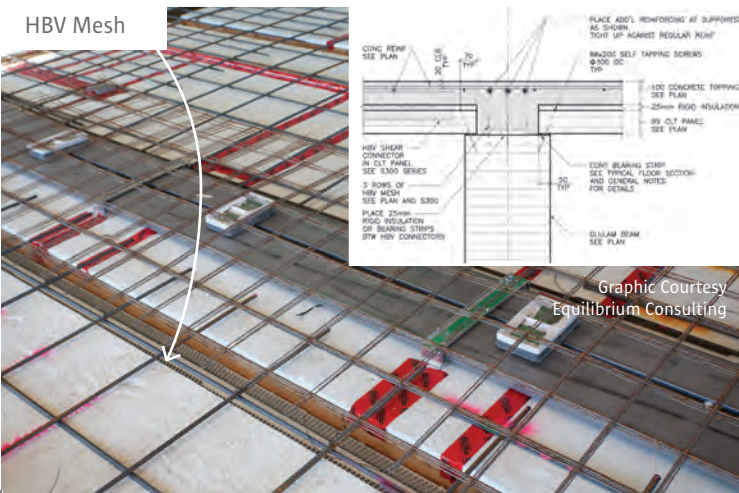
HSK Connectors

HSK connectors are particularly suited for creating rigid moment frames in wood structures. A series of heavy gauge perforated metal plates are installed in factory-cut grooves of the elements to be joined. The rigid connection is achieved by injecting an epoxy-based adhesive system into the connection through pre-drilled holes. The size and number of plates used, and the number of perforations in the plates, is dependent on the geometry of the joint, the size of the elements to be joined and the forces for which the system is designed.

An HSK system can be used for end-to-end connections where the connectors are let into either end of the elements to be rigidly joined. They can also be used to attach the end of one element onto the broad side of another element. In this case, a metal plate is mounted onto the broad side of the receiving element. Perforated HSK mesh plates are factory-welded perpendicular to the metal plate for insertion into factory-cut grooves in the end of the element to be joined. The plates are glued in place with a proprietary epoxy-based adhesive system. Depending on the joint configuration and erection requirements, many HSK connectors can be factory installed.

Sherpa Connectors

Sherpa connectors are high-strength aluminum dovetail connections which are precision installed in-plant. Once on site, elements are simply slipped into the other to create an invisible form-fitting connection.



Wood-Concrete Composite Floor System

The second floor wood-concrete composite floor system of The Hangar is accomplished by creating a shear connection between the glulam floor beams, the CLT panels in certain areas and the concrete topping using HBV shear connectors. The design for this floor, which would house the main exercise room of the Hangar, was based on solid wood design for vibrations. Since wood structures are considerably lighter than concrete structures, vibration is an important consideration.

Bearing strips were installed on the tops of the glulam beams before laying up the CLT panels. The CLT panels were affixed to the top edges of the glulam beams using self-tapping, fully-threaded screws. HBV shear connectors were then let into the CLT panels where required and strips of HBV mesh plates were vertically embedded into the factory grooves in the top edges of the glulam beams and glued in place.¹¹ Rigid insulation was installed between the HBV mesh on the CLT panels and between the rows of mesh in the glulam beams before pouring the concrete.¹²

The CLT panels act as formwork for the concrete and are left apparent as the finished ceiling below.

¹¹Three rows of mesh are used in the transfer beam; two rows of mesh are used in the smaller beams.

¹²The rigid insulation was included to improve the acoustic separation.



The Roof System

To achieve the athletic expression desired by the design team for the roof structure, slender was better. Eric Karsh, principal engineer at Equilibrium Consulting, had a vivid memory of the balsa wood airplanes of his youth and thought “what if we could punch the elements we needed out of CLT panels.” CLTs would allow a thinner and deeper profile than would glulams, and efficiencies could be created by cutting several beams out of one CLT panel with no need to lay up custom curved glulam beams. The honeycombed roof structure, borrowed from the Mosquito Bomber’s wing structure, would get the most out of the thin CLT elements.

A one-way moment frame is used to the north of the transfer beam and standard beam construction is used for the shorter roof portion south of the transfer beam. The moment frame is achieved using an HSK connection system. The standard beam construction portion uses Sherpa connectors. The bridging elements to north and south of the transfer beam are also connected using Sherpa connectors. The bridging elements to the north of the transfer beam keep the slender moment frame elements from buckling.

The main elements, or ribs, of the moment frame are set at approximately 2.3 metres on centre.¹³ The ribs are approximately 940 mm deep at the transfer beam where they are attached using a shear hanger. They expand to approximately 1500 mm deep at the columns along the north wall where they transition via the first moment connection (the 45-degree split joint). Not coincidentally, a moment joint is the most “athletic” of structural joints, and is used to link the forces within the beam and column rather than separating them. The columns taper down to approximately 600 mm at the base and are attached to the glulam beams of the second floor via the second moment connection.

Shear Connection:

Specially designed HSK connectors were factory-installed to the ends of the rib beams. The base plate is hung and inset into pre-cut grooves in the transfer beam.



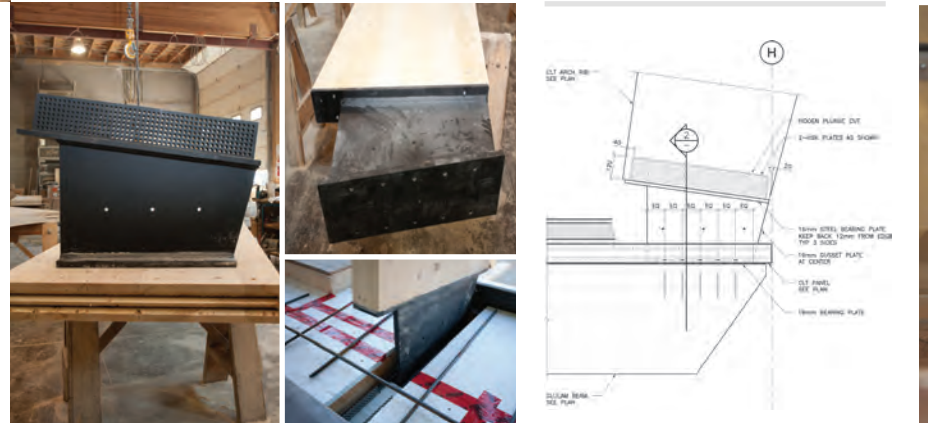
Moment Connection # 1:

T-shaped HSK connectors are used to connect the moment frame at the 45-degree splice joint at the north wall where the roof ribs form a continuous curve to become the columns. The T-shaped connectors were factory-installed to the column portions of the moment frame ribs and epoxied on site to their beam counterparts.



Moment Connection # 2:

The base of each column uses HSK connectors that were also factory-installed. Two base plates are separated by a vertical metal plate in these HSK connectors. This keeps the bottom of the column off the floor to prevent staining when floors are washed.¹⁴



¹³The solidifying bridging elements are also installed at 2.3 metres on centre.

¹⁴The column bases are attached to the second floor glulam beams using partially threaded self-tapping screws.



THE CONSTRUCTION PHASE

There were technically two construction phases for the FWC: off site and on site. CLT and glulam fabrication as well as the connection detailing took place off site at the Structurlam manufacturing facilities in Penticton. The erection of the structure took place on location at the UBCO campus.

Off-Site Manufacturing

Early involvement of the fabricator during the bidding process created ample opportunity to plan for maximum optimization during the manufacturing process. The three-metre by 12-metre, three-ply CLT panels used in The Hangar were pressed in three-panel pressings. These were subsequently shaped and tooled using a five-axis CNC router into the necessary configurations. CadWorks 3D modelling was essential in determining the beam/column cut-outs in the panels to keep waste to a minimum.

All the CLT and glulam elements left the manufacturing facility ready for installation. Sherpa connectors were all pre-installed. Since HSK connectors form a continuous joint between two elements, only one side of the connector could be pre-installed. Factory grooves were provided in the elements that would be bonded to the other side of the connector on site. Two HSK plates were needed, one at each glue line, for each of the moment frame connections. Grooves were also provided on the edges of the glulam beams for receipt of the HBV mesh, and on the CLT transfer beam for receipt of the HSK connectors.

The UBCO Campus – On Site

On-site construction started in April 2012 and the sequencing of wood package arrivals had to be coordinated appropriately from start to finish.¹⁵ All concrete and structural steel work had to be completed before the first CLT packages started to arrive in July. One of the main on-site challenges was pouring the 12-metre-long, 10-metre-high shear wall without a second floor in place to work from.

The first CLT panels to go up were the box rooms at the first floor: walls, ceiling and corridor benches. The ceiling actually doubles as the floor for the mezzanine level of the mechanical room. The glulam transfer beam was then installed followed by the glulam beams that would support the wood-concrete composite floor. The next shipment of CLT panels was destined for the second floor and catwalk. Once those were installed and the four interior HSS columns erected, HBV mesh were epoxied into the panels and glulams, rigid insulation was laid down, and electrical conduit and steel reinforcement were positioned. The second floor concrete topping was poured on October 2.

¹⁵There were time and space (staging) implications for wood package deliveries which required close coordination between the manufacturer and the erector.



Shear Walls



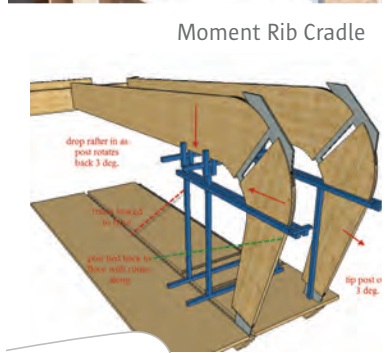
Box Rooms



2nd Floor: Glulam Transfer Beam



Roof Level: CTL Transfer Beam



Moment Rib Cradle

14 Courtesy Nicola Logworks



Hangar and Link Roof Decks

The stage was set to start bringing in the roof structure. The glulam beam at the south wall was installed, as was the CLT transfer beam, and the moment frame ribs were next. John Boys at Nicola Logworks, who was in charge of putting up the wood structure, was also involved very early in the project. He had already determined that assembling the beam/column ribs on the ground then raising them into place would create too many stresses on the ribs and developed a cradling system to facilitate the erection.¹⁶ Two rib beams were installed at a time, cradle in place at the north wall to support that end, and the column portions were brought in and pivoted into position.¹⁷ The bridging elements were dropped in, then the moment joints were epoxied.

Epoxying the moment joints on site proved to be a challenge. The volume of epoxy for the joint geometry was calculated and hydrostatic pressures that can build with the injection of large volumes were factored in. Vent holes were needed to keep air from getting trapped during injection but leaks had to be prevented to ensure the proper volume remained in the joint to establish the strength needed in the connection. All-in-all, each of the moment connections at the front wall took two hours a

piece to execute: one and a half hours of preparation and a half hour for the epoxy injection.

Once the roof structure was in place, the CLT panels for the roof deck arrived and were installed. The last roof panel was installed on September 14, seven weeks after the first panel went in. During two of those weeks there was no work on the wood structure, so only five weeks were needed to erect the wood structure.

The last challenge was getting the roof system sealed and watertight. A self-adhering composite membrane was applied to the roof but more than a hundred 100-mm holes were drilled through the CLT panels for electrical boxes and their conduits that all sat on the top of the roof. It took several weeks before the roofs of the main pavilion and the link were watertight.

The speed of the CLT erection was a positive surprise, avows Richard Lowe at Kindred Construction. “We were actually ahead of schedule, even with the complicated joining and gluing that had to happen on site.” Site waste was also practically non-existent. Almost a year to the day, The Hangar will be up and *running*.

¹⁶Two cradles were used, each holding two ribs.

¹⁷Dietrich’s 3D modeling proved instrumental in orchestrating this procedure.



THE FINAL PRODUCT

Throughout this new building on the UBC Okanagan campus, the wood structural system, all of which has been left apparent, is bright and light. It helps to create an atmosphere conducive to a good workout – no matter how motivated one might be, it always helps to have an inviting environment. The beauty of this structure in combination with its views into the valley will actually inspire people to want to use its facilities.

Much like the team that made it possible, The Hangar is a perfect example of the whole being greater than the sum of its parts. The surface tension created by the thin roof deck and its taut moment frame are synonymous with the sinuous muscle and dynamism of an elite athlete. Its lithe body speaks of strength, of elegance and of the spirit of flight – and the analogy becomes reality.

There will be fitter people walking around the UBCO campus from here on out.



UBCO Fitness and Wellness Centre

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NATIONAL PARTNERS



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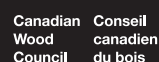
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