Waterloo Wellington Flight School

Aileron Consulting Group

Aileron Consulting Group (ACG) was tasked with redesigning the Waterloo Wellington Flight Centre to act as a beacon of sustainable innovation and set the standard for flight school facilities across Canada. The final proposed design considers aspects such as social impact, environmental sustainability, and economic feasibility to achieve a truly innovative design for one of Canada's largest flight schools. The team was able to tour the existing flight school facility and gain insight from instructors and staff members on the functionality and key aspects of each programming space. The feedback, and particularly the concerns, were all addressed in the floor planning stages in order to achieve proper flow while optimizing the social experience between staff, students, and visitors throughout the building.

The structure of the building is primarily made up of mass timber elements, including glulam posts and beams, cross-laminated timber (CLT) panels, and hollow-core mass timber (HMT) panels to achieve open office and academic spaces with longer spans. This material was selected due to the various social and environmental benefits of using timber. Prefabricated timber typically produces less waste, potentially reducing costs, while resulting in a smaller carbon footprint than typical concrete construction. Elements of the structure are exposed throughout the building providing its occupants with a welcoming and aesthetically pleasing environment that promotes social connections and increased work productivity, among other timber-related benefits. Hybrid timber-steel trusses are used to support the timber structure in the main atrium and long spans of the hanger.

Architecturally exposed black steel was added to create an openness to the roof structure and highlight steel's historic importance to the aviation industry. The mass timber elements also play a key role in reaching carbon neutral for the building. Overall, the structure has a carbon offset of approximately 500,000 kg CO2 that can be used to balance other emitting project items such as; cladding, interior partitions, insulation, finishes, and parking lot and apron construction.

In terms of energy performance, the building takes advantage of the natural geothermal heating and cooling opportunity available in the Region of Waterloo, and the existence of an upper and lower aquifer in the ground. Net-zero energy was achieved through the use of 403 kW PV system totalling a surface area of 1750 m^2 and producing an estimated 400,000 kWh of energy annually. This was made possible through the implementation of a high-performance enclosure, energy-saving building systems, and three-part lighting/window design.

Ultimately, the design was able to achieve a state-of-the-art flight centre that has the potential to become a beacon of sustainable innovation in aviation through a number of building performance, structural system, and functional building solutions. The design was able to achieve net-zero energy while providing inspiring spaces and views of the apron and greater YKF airport. The aesthetically pleasing exposed mass timber structure of the flight centre will inspire students, staff, instructors, and community members, with a new interest in the combination of sustainability and aviation.

Aileron Consulting Group

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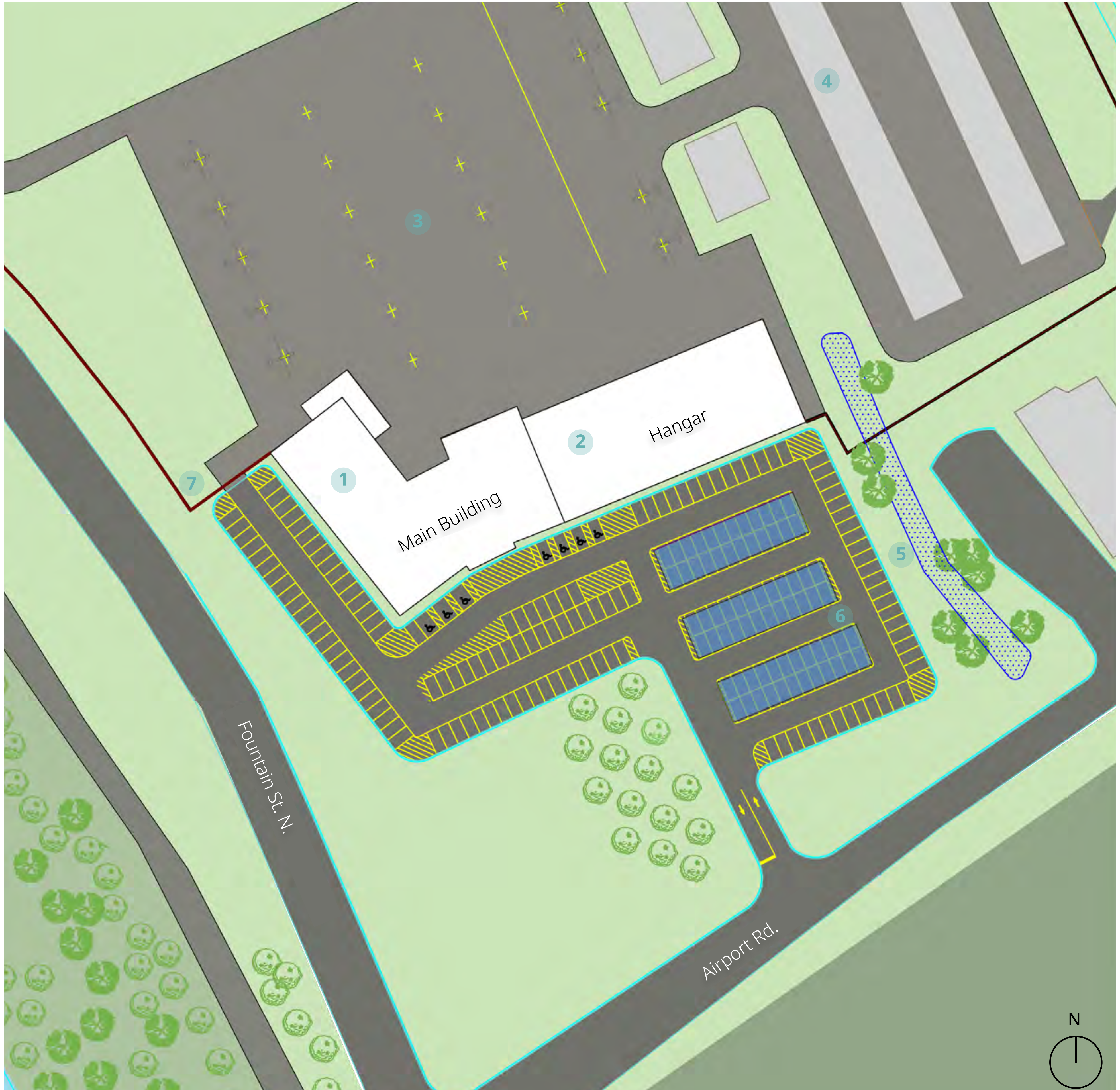


1.0 DESIGN CONCEPT

CONCEPTUAL SITE - 1:1000

The proposed site is located directly west of the existing flight centre and is currently occupied by Hangar #7 (owned by YKF) and several private airplane hangers.

This site can be accessed by vehicles via Airport Rd. to the south, leading directly to the parking lot along the south and west sides of the building. The entire north side of the site, behind the building, makes up the apron for the flight centre. This includes space for aircraft parking and refueling, access to the hangars, and access to the runway.

The proposed development will include an entirely redesigned 3000 m² main building as well as a 750 m² heated hangar and a 750 m² unheated hangar. The L shaped building is oriented along the south and west axis of the site as this fits best with the sites surroundings (i.e. apron placement for runway access and site access from Airport Rd.), while also optimizing sun exposure, which will allow for passive solar heating and lighting strageties to be implemented.

1. Proposed 2 Story Main Building
2. Proposed Hangar
3. Existing Hangar #7 Apron Area
4. Existing Private Hangars
5. Storm Water Pond
6. New PV Structure
7. Security Fence & Gate

MAIN BUILDING – FRONT ENTRANCE

The proposed design for the Waterloo Wellington Flight Centre acts as a flagship for innovation in flight schools across Canada. Its exposed mass timber structure allows for open-concept spaces, passive and active energy reducing strategies, and optimized floor plans to accommodate the current required programming and any future changes, while maintaining program conscious flow throughout the flight centre.

The "L" shaped building, inspired by the shape of an aircraft body and single wing, achieves net-zero energy through a number of measures such as; a high performance building enclosure, photovoltaic energy generation, and ground source heat pumps. While operational emissions are a key focus of the net-zero design, the building also aims for a low embodied carbon design. Emissions embodied in the construction materials and processes are reduced by utilizing low carbon and renewable materials, sourcing products locally to reduce transportation emissions, and through carbon storage in the structure.

Another key benefit to the prefabricated timber structure is it can also be easily transferred to other sites across Canada. Prefabricated elements can be delivered to the site where prefabrication, along with the high strength to weight ratio of wood, allows for smaller cranes and less crew needed in building assembly. The prefabricated elements can also be scaled with additional bays quickly and easily added to the design.

HANGAR - UPPER LEVEL MEZZANINE

HANGARS

Two separate hangar spaces are provided for the facility, a heated space and an unheated space. The heated hangar, located adjacent to the main building provides space for everyday aircraft maintenance and storage, as well as a feature area for large events at the flight centre. Approximately 8 planes can be parked in the heated hangar. The unheated hangar provides spaces for battery charging and storage, while also having the capacity for 8 planes to be parked.

The hangars required an open spanning space, as the use of columns or other supports within the area of the structure would not allow for the designated programming. In order to achieve the long spans, the structure utilizes large curved glulam beams in conjunction with steel to form a hybrid truss system. A large sliding track door on each side of the hangar provides access to the apron and taxiways. The 25m openings are spanned by a large steel truss.

The Waterloo Welling Flight Centre has a long history of driving aviation in Waterloo and the surrounding region. The innovative new flight centre will allow for the continued development of aviation locally, while also serving as a beacon of sustainable innovation in aviation globally.

MAIN BUILDING - GROUND FLOOR

The first floor of the main building requires a range of programming to be accomodated. The team developed a plan that includes all necessary spaces to accomodate for students, administration, and staff/ instructor spaces in a way that enhances the flow of the building, while into consideration social elements and noise. This level includes the following programming:

- Main Lobby & Atrium
- Washrooms (4)
- Front Desk
- Coffee & Donuts (C&D)
- Bookstore
- Student lounge
- Lecture Hall
- Classroom
- Briefing Rooms
- Debriefing Rooms
- Dispatch & Dispatch Office
- CFI Office
- Desk Area (Testing Area)
- Flight Instructor Mail Room
- Flight Instructor Lounge
- Flight Instructor Locker Room
- Storage Room
- Server Room
- Runways Cafe
- Mechanical & Garbage Room

The flow of different occupants within the flight centre was a key factor in the design. Students, instructors, staff and community members are easily able to flow throughout the building without overloading corridors or interrupting the quieter work areas such as the admin offices, flight simulators, and classrooms.

A secondary entrance is provided to allow admin and staff to quickly arrive from staff parking to their corresponding workspaces.

GROUND FLOOR PLAN - 1: 250

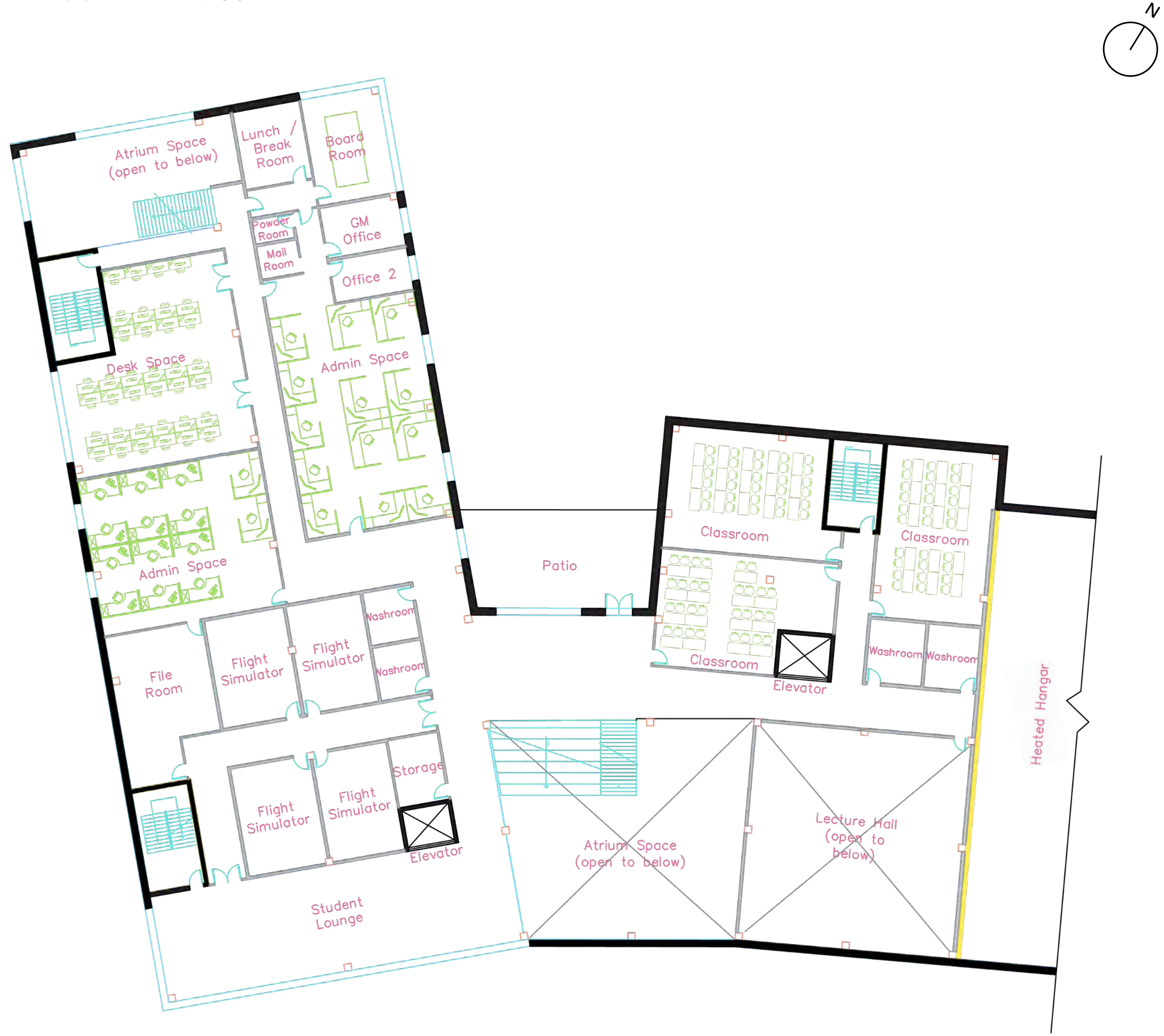
MAIN BUILDING – SECOND FLOOR

Similar to the ground floor, planning for the second level required the consideration of separate staff/instructor and student spaces including the following:

- Lecture Hall (access from both levels)
- Washrooms (4)
- Classrooms (3)
- Student Lounge
- Flight Simulators (4)
- File Room
- Storage Room
- Administrative Work Space
- Secondary Administrative Work Space
- Open Desk Work Space
- General Manager (GM) Office
- Break Room
- Board Room
- Admin Powder Room

Bridging the gap between the two spaces is the upper walkway adjacent to the main atrium and the exterior second storey patio overlooking the apron and runways.

2ND FLOOR PLAN – 1:250



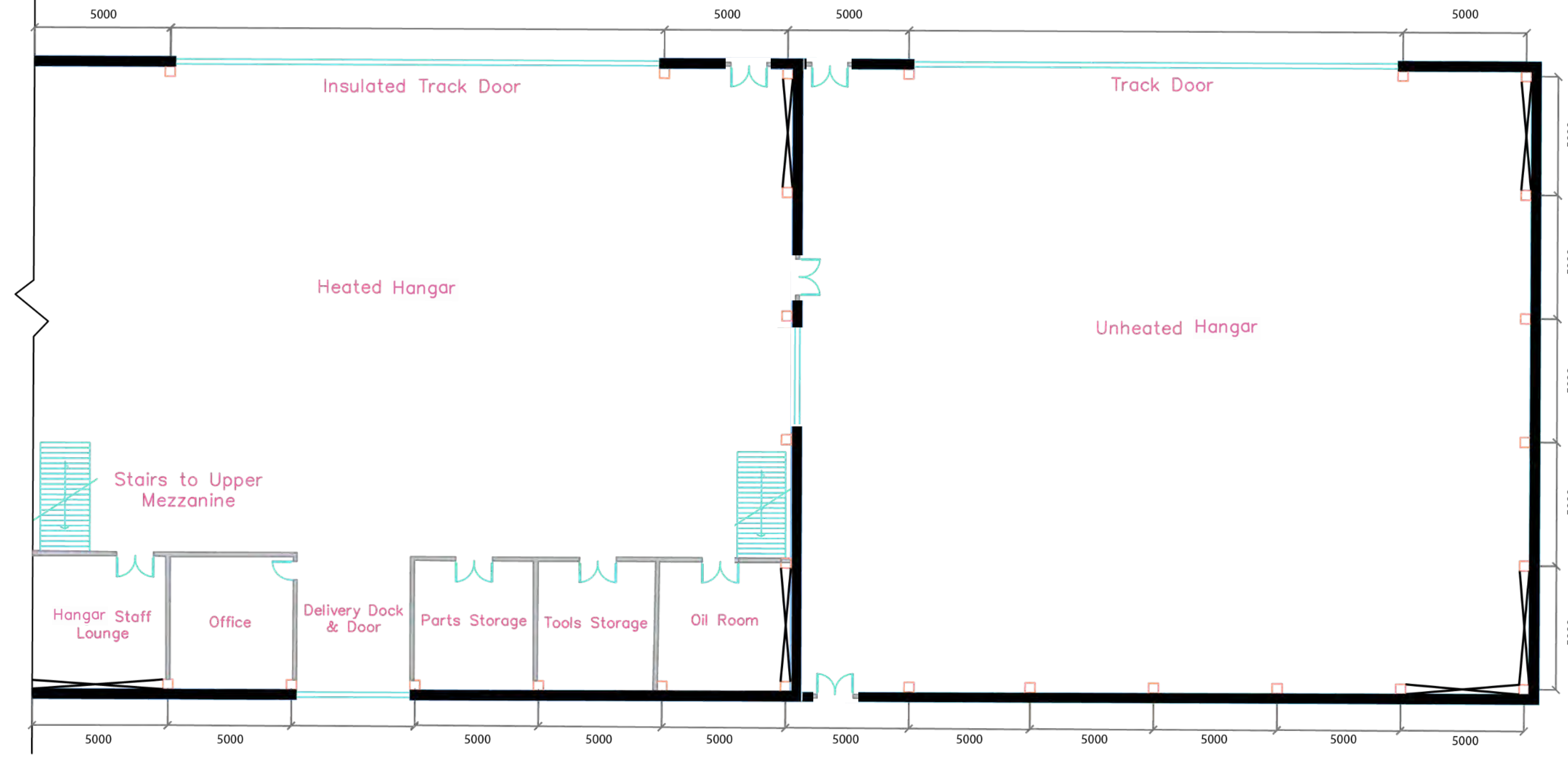
HANGARS

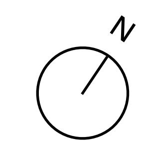
The large hangar is divided into two spaces, a conditioned portion closest to the main building, and an unconditioned space furthest from the main building. The conditioned portion of the hangar serves as the aircraft maintenance area where technicians can actively maintain and service the fleet of aircraft. This part of the hangar also contains:

- Staff office
- Staff lounge
- Upper and lower parts storage areas (new and quarantined parts)
- Tool room
- Oil and flammable storage
- Delivery dock

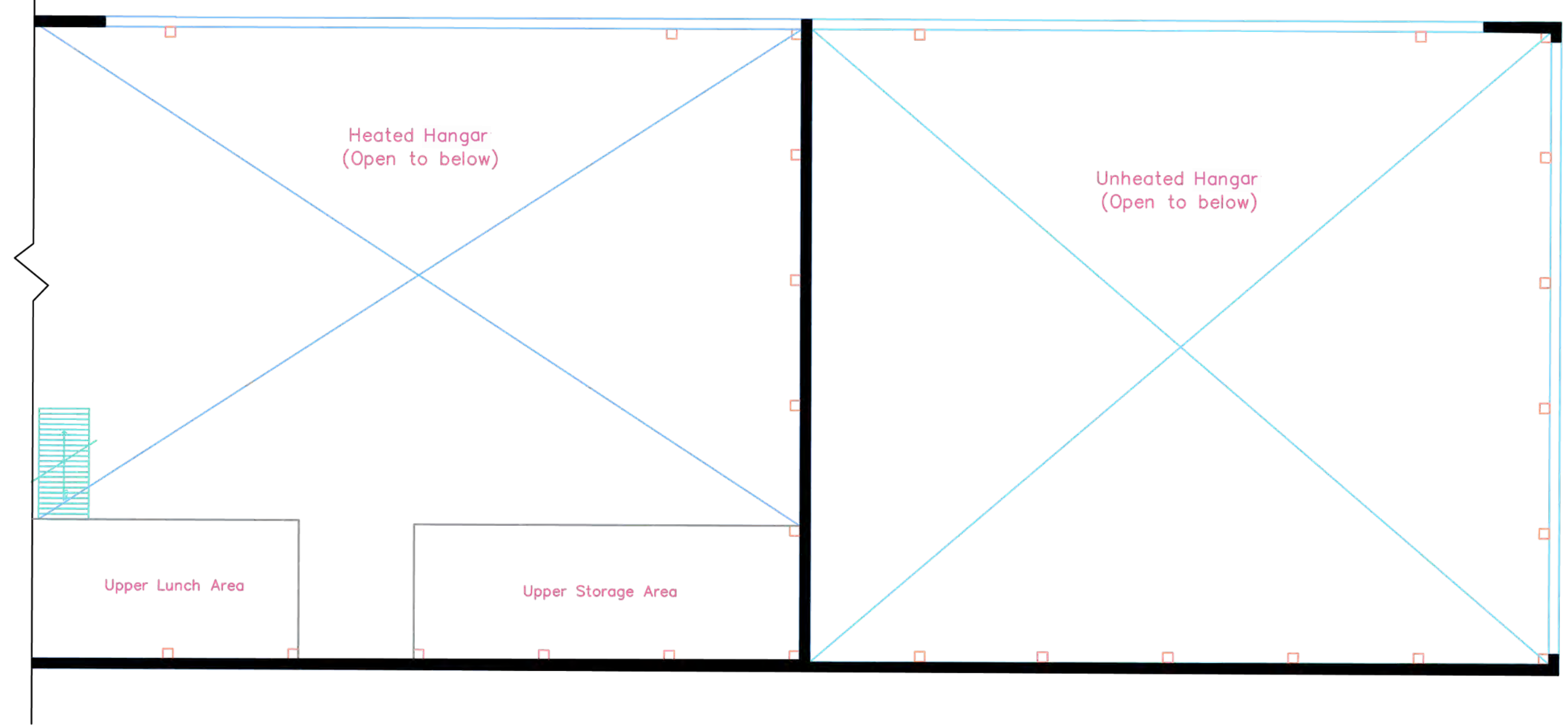
Between the two hangars is a double man door and an overhead door which allows for movement between the two hangars without significant heating or cooling loss.

LOWER LEVEL - 1:250





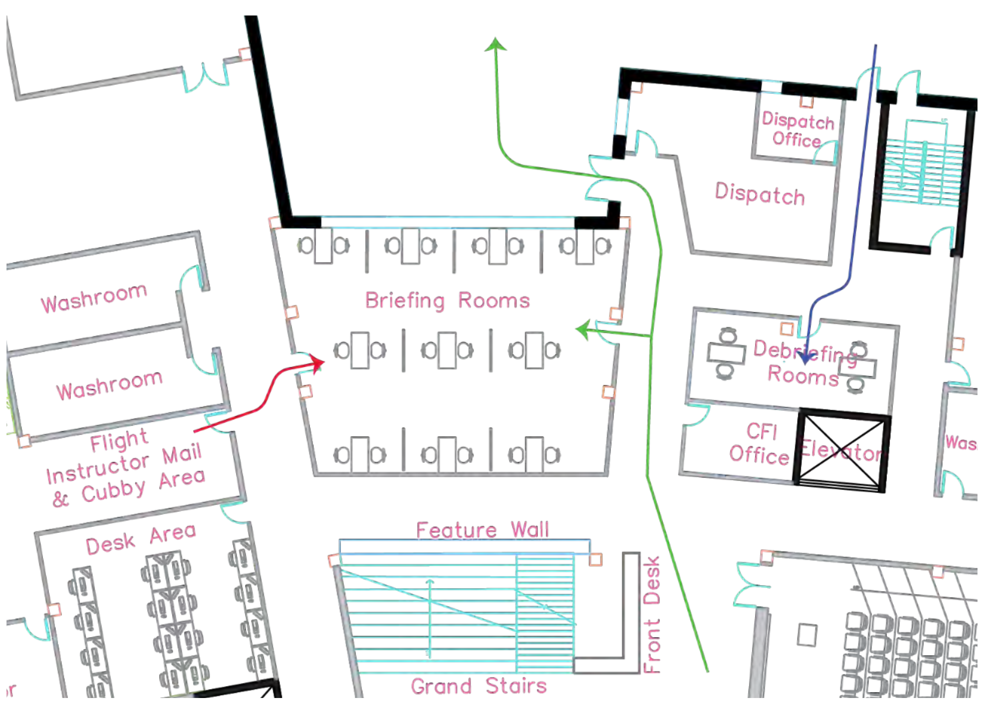
UPPER LEVEL - 1:250



FLOOR PLAN FEATURES

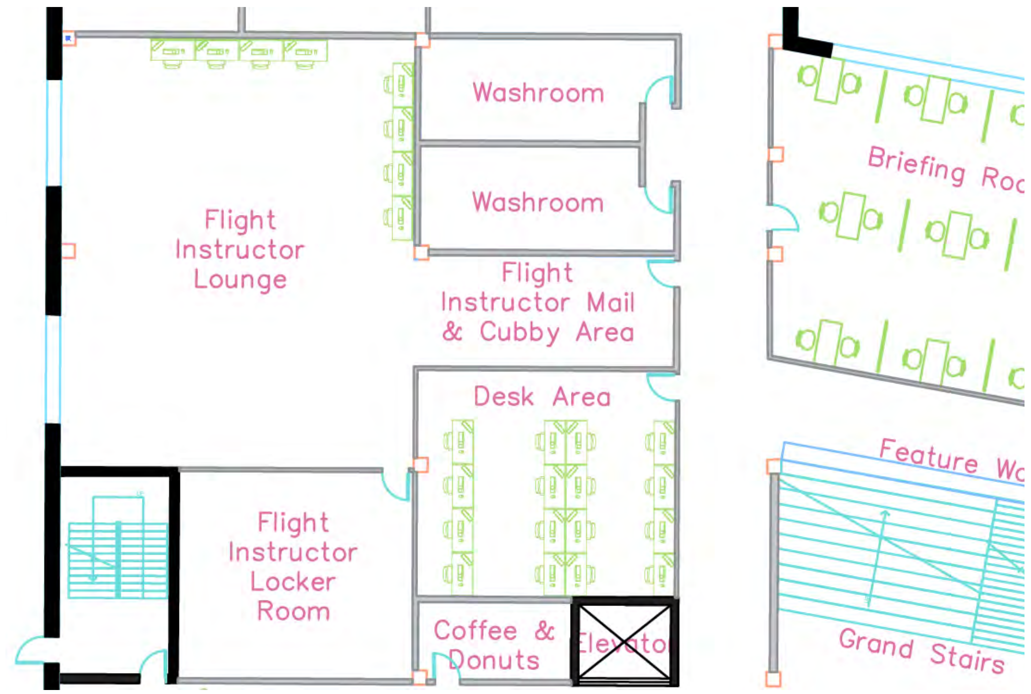
In the planning stages of the main building's programming and planning, the team toured the existing Waterloo Wellington Flight Centre and received feedback from an instructor on the existing conditions and any areas of concern. Addressing concerns for these key facility spaces was a main focus in the design process.

The dispatch area in the building is a high traffic space with students, instructors, and pilots navigating in and out throughout the day. A major focus in the layout design of the ground floor was optimizing the functionality of the dispatch area. The team completely rethought the existing dispatch space and created a layout that directs one-way flow of traffic through the area. Upon arrival, students and instructors can make their way to the briefing rooms before a lesson, pass by dispatch to exit onto the tarmac for their lesson, re-enter through a different doorway on the opposite side of dispatch after their flight, and make their way to the debriefing rooms.



Ground Floor - Dispatch Flow of Traffic

The team allocated a restaurant space for Runways Café, which acts as a gathering area for the flight school and the greater airport community. A Coffee & Donuts (C&D) and bookstore are also included as these spaces will appeal to students, staff, and visitors passing through the flight centre.



Ground Floor - Flight Instructor Area

A large space on the ground floor has been provided for flight instructor use. This space includes a designated mail area, a locker area for valuables, and a spacious lounge and workspace to accommodate all instructors passing through daily. This was specifically requested by an instructor as the current space cannot accommodate for having a majority of the flight instructors using the space at a given time.

A designated student testing room is located by the instructor lounge. The Waterloo Wellington Flight Centre currently offers a portion of the Transport Canada certification examinations and requires a proper space for testing. The large space provided may also accomodate for future growth of the flight school and additional certification examinations being offered.

The classrooms on both levels are located on the north side of the building overlooking the apron and runways (further out). This allows for instructors to utilize the view for educational purposes, while also aiming to motivate and inspire students in the classroom.

Additional Key Spaces:

- Open office spaces for administration and staff/visitors that require a quiet workspace. A board room and break room are also provided adjacent to these spaces, keeping all staff space separate from any areas that students might pass through.
- Four flight simulator rooms are provided just before reaching the office area of the floor, in a designated hallway. This locates the simulators in a quiet space away from the main flow throughout the building (separated by doors to ensure no unnecessary traffic passes through).
- Student lounges are provided on both levels of the main building. The existing flight centre does not provide space for students to spend time in outside their flight training, leading to few students spending any additional time at the flight school.
- A patio for staff and students is provided on the second floor overlooking the apron and runways

2nd Floor - Main Admin Area

DESIGN INFLUENCE

The main entrance of the flight school is a large, open atrium space with exposed timber-steel trusses, and ascending seat-stairs. In addition to welcoming occupants, the entrance is a perfect location for hostings flight school and community outreach events. A highlight of the main entrance is the scaled aircraft hung overhead. This creates a truly dramatic feature space within the flight school.

Adjacent to the atrium space is the front desk and large amphitheatre lecture hall. The front desk is centrally located to help guide students, instructors, and visitors as they enter the building. The large 120 seat amphitheatre is a key space within the flight school for teaching activites and event presentations. Continuing past the front desk leads to the flight training areas (dispatch and briefing rooms) with direct access to the tarmac. Up the acsending seat-stair is access to the teaching classrooms, rooftop patio, flight simulators, and office area. The large column grid and limited large load-bearing make for an ease of locating spaces and flow throughout the building.

The open concept plan throughout the flight centre is a must-have in order to be able to repurpose spaces as needed throughout the building's lifetime. The design offers flexibility and extends the useful life of the structure in an evolving teaching environment.

RUNWAYS CAFÉ

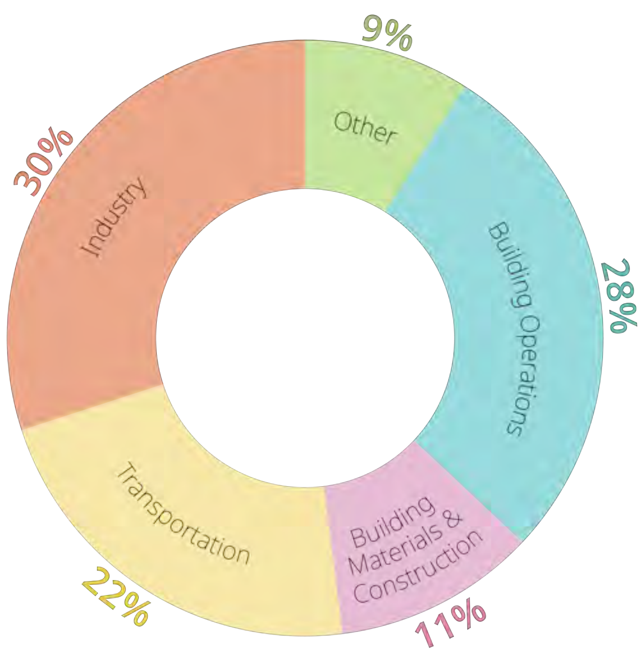
A large space in the north end of the building facing the tarmac and runways is the perfect location for the revamped Runways Café. The restaurant and lounge acts as a gathering location for students, staff, and instructors at the end of a training day but also offers a unique location for the greater aviation community to come gather, talk aviation, and watch aircraft.

The restaurant also features a large exterior patio giving patrons an up close and personal view of the flight school and greater airport activites. The patio is surrounded by a greenspace between the two arms of the building.

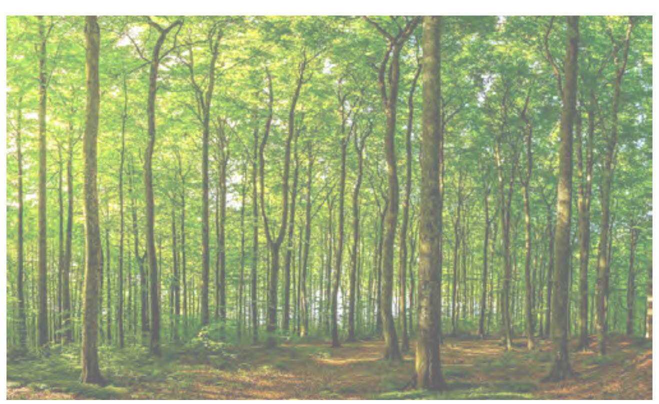
2.0 BUILDING DESIGN

STRUCTURE

Mass Timber = large structural panels, posts, and beams that are exceptionally strong and versatile, made by state-of-the-art technology which glues, nails, or dowels smaller wood products together.



Word's Energy Related Carbon Emissions



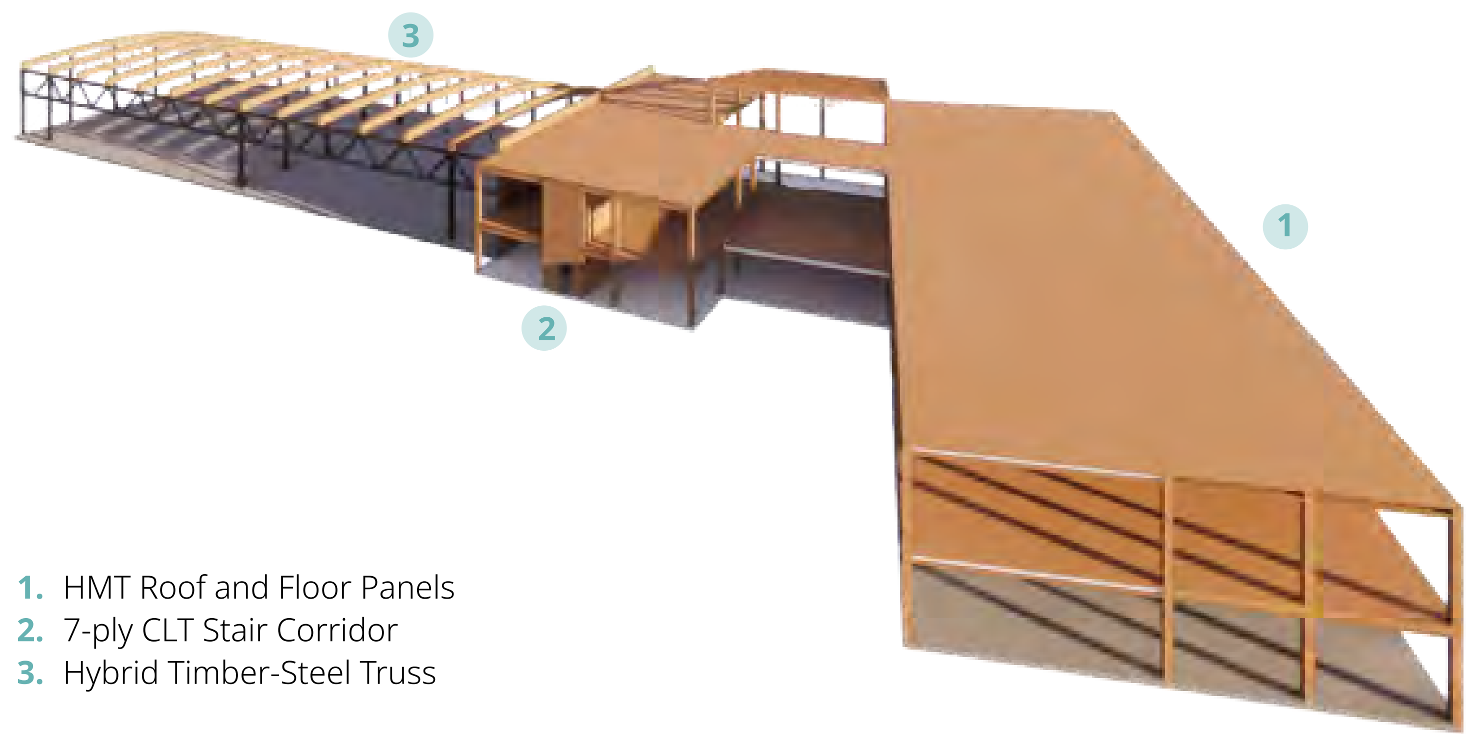
BIOPHILIA

"The innate human instinct to connect with nature and other living beings"

The operations emissions of our buildings draw a lot of focus with ever improving energy standards, however, the **emissions embodied in our materials and processes** used to construct our buildings also plays an ever-growing role. This is **addressed in our design** through:

- Utilizing low-carbon emission materials
- Choosing renewable materials
- Limiting transportation and shipping by selecting locally available materials
- Storing carbon in the structure (carbon sequestration)

Building Structural Diagram



1. HMT Roof and Floor Panels
2. 7-ply CLT Stair Corridor
3. Hybrid Timber-Steel Truss

Why Build with Mass Timber?

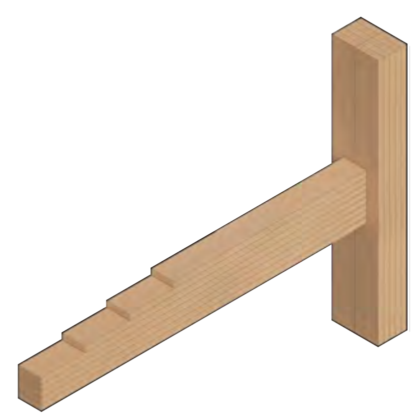
ENVIRONMENT
- Smaller carbon footprint
- Carbon sequestration (storage)
- Renewable
- More prefabrication = less waste

CONSTRUCTION
- Light weight relative to strength = smaller foundations and easier construction
- Less time on site (less disruption)
- Increased design longevity
- Quieter job site

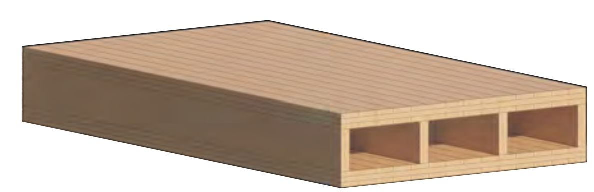
HEALTH
- Studies show exposed mass timber can aid in stress reduction
- Increased happiness
- Greater social connections

ACADEMICS
- Increased work productivity and classroom learning
- Reduced absences
- Aesthetically pleasing

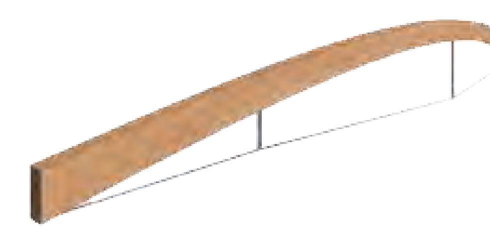
Cross-Laminated Timber (CLT)
will form load-bearing walls and prefabricated envelope



Glue-Laminated Timber (glulam)
will serve as load-bearing beams and columns



Hollowcore Mass Timber (HMT)
UWaterloo developed long span floor and roof panel



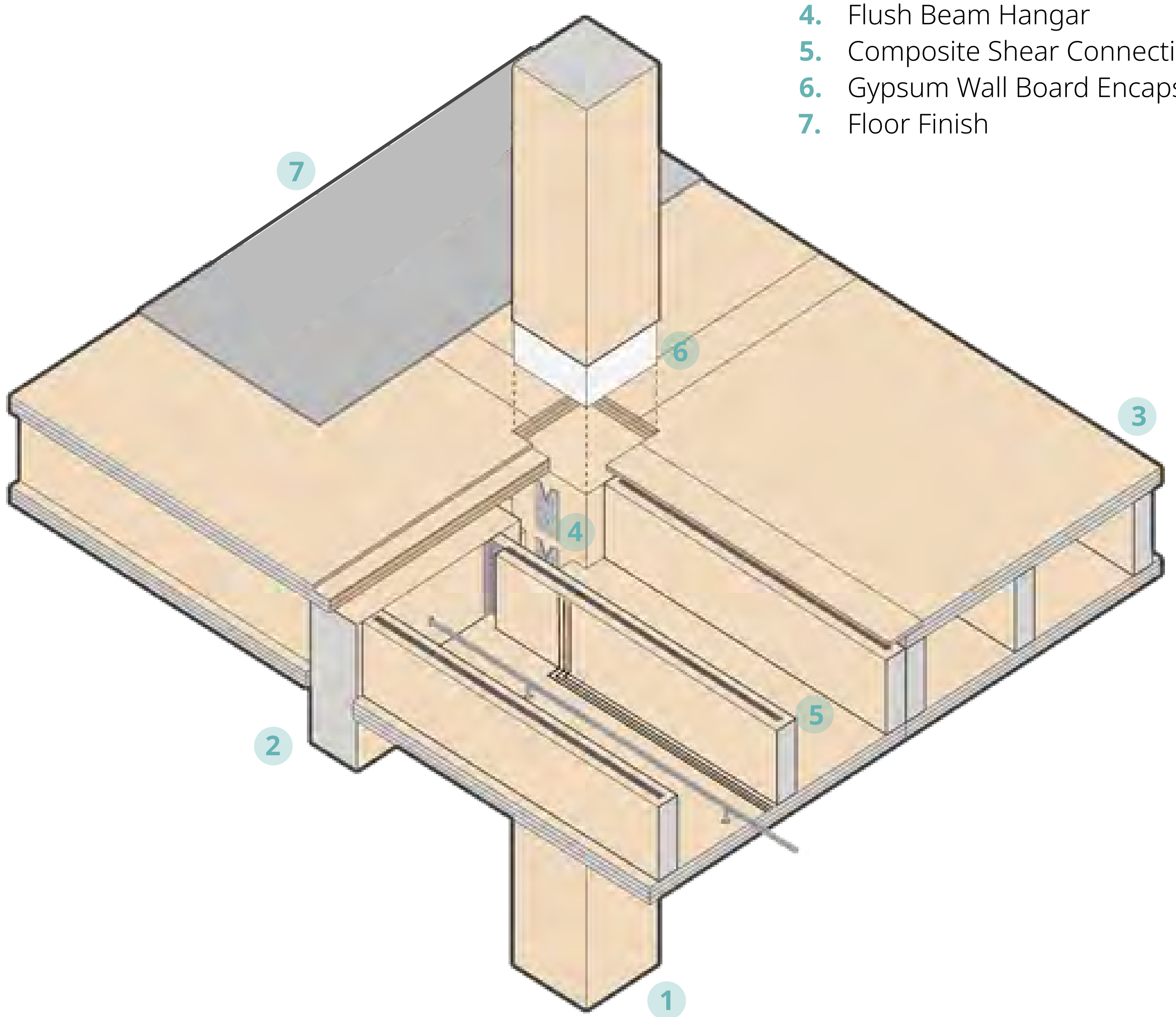
Hybrid Timber-Steel Trusses
support the roof of the hangers and large open atrium

HOLLOWCORE MASS TIMBER (HMT)

Novel wood structural system **researched and developed at the University of Waterloo** that achieves a clean ceiling in the large, open floor plan office and academic spaces, a feat not possible with current mass timber products.

HOLLOWCORE MASS TIMBER (HMT) Diagram

1. Glulam Column
2. Glulam Beam
3. Hollowcore Mass Timber Panel
4. Flush Beam Hangar
5. Composite Shear Connection
6. Gypsum Wall Board Encapsulation
7. Floor Finish



Lateral wind and seismic forces are resisted by a combination of CLT shear walls used for the stair and elevator cores, and steel tension-only X-braces. The steel X-braces supplement the already existing CLT cores, are highly materially efficent without block large portions of the exterior of the building.

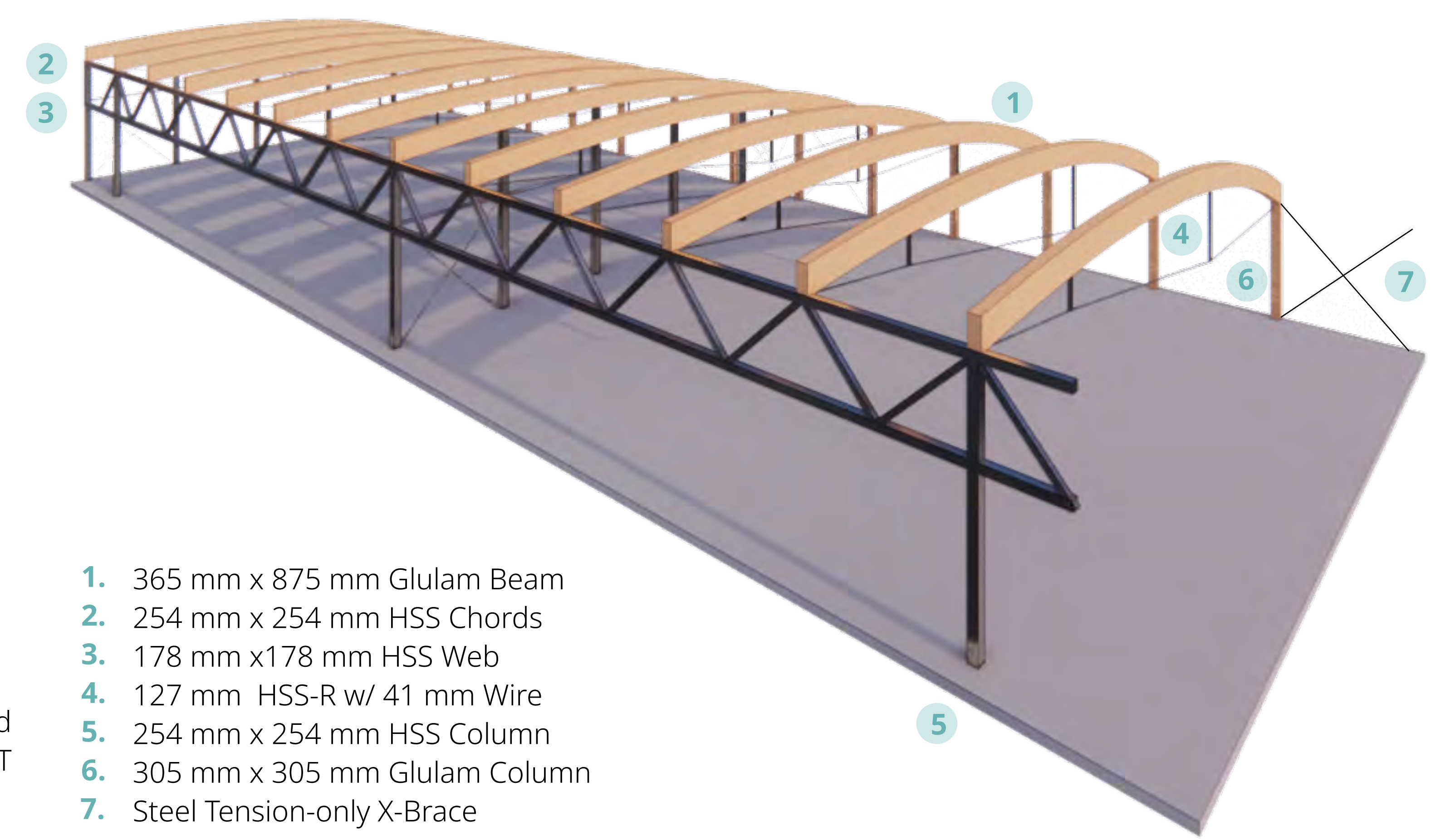
LONG SPAN CURVED TIMBER-STEEL TRUSSES

The long spans of the hangar roof posed a particular structural challenge, along with the sliding hangar doors creating a 25m (80 ft) clear span to allow for the movement of multiple aircraft. The approach for the curved timber-steel trusses drew inspiration from aircraft wings of the past.

The trusses spanning the hangar use curved glulam beams to form the wing-like shape of the hangar roof, while a post-tensioned steel cable and king posts give an open-air feel to the structure below. This structural system is a prime example of using the strengths of each material in a highly efficient way.

The truss clear spanning the hangar door is formed using steel HSS sections and designed to support the curved timber-steel trusses above, as well as a moment frame supporting lateral loads on the hangar. Overall the light-weight structure aims to emulate the aircraft it shelters.

Hangar Structural Diagram



1. 365 mm x 875 mm Glulam Beam
2. 254 mm x 254 mm HSS Chords
3. 178 mm x178 mm HSS Web
4. 127 mm HSS-R w/ 41 mm Wire
5. 254 mm x 254 mm HSS Column
6. 305 mm x 305 mm Glulam Column
7. Steel Tension-only X-Brace

3.0 SUSTAINABILITY & INNOVATION

ENERGY ANALYSIS

To achieve net-zero energy, the proposed building design must be able to, averaged over a year, generate on-site the same amount of energy as it consumes.

Using the EnergyStar Property Manager: *"Canadian Energy Use Intensity by Property Type"* technical reference, an annual energy consumption estimate was calculated based on the gross areas of the main building and heated hanger areas.

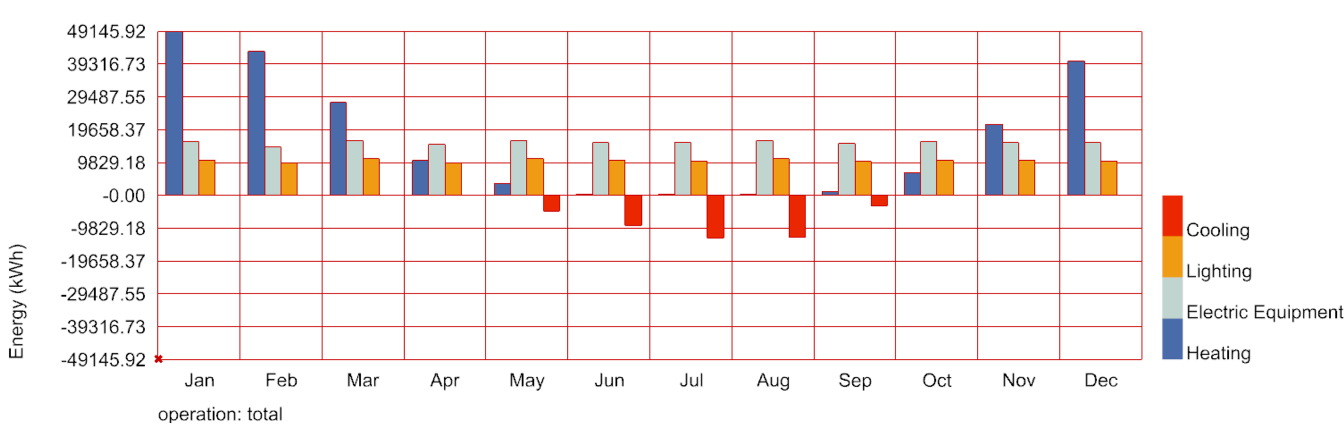
Based on the expected programming of the design, the main flight school building was classified as a 3000 m^2 *"College and University"* space while the heated hanger was classified as a 750 m^2 *"Vehicle Repair Services"* space.

The average typical building in Canada with the chosen occupancy is estimated to use 1,034,160 kWh of energy per year. Based on emperical data, a high performance building with the appropriate design strategies can reduce this value in half. In addition, the proposed design is equipped with an efficient geothermal heat pump system, reducing the heating & cooling loads to a third of a typical gas boiler system. This leads us to estimate a conservative annual 400,000 kWh energy demand.

To test this value, the building was modelled and analyzed using the EnergyPlus program. After multiple iterations, EnergyPlus predicts an estimated 415,400 kWh annual consumption

ENERGYPLUS RHINO ANALYSIS

In using a parametric energy analysis software, the team was able to optimize the building design, and ensured it could be quickly and easily adapted for locations across Canada. The results of the analysis is summarized below.



NET ZERO ENERGY DESIGN

Many of the chosen energy design strategies were derived by studying evolv1, a commercial net-zero energy building located in Waterloo, ON. Energy generation on site is primarily performed through the use of photovoltaics (PV). All PV arrays are strategically placed to be south facing to maximize energy generation. These arrays can be found on the rooftop of the main building and on standalone "Mercury" PV array structures.

To achieve net zero energy, a 403 kW solar array system consisting of 1750 m^2 of PV will be used to counter the annual 400, 000 kWh consumption. These values are consistent with the evolv1 building which has 6000 m^2 of PV, generating 850, 000 kWh of energy to service a 9000 m^2 three-story building.

Rooftop PV - 161 kW

The rooftop area of the main building supports an estimated 700 m^2 of rooftop PV arrays. The team chose to use the bifacial mono PERC PV modules from Canadian Solar Inc. which, at peak performance, are rated to be 460 W. These PV modules have the capability to generate up to 30% additional energy from back PV cells. This is ideal as both the rooftop PV arrays and parking PV structures will have exposed back surface areas.

Bifacial Mono PERC PV Modules

SITE CONDITIONS

South-facing PV arrays on the evolv1 building generate an estimated 1100 kWh annually per kW of PV. These values are used to estimate the capabilities of our design as the building shares the same regional conditions, orientation, and PV system as evolv1.

PV Array Structure - 242 kW

Mercury HelioStations are standalone PV array structures designed by the VCT Group. These structures are placed in the parking lot to generate energy while providing shelter for vehicle parking below. Additionally, these structures come equiped with EV charging stations located near the supports. An estimated 1050 m^2 of PV will be supported by these structures

HIGH PERFORMANCE ENCLOSURE

A high performance building enclosure was designed to reduce energy transfer between the conditioned interior and exterior spaces. The wall and roof assemblies are listed below according to layers from the interior to exterior conditions.

Wall Assembly - R28

- 12.7 mm Gypsum Wall Board
- 38 mm x 38 mm Wood Stud/ Service Cavity
- 105 mm 3-ply CLT (Structure)
- Blueskin SA Membrane (Air, Water, & Vapour Barrier)
- 102 mm Rockwool Insulation
- 25 mm Ventilated Air Gap/ Clipping System
- Aluminum Panel

Roof Assembly - R51

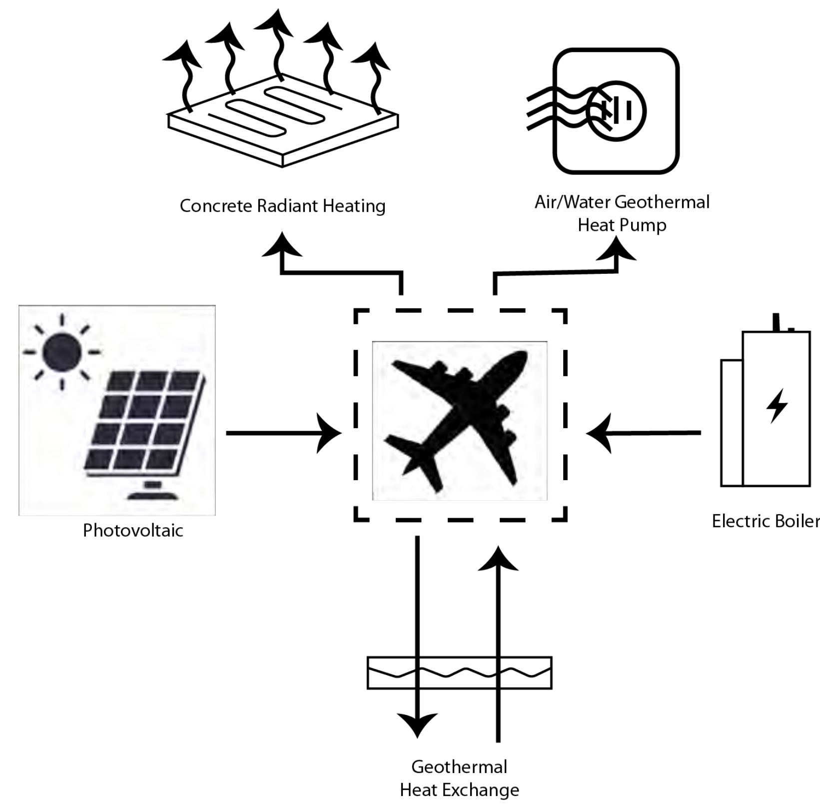
- 430 mm HMT Panel (Structure)
- Blueskin SA Membrane (Air, Water & Vapour Barrier)
- 203 mm XPS Insulation
- Filter Fabric
- 100 mm Ballast

Hangar Roof Assembly - R52

- 315 mm Roof Purlins (Structure)
- 19 mm Plywood Decking
- Blueskin SA Membrane (Air & Vapour Barrier)
- 229 mm XPS Insulation
- OSB Sheathing Screwed Through Rigid Insulation
- Building Paper (Water Barrier)
- Steel Roof Panels

In addition to having a high R-value, air tightness and continuity of control layers at joints should be prioritized. Ensuring a continuous air barrier improves building energy performance and overall building durability.

BUILDING SYSTEMS – GEOTHERMAL HEATING & COOLING



The building's mechanical design contributed greatly towards reducing the building energy demand. By incorporating the use of geothermal energy through geothermal - electric heat pump systems with heat recovery ventilators, the use of low-flow fixtures, and drain water heat-recovery mechanical systems were optimized to be more efficient, ultimately reducing the energy demand.

Electric boilers will be installed to provide supplementary heating and cooling when necessary during the year. This allows the building to remain combustion-free.

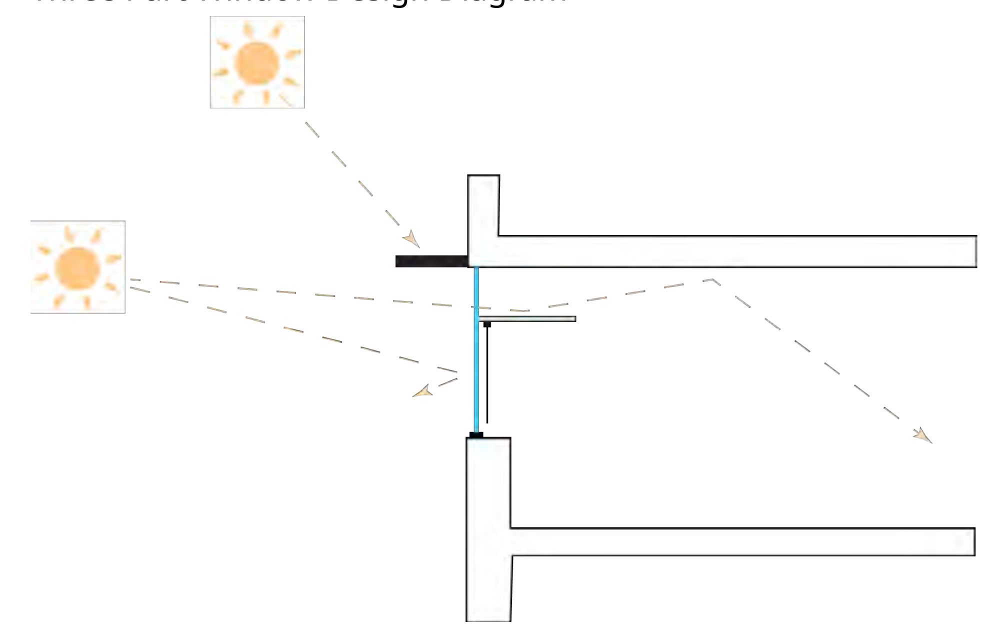
GREYWATER SYSTEM & RAINWATER COLLECTION

A flight school has significant non-potable water consumption levels from occupant uses to runway and aircraft cleaning. A greywater reuse system is integrated into the proposed Waterloo Wellington Flight Centre in order to significantly reduce the building's water consumption which will in turn, be economically and environmentally beneficial. Water can be collected and filtered from the large rooftop area above the building.

WINDOWS AND THE SUN

The final building design has an optimized window-to-wall ratio. This ratio was optimized to reduce heat loss through window systems while maximizing natural light in the building. The north face of the building features the most glazing area to bring in natural light without direct heat from the sun; while providing a number of spaces in the building with views of the apron and runways.

Three Part Window Design Diagram



Windows along the east and west faces of the building are equipped with sun shading devices that can be controlled throughout the day as the sun rises and sets

In addition, windows selected demonstrated advanced thermal performance, and contributed to overall energy savings. By making use of triple-glazed, low-e, fibre-glass casement windows, overall heating and cooling loads on the building were reduced.

LED LIGHTING

The building is equipped with an LED lighting system with sensors that can also be occupant-controlled. This allows for lighting throughout the building to be scheduled according to each space's programming and lighting requirements.

EMBODIED CARBON

Embodied carbon is the **CO2 emissions associated with materials and construction processes of a building**. It includes any emissions created during manufacturing process of building materials (material extraction, transport to manufacturer, manufacturing), the transport of those materials to the job site, and the construction practices used.

Mass timber is currently the most carbon-efficient building material for multi-storey construction. Even without considering carbon sequestration, prioritizing more mass timber would result in a significant drop in avoided carbon emissions [Mantle Developments].

The total carbon offset can be used to **balance other emitting project items** such as; cladding, interior partitions, insulation, finishes, and parking lot and tarmac construction. **Other solutions** to reduce the project's carbon footprint not captured in the carbon analysis:

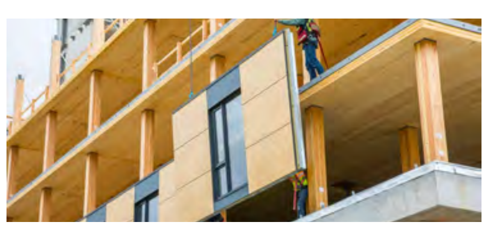
CarbonCure (injection of captured CO2 into fresh concrete)

CARBON CURE™

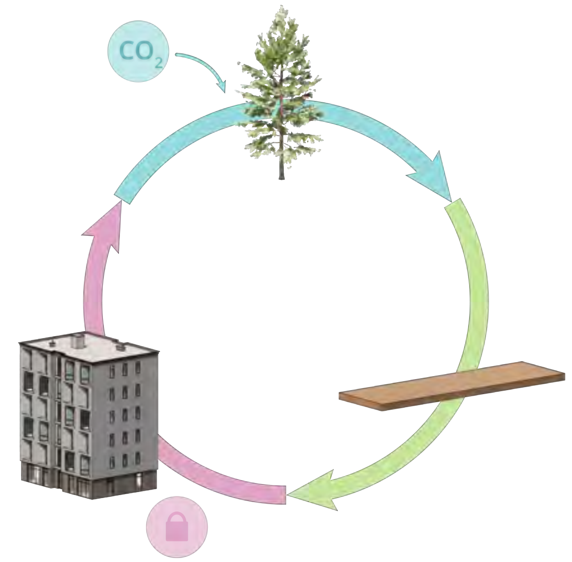
Choosing **locally sourced** material procedures

ELEMENT5 MASS TIMBER STRUCTURES

Prefabrication reduces time on site and material waste



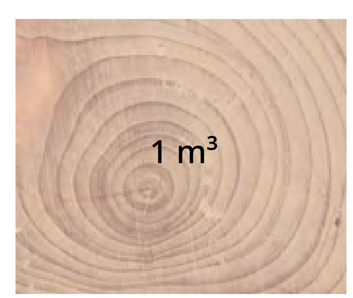
Recycled Aggregate materials



1125 m³ of wood is equivalent to:

- **300 cars** off the road for a year
- **165 houses**' energy for a year
- **4 minutes** U.S. and Canadian forests to grow this amount of wood

Wood, when harvested from sustainably managed forests, is **one of the only renewable construction materials**, with the added benefit of absorbing and storing carbon dioxide during its growth (**carbon sequestration**) . Incorporating more of it into structures can contribute to a reduction in global emissions when compared to other construction materials.



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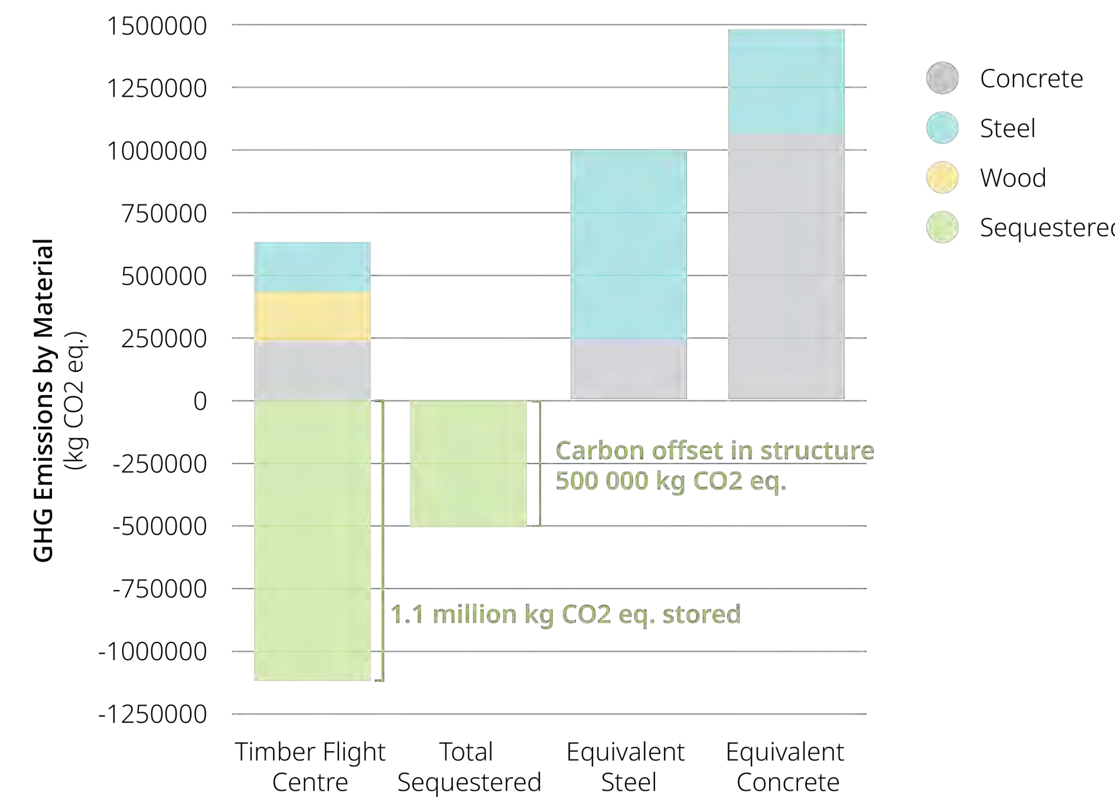
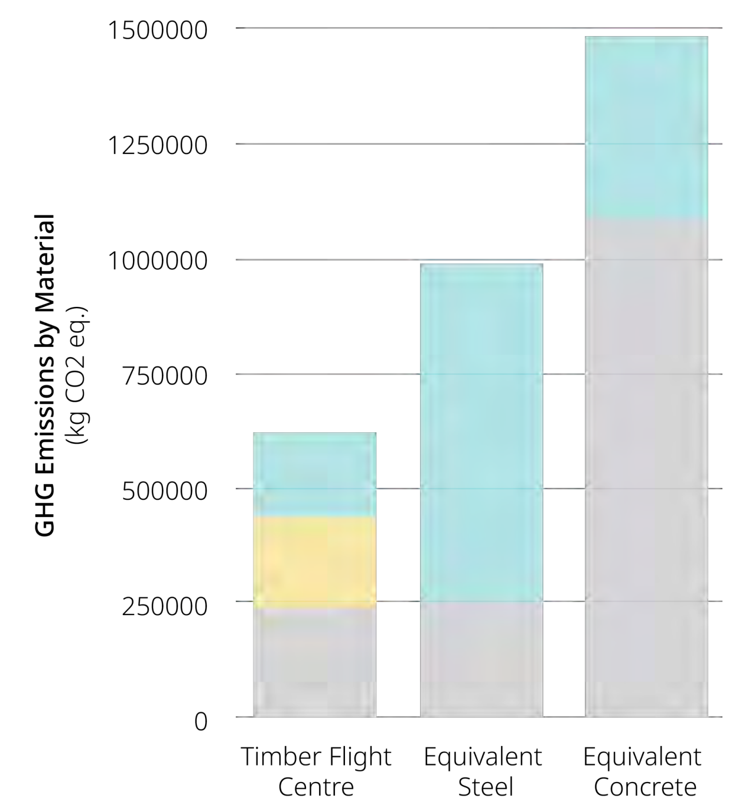
1 metric ton CO_2*

**Canadian Wood Council - Carbon Calculator*



Carbon Analysis of Structure Materials
(including sequestered carbon)



Carbon Analysis of Structure Materials