The Benefits of Mass Timber Workforce Communities

A Study for Northwestern Mining Workforce Communities

Prepared for Thunder Bay Community Economic Development Commission

Authored by Studio VMA Inc.

in consultation with, Element 5, Introba, Hanscomb, Relay Development & Ontario Wood WORKS!

September 11, 2023

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THUNDER BAY CEDC COMMUNITY ECONOMIC DEVELOPMENT COMMISSION

CRIBE centre for research & innovation in the bio-economy

Birds eye view of the proposed mass timber Living Quarter dormatory with optional porch and solar panels.
The living quarters are connected by an internal Arctic Corridor to protect workers from harsh winters.

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Conceptional street elevation, mass timber Living Quarter dormatory with optional porch and solar panels.

Executive Summary

Introduction

Northwestern Ontario, including the City of Thunder Bay, is poised to seize a significant regional economic development opportunity in the mineral exploration and mining sector. With a focus on gold, palladium, nickel, copper, platinum, graphite, chromite, iron, and lithium, the region boasts six operating mines and 15 exploration projects that are set to become producing mines in the next decade. The global demand for these minerals, such as cobalt, copper, nickel, uranium, lithium, and platinum group metals, has increased due to their essential role in various technologies, including smartphones, electric vehicle batteries, and clean tech industries.

In response to the imminent surge in mineral exploration and processing, the Thunder Bay Community Economic Development Commission (CEDC) took proactive steps by conducting a comprehensive Mining Readiness Strategy in 2021. This strategic study served as the foundation for the 2023-2025 Strategic Action Plan, encompassing ambitious goals to propel the region of Thunder Bay into a leading position in the global mining and forest products services, supply, and manufacturing sectors. To achieve this vision, the CEDC is committed to attracting, integrating, and retaining a highly skilled workforce, with a focus on engaging youth, national and global immigrants, and regional Indigenous communities. Moreover, CEDC aims to foster a safe, welcoming community that offers its residents comprehensive healthcare, education, and abundant employment opportunities while maintaining an affordable, high-quality lifestyle.

Objective

The objective of this study is to assess the advantages of employing Mass Timber, with a particular focus on Cross-Laminated Timber (CLT), as a solution for the infrastructure challenges faced by communities engaged in the mining sector. This initiative complements CEDC's overarching 2023-2025 Strategic Action Plan and the Mining Readiness Strategy, aiming to position the region as a hub for both environmental stewardship and economic vitality in the mining industry. Critical factors underpinning this study include the long-term durability of Mass Timber structures, the health and well-being of community members, enhancing workforce stability, reducing carbon emissions, and bolstering Canada's bioeconomy.

Design Strategy Statement:

This design strategy is committed to illustrating the multifaceted benefits of employing Mass Timber in the construction of workforce communities and mining camps, with a particular focus on the environmental, health, and economic implications. Central to this effort is the introduction of a prototype design for modular Mass Timber living quarters and auxiliary structures, specifically engineered for the unique demands of future mining communities in Canada's northern regions.

By rigorously evaluating financial feasibility and embodied carbon metrics, we aim to present a compelling case for Mass Timber as a cornerstone of sustainable and fiscally responsible development. We intend to demonstrate how this innovative construction material can dovetail with Canada's bioeconomy, advocating for judicious resource management while nurturing prosperous, resilient communities.

Key Design Focus Areas:

- **Long-term Durability and Low Maintenance:** Our prototype leverages the intrinsic strengths of Mass Timber to provide structures that can withstand the test of time and elements, reducing the need for frequent maintenance.
- **Superior Construction Quality:** The design incorporates high thermal performance features that not only diminish energy consumption but also substantially improve the comfort of occupants, a critical consideration in the harsh climatic conditions of Canada's north.
- **Remote Location Adaptability:** Utilizing a modular construction approach, the design optimally addresses the unique logistical challenges posed by remote locations, thereby streamlining the transportation of materials and labor.
- **Health, Wellness, and Workforce Retention:** By incorporating design elements that focus on the well-being of residents, the proposed structures aim to contribute positively to both individual health and broader community retention rates.
- **Resource Efficiency and Circular Economy:** The kit-of-parts design strategy accentuates the importance of long-term resilience. It aims for adaptability and flexibility, enabling the reuse and relocation of modular units in line with circular economy principles. This approach not only minimizes waste but also maximizes resource utilization, thus laying the groundwork for both resilient and environmentally responsible construction practices.

Climate change is an urgent crisis that affects every aspect of our world, from environmental stability to economic, social, and cultural systems.

With buildings and the construction industry being significant contributors to greenhouse gas emissions, our actions in this sector hold the key to mitigating the impacts of climate change.

As we strive to create regenerative cities and foster healthy communities, embracing low-carbon building materials and construction methodologies becomes imperative.

Veronica Madonna

Key Findings

Environmental Impact
- Mass Timber buildings show a significant reduction in Global Warming Potential (GWP) over a 30-year span compared to traditional building methods.
- When considering life expectancy, Mass Timber buildings emit effectively half the carbon compared to baseline structures, contributing to net-zero carbon goals.

Economic Benefits
- Mass Timber's intrinsic long-term salvage value outperforms that of conventional light frame construction. The innate long-term salvage worth of Mass Timber surpasses that of traditional light frame structures. This is further reinforced by its more enduring and resilient structural system, capable of multiple relocations without degradation.
- The use of Mass Timber aligns with the region's ambition to be a frontrunner in sustainable economic development, specifically by enriching the bioeconomy.

Social Advantages
- Mass Timber buildings offer robust, long-lasting housing solutions that can improve the quality of life for remote, northern workforce communities.
- Crafted for seamless disassembly, these structures can be repurposed, offering flexibility in community planning and adaptability to changing population dynamics.

Technological Innovations
- The units feature plug-and-play mechanical and electrical systems, which facilitate maintenance and adaptability.
- Modular Mass Timber construction is particularly suited for remote locations, as they can be easily relocated without compromising structural integrity.

Recommendations

Mass Timber holds significant promise as a sustainable, economically viable, and socially responsible building material for Northwestern Ontario's mining sector. Its adoption is crucial for Thunder Bay to realize its vision of becoming a global leader in sustainable economic growth while offering a high quality of life for all residents within workforce communities.

- **Promote Mass Timber:** Engage key stakeholders from the mining and forestry sectors to drive the adoption of Mass Timber for new infrastructure projects.
- **Invest in Research:** Allocate resources for further studies to quantify the health and well-being benefits that Mass Timber buildings offer over conventional structures. As well as invest in modular building prototyping.
- **Collaborate:** Foster partnerships between public and private sectors to accelerate the development of Mass Timber technologies and methods.
- **Policy Support:** Implement favorable policies to encourage the use of Mass Timber, considering its positive impacts on carbon reduction, economic growth, and community well-being.
- **Adopt a Life-Cycle Approach:** Emphasize the long-term economic and environmental benefits of Mass Timber over traditional building materials in decision-making processes.

Acknowledgements

We would like to express our sincere appreciation to the Thunder Bay Community Economic Development Commission (CEDC) and the Centre for Research and Innovation in the Bio-Economy (CRIBE).

We are grateful to all the direct and indirect contributors to this research for their time, expertise, and commitment to advancing sustainable and responsible development in Canada's northern communities. Thank you all for making this study not just possible, but profoundly impactful.

The Thunder Bay Community Economic Development Commission (CEDC) is an organization dedicated to promoting economic growth, development, and diversification in the city of Thunder Bay, located in Northwestern Ontario, Canada. The CEDC works to attract investment, support local businesses, and create job opportunities to enhance the economic well-being of the community.

The Centre for Research and Innovation in the Bio-Economy, CRIBE, is an independent, not-for-profit corporation that works to support and develop a sustainable, profitable forest bio-economy in Ontario.

From the forest to consumer products, the forest bio-economy encompasses all innovative, low-carbon materials derived from sustainably sourced forest biomass, and the supply chains that serve to produce those materials

CRIBE brings together researchers, the forest sector, and end users to create and commercialize innovative forest-based, low-carbon solutions. Since 2009, CRIBE has deployed more than $30 million in innovation funding, built the thriving Nextfor collaboration network of bio-economy stakeholders, and developed the Forest EDGE: the first-of-its-kind Forest Economic Development Geospatial Engine.

Sustainable Synergy

The Interplay of Forestry and Mining in Northern Ontario, Canada

The bioeconomy plays a crucial role in Canada's sustainable economic development and environmental stewardship. It encompasses the production and utilization of renewable biological resources, such as agricultural crops, forestry products, and waste streams, to create a wide range of goods and services. Embracing the bioeconomy is essential for Canada as it fosters innovation, promotes the development of green technologies, and supports the transition towards a low-carbon, circular economy. By leveraging its abundant natural resources and investing in research and development, Canada can harness the potential of the bioeconomy to drive economic growth, create jobs, and reduce greenhouse gas emissions, contributing to a more resilient and sustainable future.

In Northern Ontario, Canada, the relationship between forestry and mining is significant and interconnected due to the region's rich natural resources. Both industries are major contributors to the region's economy and have historically played vital roles in shaping its development.

Forestry is a longstanding pillar of the economy in Northern Ontario. The region is abundant in vast forests, making it one of the primary forestry hubs in Canada. The forestry sector supports various industries, including lumber, pulp and paper, and biomass energy production. It creates employment opportunities for local communities and drives economic growth in the region.

On the other hand, mining is another crucial industry in Northern Ontario, driven by the region's vast mineral resources. The area is renowned for its deposits of gold, nickel, copper, and other valuable minerals. The mining sector is a significant employer and contributes significantly to the region's export revenues and economic prosperity.

The relationship between these industries is intertwined in several ways. Both forestry and mining operations often require access to large tracts of land, leading to potential overlaps and shared land-use considerations. For instance, exploration activities related to mining may impact or require coordination with existing forestry operations, and vice versa. Managing land use sustainably and minimizing environmental impacts are essential goals for both industries.

Moreover, the two sectors can also complement each other economically. The demand for timber and wood products from the forestry sector may support the construction and infrastructure needs of the mining industry. Conversely, the mining sector's demand for various goods and services may provide economic opportunities for forestry-related businesses.

However, it is crucial to balance the activities of both industries to ensure sustainable development and protect the region's natural resources. Collaboration between stakeholders, including governments, industry players, and local communities, is essential to strike a harmonious balance that maximizes economic benefits while preserving the environment and the cultural heritage of Northern Ontario. Through careful planning, responsible resource management, and cooperation, the relationship between forestry and mining in Northern Ontario can continue to contribute positively to the region's economic growth and environmental well-being.

This report aims to highlight the environmental and health benefits of using mass timber for the development of workforce communities and mining camps while showcasing opportunities for modular construction to manage remote northern communities with durable construction and long-term value. Additionally, it will present a prototype design of a modular mass timber living quarter and support buildings tailored for a future anticipated mining community. The report will access the financial feasibility and embodied carbon accounting.

Moreover, it will emphasize that this innovative approach can serve as a model for sustainable and healthy development in Canada's north, establishing a strong relationship with Canada's bioeconomy and promoting responsible resource utilization while fostering thriving and resilient communities.

Building a Sustainable Future: The Vital Role of Mass Timber and Modular Construction for Mining Camps in Northwest Ontario

The importance of incorporating mass timber and modular construction, alongside prioritizing health and wellness, climate change mitigation, and carbon reduction, cannot be overstated for mining camps in Northwest Ontario. Embracing sustainable and innovative construction methods like mass timber and modular construction can significantly reduce the environmental impact of mining camp development by utilizing renewable and locally sourced materials while promoting faster and more efficient construction processes. Additionally, investing in the health and wellness of the workforce is essential to ensure a safe and productive work environment, leading to increased job satisfaction and retention. Considering the mining industry's significant carbon footprint, addressing climate change and implementing carbon reduction strategies becomes paramount to aligning operations with global sustainability goals. By holistically integrating these elements, mining camps in Northwest Ontario can spearhead responsible development practices that uphold environmental stewardship, employee well-being, and a more sustainable future.

Advancing Sustainability in Remote Mining Camps: The Transformative Potential of Mass Timber Modular Construction

Mass timber modular buildings bring multiple positive impacts to mining camps in Northwest Ontario. First, they enhance health and wellness by improving indoor air quality and providing a more comfortable living and working environment. Second, mass timber aids in climate change mitigation by sequestering carbon dioxide, reducing carbon emissions compared to traditional building materials. Third, modular construction decreases energy consumption and waste generation, resulting in significant carbon reduction. Additionally, the efficiency of off-site manufacturing allows for faster construction in remote areas, like Northwest Ontario. The warm and inviting aesthetics of mass timber contribute to occupants' well-being and morale. By embracing this sustainable solution, mining camps can prioritize health, environmental stewardship, and climate action, while creating pleasant and efficient living and working spaces.

The Thriving Hub of Mining and Exploration in Northwestern Ontario

As a pivotal hub for regional exploration, the mining industry holds a prominent position in Thunder Bay's economy and workforce. An estimated 850 people living in Thunder Bay and surrounding areas are directly employed in mining jobs, covering a wide range of roles from engineers and geologists to technicians and administrative staff. This not only contributes to local employment but also brings skilled workers into the community.

In addition to the people directly involved in mining, Thunder Bay is home to approximately 500 mining service and supply companies. These companies offer a spectrum of services including exploration, drilling, logistical support, and equipment supply, creating a robust support ecosystem for the mining sector. The presence of these service and supply companies also means that mining operations can function more efficiently and effectively, further driving the economic importance of this sector to the region.

In recent years, new discoveries, and a strong metals market, have driven interest in exploration and mining in Northwestern Ontario.

Legend

- ● Key Towns in NW Ontario
- First Nations Communities
- Major Exploration Project
- Producing Mine
- Numbered Hwys

Major Exploration Projects

Map #	Project Name
1	Albany Graphite Deposit
2	Bateman
3	Bending Lake Iron
4	Black Thor
5	Blackbird Chromite
6	Brookbank
7	Cameron Lake
8	Dixie
9	Dona Lake
10	Eagle s Nest
11	Georgia Lake
12	Goldlund
13	Goliath
14	Great Lakes Nickel
15	Hammond Reef
16	Greenstone Mine
17	Hasaga
18	Huronian
19	Junior Lake
20	Koper Lake
21	Marathon PGM
22	Moss Lake
23	Northmet
24	PAK-Spark
25	Pickle Crow
26	Root Lake
27	Separation Rapids
28	Seymour Lake
29	Springpole
30	Sunday Lake
31	Thierry
32	Thunder Bay North
33	Wabassi Project
34	Western Lake St. Joseph
35	Winston Lake Mine
36	Ishkoday Property
37	Pickle Lake Gold Project
38	Kenbridge Ni-Cu Deposit

Reference data from Land Information Ontario and Ministry of Energy Northern Development and Mines.
Projection: NAD83 UTM Zone 16N
Map by D Thomson
January 20, 2023

Mining in Northwestern Ontario

The Vision

Enriching Environments, Designing for Regeneration

Focused on workforce communities and mining camps, the use of mass timber in building construction holds the potential for a multifaceted impact encompassing social, economic, environmental, and cultural benefits. This sustainable and innovative approach addresses a wide range of societal needs, making it a valuable consideration for addressing the challenges in these specific contexts. The report is anchored in a comprehensive value system and vision that seeks to optimize the positive outcomes of mass timber utilization, contributing to the well-being of communities, fostering economic growth, preserving the environment, and respecting cultural heritage. For Studio VMA, we believe in the power of design and the ability to make positive impact on these critical and interrelated.

Encouraging Health and Wellness to Support Employment Retention

The incorporation of mass timber in the development of mining camps presents significant opportunities for enhancing health and wellness among the workforce. Mass timber buildings offer several key advantages that contribute to a healthier and more conducive living and working environment. First and foremost, the use of natural wood materials contributes to improved indoor air quality, as wood has the inherent ability to regulate humidity and reduce the presence of indoor air pollutants. This cleaner and fresher indoor air fosters better respiratory health and overall well-being for the camp's occupants. Additionally, the warm and inviting aesthetic of mass timber creates a calming atmosphere, promoting mental wellness and reducing stress levels among the workers. The biophilic design elements of wood also foster a connection to nature, which has been proven to positively impact psychological health and productivity. Furthermore, the acoustic properties of mass timber minimize noise pollution within the camp, creating quieter and more peaceful living spaces. By prioritizing health and wellness using mass timber, mining camps can create environments that support the physical and mental health of their workforce, leading to improved job satisfaction, retention, and overall productivity.

Addressing the Climate Emergency

With buildings contributing over 40% of the global greenhouse gas emissions, it is more critical than ever that we address zero carbon emissions in every building design. With wood's amazing ability to sequester carbon and grow naturally from the sun's power, significant impacts can be made in reducing embodied carbon. Coupled with passive and efficient design, wood holistically addresses carbon and is the future of design. Studio VMA and the Project Team bring extensive experience designing Mass Timber and Net Zero Carbon buildings that take a passive first approach moving architecture beyond sustainability and designing for regeneration.

Designed for Cost Effectiveness and Functionality

In designing workforce and mining camps, we place a strong emphasis on optimizing systems to achieve both short-term cost-effectiveness and long-term value. Our approach is guided by a comprehensive understanding of the specific needs and challenges of these environments. We carefully assess and integrate efficient infrastructure, utilities, and facilities that minimize operational costs while maximizing functionality and productivity. By strategically considering long-term value, we aim to create enduring solutions that not only meet the immediate needs of the camp but also offer longevity and adaptability. Our focus on optimizing systems ensures that the camp operates efficiently, with reduced energy consumption and maintenance costs. Simultaneously, we prioritize durable construction and quality materials to ensure the infrastructure stands the test of time, maximizing the overall value and return on investment for our clients. By combining cost-effectiveness and functionality with a long-term perspective, our design solutions empower workforce and mining camps to thrive sustainably and efficiently for years to come.

Building upon Canadian Traditions and Values

As Canadians, wood has a long tradition in many communities and is part of our national and cultural identity. With a rich history in many Canadian towns, wood embodies our national and cultural identity, evoking a sense of pride and belonging among community members. Introducing mass timber and prefabrication takes this sense of heritage to new heights, presenting workforce communities with innovative solutions that prioritize durability and sustainability. By connecting tradition with cutting-edge approaches, we create environments that not only endure but also empower the workforce to thrive. This holistic approach fosters a genuine sense of connection and cultural heritage, instilling a strong sense of purpose and pride within the community. Together, we build a future that honors our past, supports a sustainable workforce, and celebrates the unique essence of Canadian tradition in the heart of every community member.

Building for Durability, Long-Term Value and Resiliency

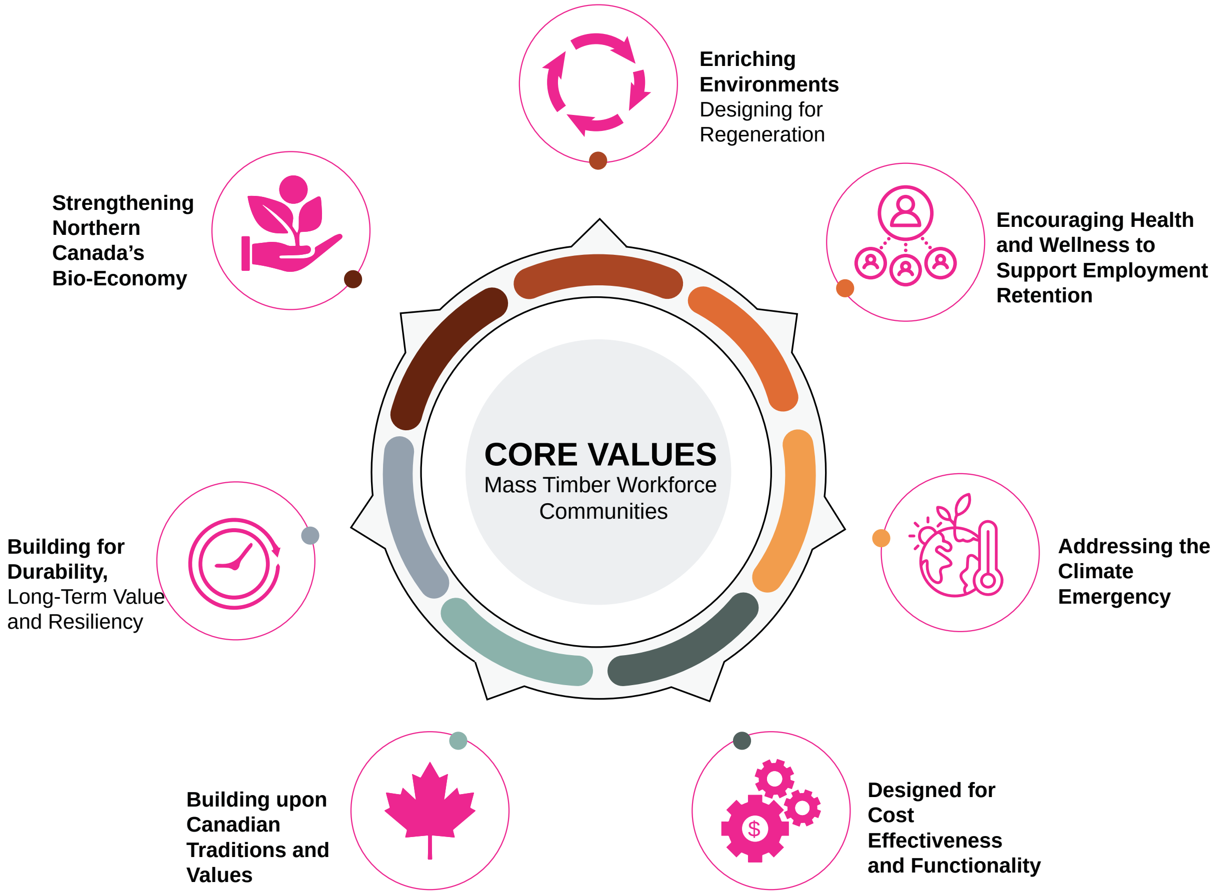
In designing for durability and long-term value in workforce communities and mining camps, we acknowledge the unique challenges posed by harsh climates and conditions. Our goal is to provide a comprehensive design solution that meets the specific needs of these environments. This entails creating infrastructure that is not only durable and robust but also allows for the flexibility and movability of structures to adapt to changing requirements. Our emphasis on high performance ensures reduced energy costs and increased comfort for the users, resulting in long-term social, environmental, and economic value. By prioritizing these key elements, we aim to deliver lasting and sustainable solutions that optimize the overall well-being of the workforce, support efficient operations, and contribute to the resilience and success of the mining camp or community for years to come.

Strengthening Northern Canada's Bio-Economy

Empowering Northern Canada's bioeconomy, we embrace the transformative potential of mass timber. Through innovative and sustainable design practices, the abundant wood resources of the region become a catalyst for economic growth, environmental sustainability, and social well-being. With mass timber at the forefront of construction, vibrant communities, and resilient industries flourish, harmonizing with nature's gifts. Our approach honors Northern Canada's cultural heritage, advocates for responsible resource management, and leaves an enduring legacy of prosperity for future generations.

Addressing Building Challenges of Northern Communities

Building in Northern Ontario presents unique challenges due to its remote and often harsh environment. Harsh winters, limited access to resources, and challenging transportation logistics can hinder construction timelines and increase costs. Additionally, the region's expansive geography poses difficulties in coordinating and delivering construction materials and equipment. The need for durable structures that can withstand extreme weather conditions adds complexity to design and construction. Moreover, addressing the specific needs of Indigenous communities and respecting their cultural and environmental concerns further contributes to the intricacies of building in Northern Ontario.



Methodology

This study offers a comprehensive investigation into the utilization of prefabricated modular mass timber structures tailored for workforce communities, particularly mining camps situated in northwestern Ontario. Through a thorough research analysis and extensive design exploration, the study delves into various aspects of this approach. The outcomes encompass a comprehensive cost evaluation and a carbon footprint assessment, alongside a detailed strategy for design implementation.

It is important to note that the study's scope was limited to a high-level program outline and a general overview of the site location. Unfortunately, specific details pertaining to the actual site, including geotechnical and topographic information, were not provided. As a result, the study does not encompass the aspects related to site and foundation development. Despite this limitation, the study serves as a valuable resource in shedding light on the potential benefits and challenges associated with employing prefabricated modular mass timber structures for workforce communities, with a particular focus on mining camps in the unique context of northwestern Ontario.

The results illustrated in this study are very much the collaboration work by all team members. The project team included Studio VMA Inc as lead Architect, Element 5 as mass timber design and structural engineering, Introba as mechanical and electrical engineering, Hanscomb as building cost analysis and Ontario WoodWORKS! and Relay Development in advising.

The team members are experienced in mass timber building design. All efforts were taken to ensure a sound concept design; however, this design should be seen as high-level, and the cost and carbon analysis results from the process. The design limits are according to the project team, information, and time frame available. The information provided in this report should be seen for informational purposes. It should not be treated as a substitute for schematic design or a thorough design process. In no event shall Studio VMA Inc. or their consultants be held liable for the work described within this report. Work within this report is the creative property of Studio VMA.

Mass timber and low-carbon design solutions in building design are rapidly evolving in Canada. Due to the constantly changing nature of this topic, primarily related to building codes in various jurisdictions, all information in this report should be independently verified through the local Authorities Having Jurisdiction (AHJ).

The Team

This case study project could not have been possible without our team's dedication and interdisciplinary collaboration –

Studio VMA Inc.

Studio VMA is a licensed architectural practice, and design collaborative focused on addressing environmental and human health issues through low-carbon design principles. Studio VMA is an industry expert in mass timber and low carbon design with experience in various building types, including educational buildings, multi-unit residential and mixed-use, housing and more. In 2021, Studio VMA, in collaboration with Ontario WoodWORKS!, completed the Canadian Guide to Mid-Rise Wood Construction, providing the industry with a framework of fundamental principles to optimize the success of mass timber construction.

Element 5

Element5 is a dedicated team of designers, craftspeople and assembly experts specializing in modern timber building design, fabrication, and assembly. They are currently Ontario's only manufacturer of mass timber products and their years of experience in fabricating and installing these highly innovative systems. For the feasibility study, Element5 will provide the structural engineering services for the mass timber system.

Ontario Wood WORKS!

Wood WORKS! is an industry-led Canadian Wood Council program that is intended to help increase the use of wood in non-residential, mid-rise and tall building markets in Canada. The initiative seeks to build proficiency in using wood through training, networking, and direct technical support.

Introba

Introba is one of the world's largest building engineering and consulting firms with more than 1,000 employees in offices across the United States, Canada, the United Kingdom, Serbia, and Australia. Committed to reshaping the world, Introba's problem solvers combine cutting-edge digital solutions with emerging innovations and industry-leading sustainability strategies to transform the built environment.

Relay Development

Relay Development are a team of engineers, developers, and builders that are rethinking how we design and assemble buildings. They specialize in the utilization of mass timber and prefabrication to deliver higher quality sustainable projects faster than conventional construction.

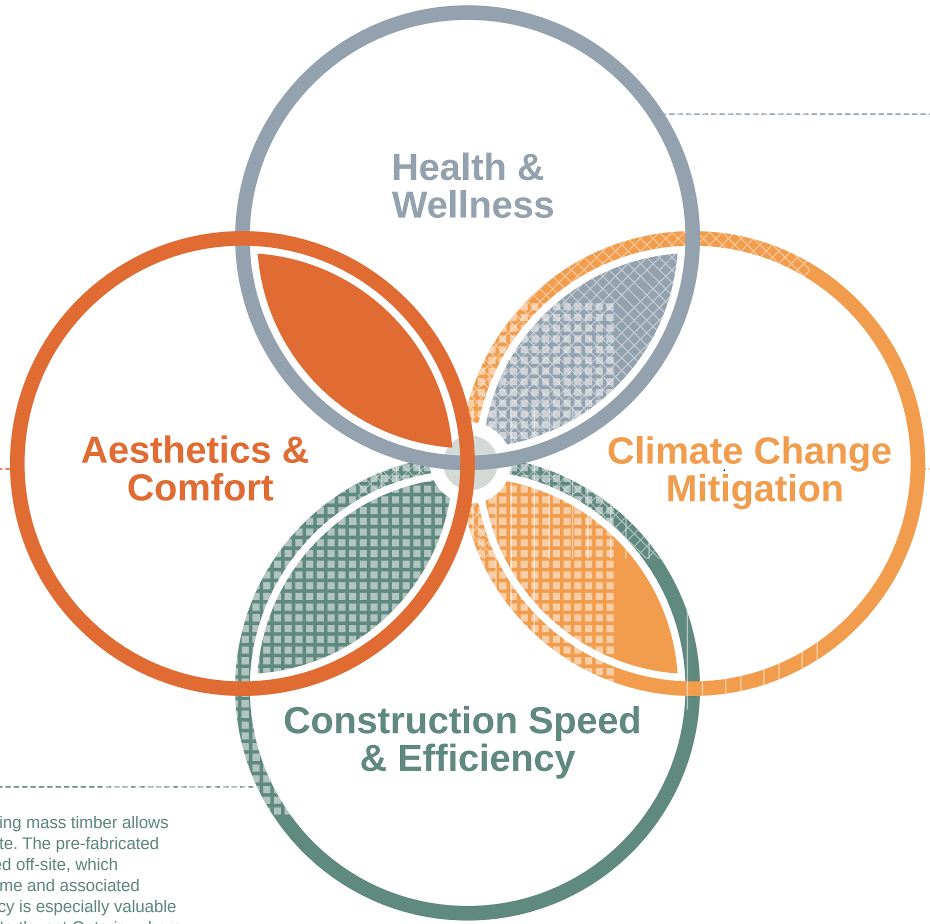
Hanscomb

Hanscomb is a nationwide firm of Quantity Surveyors and Cost Consultants. The strength they add to projects comes from our experience, expertise and dedication of our people and worldwide associates to provide clients with defensible cost data and strategies for moving their project(s) forward.

What is Mass Timber?

Advantages of Mass Timber Modular Construction

- Health & Wellness
- Aesthetics & Comfort
- Construction Speed & Efficiency
- Climate Change Mitigation



Mass timber has been shown to contribute to a healthier indoor environment. The use of natural wood materials in construction can improve air quality, as wood has the ability to regulate humidity and reduce the risk of indoor air pollutants. This creates a more comfortable and healthy living and working environment for the mining camp's occupants, promoting better physical and mental well-being.

Mass timber offers a warm and natural aesthetic that contributes to the well-being and morale of the mining camp's occupants. The use of wood in the interior spaces can create a calming and inviting atmosphere, promoting mental wellness and positive employee experiences.

Mass timber is a sustainable building material that sequesters carbon dioxide from the atmosphere. Trees absorb CO2 during their growth, and when used in construction, the carbon remains stored in the wood products, effectively reducing carbon emissions associated with traditional building materials like concrete and steel. Choosing mass timber for construction in mining camps helps to mitigate the camp's carbon footprint and contribute to the region's efforts to combat climate change.

Modular construction using mass timber allows for faster assembly on-site. The pre-fabricated components are produced off-site, which minimizes construction time and associated energy use. This efficiency is especially valuable in remote locations like Northwest Ontario, where harsh weather conditions and limited access to resources can pose construction challenges.

What is Mass Timber

Mass timber uses state-of-the-art technology to glue, nail, or dowel wood products together in layers. The results are large structural panels, posts, and beams. These exceptionally strong and versatile products are known as mass timber.

Mass timber products are solid, structural load-bearing components such as columns, beams, and panels. They are typically manufactured off-site in factories by fastening multiple layers of wood together with glue, dowels or nails, and are engineered for high strength. They have similar fire and seismic performance as concrete and steel but are significantly lighter in weight and outperform traditional light-frame wood construction.

Mass timber products are thick, compressed layers of wood, creating strong, structural load-bearing elements that can be constructed into panelized components. They are typically formed through lamination, fasteners, or adhesives. Mass timber can complement light-frame and hybrid options and is an environmentally friendly substitute for carbon-intensive materials and building systems.

The differences between Mass Timber and Light Wood Wood Framing

Mass Timber

Mass timber products consist of multiple solid wood panels nailed, glued or dowelled together, providing strength and stability in the section. It can be used as a load-bearing structure and interior finishes.

Lightweight Wood-Framing

Lightweight wood-framing construction is made up of dimensional lumber and engineered wood products that are regularly spaced and fastened together with nails, forming the building's structure. Traditionally used in low-rise residential construction, lightweight wood-framing construction is now being used to construct a more diverse range of more extensive and taller buildings.

Construction Advantage

- **Prefabrication reduces on-site construction.**
- **Speed of Construction**
- **Less disruption to local communities, less construction vehicle traffic, less noise, and less dust**
- **Fewer change orders on-site due to the highly coordinated design process**

Design Advantage

- **Inherent fire rating**
- **Enhanced thermal performance**
- **Higher precision and control**
- **Promote health and wellness**
- **Low Carbon**
- **Aesthetically beautiful**

Image courtesy of: https://www.thefalcongroup.us/mass-timber-reshaping-the-built-environment/

Canada is quickly becoming a global leader in mass timber and modular construction.

The Interactive Map of Mass Timber in Canada is currently logging over 760 mass timber projects and 20 manufacturing facilities across Canada. Over the years, British Columbia has pushed boundaries with programs like Wood First, which focuses on advancing wood use and innovative wood construction technologies.

Ontario is emerging as a leader in mass timber and modular construction due to several key factors and initiatives. First and foremost, the province's commitment to sustainable and innovative building practices aligns with global efforts to combat climate change and reduce carbon emissions. The use of mass timber, a renewable and low-carbon building material, has gained traction as it helps sequester carbon dioxide and reduces the carbon footprint of construction projects.

Additionally, Ontario's government and industry stakeholders have invested in research, development, and the promotion of mass timber and modular construction. This support has led to the establishment of specialized manufacturing facilities and an increased availability of mass timber products, making it more accessible to the construction sector.

The province has also witnessed successful pilot projects and high-profile developments using mass timber and modular construction techniques. These showcase the economic, environmental, and architectural benefits of the approach, encouraging other developers and builders to adopt similar methods.

Furthermore, the growing interest in sustainable building practices among consumers and investors has driven demand for mass timber and modular construction solutions. Companies and developers are recognizing the long-term value and market appeal of environmentally friendly projects, which further drives the adoption of these technologies.

Collaborative efforts between industry stakeholders, academia, and the government have led to the establishment of building codes and regulations that support the safe and efficient use of mass timber in construction projects. This creates a conducive environment for innovation and experimentation, further propelling Ontario's leadership in the field.

Overall, the combination of government support, research and development, successful projects, and a market-driven demand for sustainable solutions has positioned Ontario as a pioneer in mass timber and modular construction, setting an example for other regions to follow in embracing the future of sustainable building practices.

https://www.naturallywood.com/resource/interactive-mass-timber-map-canada/)

The prototype design utilized Cross Laminated Timber (CLT) which are large mass timber panels known for strength, stability and light weight nature.

Contemporary apartment building made of wood at Hamburg

Modular Construction

Modular Construction: From Projects to Products

Modular construction can be broadly defined as the production of standardized components for a structure in an offsite factory, followed by their assembly onsite. The terms offsite construction, prefabrication, and modular construction are often used interchangeably and encompass various approaches and systems. The complexity of the elements brought together can vary, ranging from single elements with standard connections and interfaces to more intricate systems.

3D Volumetric Modular: Achieving Peak Productivity

Maximizing productivity benefits, 3D volumetric solutions consist of fully fitted-out units, resembling rooms or partial rooms, that can be assembled onsite like interlocking Lego bricks. These units are constructed in timber, steel, or concrete, with timber and steel being more prevalent due to their weight and logistics advantages. The onsite assembly process involves lifting the modules into place and connecting various services, such as electrical and plumbing, although most of the work is completed in an offsite manufacturing facility.

The 3D volumetric approach offers significant efficiency and time-saving potential. However, it comes with trade-offs, including transportation costs and size limitations. Typically, the maximum width for road transport without a police escort is around 3.5 meters. This either raises the transportation expenses for larger units or constrains the size of modules, making 3D volumetric construction most suitable for projects like hotels, hostels, or affordable housing. It also proves advantageous for rooms with intricate finishes, especially wet rooms like bathrooms and kitchens.

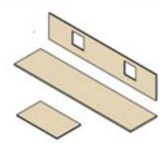
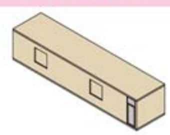
For projects requiring a high level of repeatability and a high ratio of wet to dry rooms, the 3D volumetric approach is ideal. Importantly, repeatability doesn't imply identical appearances for all units. Instead, a variety of standardized modules can be creatively combined to achieve a personalized result.

2D Panelized: Streamlining Construction

A 2D panelized solution adopts a flat-pack assembly approach similar to assembling home furniture. These panels are designed with built-in conduits for essential services like heating, ventilation, air conditioning (HVAC), and plumbing, which can be easily connected using standard connectors.

Compared to traditional construction, onsite assembly of 2D panelized solutions is simpler but more involved than assembling 3D modules, as it requires additional internal finishing. However, the advantage lies in the ease of transportation, as flat-pack panels are more convenient to transport than larger 3D modules.

The flexibility of 2D panelized solutions surpasses that of 3D modules, making them more suitable for certain projects. For instance, large open-plan offices are not very well-suited for single 3D modular elements, making 2D panels a better option. Additionally, 2D panels are particularly relevant for high-end residential projects, including single-family homes or apartments, where customization is crucial, and the ratio of wet areas to dry areas is lower.

Building Components	Prefabrication	Dimensions	Complexity	Construction
BUILDING ON SITE  Building products	Low grade of prefabrication	No limitations in size	Demanding and unique shapes	Longest construction phase
ELEMENT  Factory finished 2D surfaces	High grade of prefabrication	Wide range of possible dimensions	Repetition of slabs and patterns	Shorter construction phase
MODULAR ELEMENT  Factory finished 3D elements	Extremely high grade of prefabrication	Limited dimensions	Repetition of modular units	Shortest construction phase

Benefits of Mass Timber, Worforce Communities

The Importance of Canada's Bioeconomy

Canada's and Ontario's connection between forestry and mining positions them as leaders in the bioeconomy, and it plays a pivotal role in shaping the economic, environmental, and social landscape of the region. The vast expanse of pristine forests, abundant freshwater resources, and diverse ecosystems in these areas provides a fertile ground for the growth of a sustainable bio-based industry. The unique synergy between forestry and mining is crucial, as it enables the responsible utilization of natural resources while fostering innovation, job creation, and environmental stewardship.

The bioeconomy's significance lies in its potential to not only drive economic growth but also to promote a harmonious relationship between the environment and society, making Canada and Ontario exemplary champions of sustainability in the global arena.

One of the key pillars of the northern bioeconomy is the sustainable forestry sector. Canada is globally renowned for its extensive forest cover, and Ontario's northern regions are no exception. The responsible management and utilization of these forests contribute significantly to the economy. The forestry industry not only provides employment opportunities for local communities but also ensures the long-term viability of the sector through sustainable practices such as selective logging and reforestation efforts. Furthermore, the bioeconomy encourages the development of value-added products from forestry byproducts, such as biofuels, bioplastics, and biochemicals, reducing reliance on fossil fuels and promoting a circular economy.

The northern bioeconomy also encompasses the utilization of other renewable resources found in the region, such as biomass and agricultural waste. These resources serve as feedstock for the production of bioenergy, bio-based materials, and bio-based chemicals. The development of bioenergy systems reduces greenhouse gas emissions, mitigates climate change, and provides an alternative to traditional fossil fuel-based energy sources. Additionally, the production of bio-based materials and chemicals offers opportunities for the manufacturing sector, leading to economic diversification and innovation.

Furthermore, the northern bioeconomy has the potential to foster regional development and improve the quality of life for northern communities. By creating jobs and economic opportunities in remote areas, it helps to alleviate economic disparities and reduce dependency on resource extraction alone. The bioeconomy can encourage entrepreneurship, attract investment, and support the growth of small and medium-sized enterprises, resulting in vibrant and resilient northern communities.

Canada's and Ontario's northern bioeconomy holds immense importance due to its ability to leverage the region's natural resources sustainably. By promoting responsible forest management, utilizing renewable resources, and embracing innovation, it generates economic growth, reduces environmental impact, and enhances the well-being of northern communities. Embracing the potential of the bioeconomy ensures a prosperous and sustainable future for both Canada and Ontario's northern regions.

Mass Timber and Canada's Bioeconomy

Mass timber and wood play a pivotal role in Canada's bioeconomy, showcasing the importance of sustainable forest management and the utilization of renewable resources. As a global leader in the production of timber and wood products, Canada has recognized the immense potential of mass timber construction and its positive impacts on the environment, economy, and communities.

Mass timber refers to large, engineered wood products such as cross-laminated timber (CLT), and glulam beams. These innovative materials offer a sustainable alternative to materials such as concrete and steel, as they sequester carbon dioxide during growth and continue to store it throughout their lifespan. By utilizing mass timber, Canada can significantly reduce its carbon footprint in the construction sector and contribute to global efforts in combating climate change.

In addition to its environmental benefits, the use of mass timber also presents economic opportunities. The growing demand for sustainable and eco-friendly building materials has created a thriving market for Canadian wood products, leading to job creation and economic growth in rural and forested regions. The production and processing of mass timber require skilled labor, fostering employment opportunities and supporting local communities.

Moreover, mass timber construction offers several advantages such as shorter construction timelines, improved energy efficiency, and enhanced architectural design possibilities. These benefits contribute to the development of sustainable and resilient buildings that prioritize occupant well-being and reduce energy consumption. The versatility of wood as a construction material allows for creative and aesthetically pleasing designs while maintaining structural integrity.

Canada's commitment to sustainable forest management ensures a reliable and abundant supply of timber resources. The responsible harvesting and reforestation practices in Canadian forests guarantee the long-term viability of the industry while preserving biodiversity and protecting ecosystems. This sustainable approach aligns with the principles of the bioeconomy, which aims to maximize the value derived from natural resources while minimizing environmental impacts.

In conclusion, mass timber and wood play a crucial role in Canada's bioeconomy by promoting sustainable forest management and supporting the transition to eco-friendly construction practices. The utilization of mass timber not only reduces carbon emissions but also drives economic growth, fosters job creation, and enhances the resilience of buildings. By embracing the potential of mass timber, Canada demonstrates its commitment to a sustainable future and positions itself as a global leader in the bioeconomy.

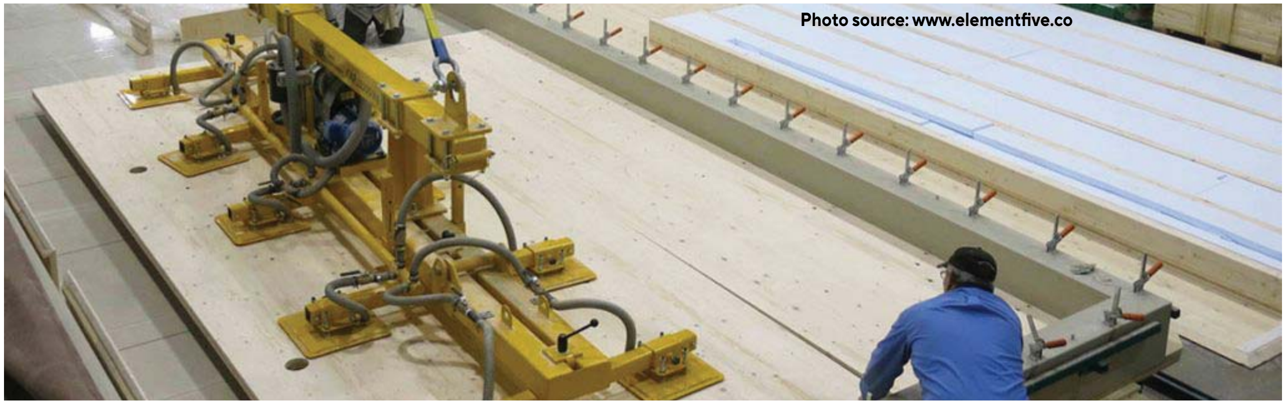


Photo source: www.elementfive.co

Challenges and Solutions in Mining Camp Housing: Improving Conditions for Remote Workforces

Mining camps in Canada face several critical challenges, both for the workers and the overall operation. Some of these challenges include:

Remote Locations Many mining camps are situated in remote and isolated areas, making access to essential services and amenities difficult. The lack of nearby infrastructure can lead to higher costs for transportation, housing, and supplies, and it may also result in social isolation for the workers.

Harsh Weather Conditions Canadian mining camps often encounter extreme weather conditions, including cold temperatures and heavy snowfall. These conditions can pose safety risks for workers and may disrupt operations, leading to potential downtime and increased costs.

Workforce Accommodations Providing suitable and comfortable accommodations for the workforce in remote areas is challenging. Temporary housing facilities need to be well-designed, ensuring the well-being and productivity of workers during their time at the camp.

Health and Safety Concerns Working in a mining camp involves inherent risks. Ensuring the health and safety of workers is crucial, and it requires strict adherence to safety protocols and procedures. Remote locations can pose additional challenges for timely medical assistance and emergency response.

Mental Health and Well-Being The isolation and long working hours in mining camps can take a toll on workers' mental health. Companies need to address this issue by providing access to mental health support and recreational activities to help workers cope with the challenges.

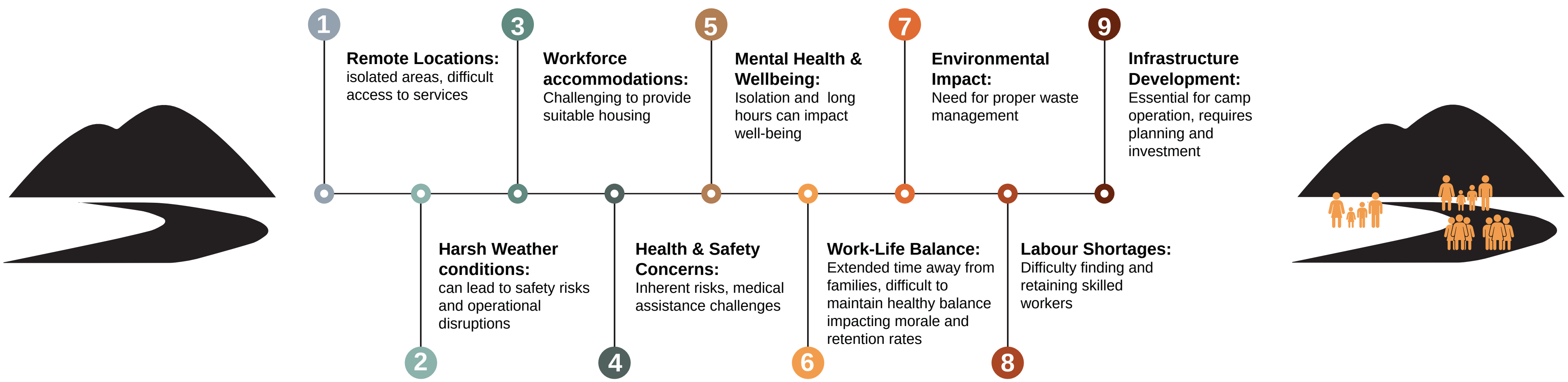
Work-Life Balance Workers in mining camps often spend extended periods away from their families and communities. Maintaining a healthy work-life balance becomes difficult, and this can affect morale and retention rates.

Environmental Impacts Mining operations in remote areas can have significant environmental impacts. Proper waste management and environmental protection measures are essential to mitigate these effects and ensure sustainable mining practices.

Labour Shortages Finding and retaining skilled workers for remote mining camps can be challenging. The limited pool of available labor and the difficulties associated with living in remote locations can lead to workforce shortages.

Infrastructure Development Building and maintaining infrastructure in remote areas require careful planning and significant investments. Access to water, power, and transportation infrastructure are essential for the successful operation of mining camps.

Addressing these challenges requires a collaborative effort between mining companies, government agencies, and community stakeholders. Sustainable practices, employee support, and community engagement are essential for creating a positive and responsible mining camp environment in Canada.



Building Resilience: Healthy and Durable Housing in Canada's Northern Communities

Building healthy and durable housing solutions in Canada's northern communities presents several challenges. The harsh and extreme climate conditions in the northern regions create a demanding environment that requires specialized construction techniques and materials. The remote locations often lack access to essential infrastructure, making transportation of construction materials and skilled labor difficult and expensive. Moreover, the high cost of building materials, coupled with limited financial resources, hinders the implementation of building developments.

Extreme Climate Conditions Northern communities experience harsh and extreme weather conditions, including extremely cold temperatures, heavy snowfall, and permafrost. Designing and constructing buildings that can withstand these conditions while providing adequate insulation and energy efficiency is essential but challenging.

Limited Access to Resources Many northern communities are remote and have limited access to building materials, skilled labor, and construction equipment. Transporting materials and resources to these regions can be costly and logistically complex.

High Construction Cost Due to the remote locations and limited resources, construction costs in northern communities are often higher than in urban areas. This can make it challenging to build affordable and sustainable housing solutions.

Limited Workforce The small populations in many northern communities result in a limited local workforce with construction expertise. This can lead to delays in construction and challenges in finding skilled workers.

Building Envelope and Durability Ensuring a durable building envelope that can withstand the extreme climate conditions is critical to prevent issues like moisture infiltration, mold growth, and structural damage.

Long-Term Maintenance Due to the challenging environment, maintaining and repairing buildings in northern communities can be more complex and costly.

Access to Basic Services Some northern communities may lack access to basic services like clean water, sanitation, and electricity, which must be addressed when planning housing solutions.

Cultural Sensitivity Building housing solutions that respect and integrate with the local culture and traditional way of life is essential for the well-being and acceptance of the community.

Many northern communities are home to Indigenous populations with unique cultural and traditional considerations. Building housing solutions that respect and incorporate these cultural aspects is essential but requires careful and collaborative planning.

Addressing these challenges requires a holistic approach that involves collaboration among government agencies, local communities, Indigenous groups, and construction experts. Sustainable and innovative building practices, along with adequate investment and support, are crucial to creating healthy, durable, and culturally sensitive housing solutions for Canada's northern communities.

Building a Greener and Healthier Future: The Advantages of Mass Timber Modular Construction for Mining Camps in Northwest Ontario

By adopting mass timber modular construction, mining camps in Northwest Ontario can proactively address health and wellness concerns, reduce their environmental impact, and contribute to global efforts to combat climate change. These innovative building practices align with sustainable development principles, making them an ideal fit for creating environmentally responsible and comfortable living and working spaces in remote mining locations.

Mass timber modular buildings can have several positive impacts on health and wellness, climate change, and carbon reduction for mining camps in Northwest Ontario:

3D Volumetric Modular Kelowna Hotel in British Columbia, Canada. Each unit was fabricated off-site.
Photo Credit: Metric Modular

Health and Wellness

Mass timber has been shown to contribute to a healthier indoor environment. The use of natural wood materials in construction can improve air quality, as wood has the ability to regulate humidity and reduce the risk of indoor air pollutants. This creates a more comfortable and healthy living and working environment for the mining camp's occupants, promoting better physical and mental well-being.

Climate Change Mitigation

Mass timber is a sustainable building material that sequesters carbon dioxide from the atmosphere. Trees absorb CO2 during their growth, and when used in construction, the carbon remains stored in the wood products, effectively reducing carbon emissions associated with traditional building materials like concrete and steel. Choosing mass timber for construction in mining camps helps to mitigate the camp's carbon footprint and contribute to the region's efforts to combat climate change.

Carbon Reduction

Modular construction reduces the amount of energy, materials, and waste generated during the construction process. Off-site manufacturing of modular components results in fewer on-site activities and transportation requirements, leading to reduced energy consumption and greenhouse gas emissions. As a result, the carbon footprint of building the mining camp is significantly reduced compared to traditional construction methods.

Construction Speed and Efficiency

Modular construction using mass timber allows for faster assembly on-site. The pre-fabricated components are produced off-site, which minimizes construction time and associated energy use. This efficiency is especially valuable in remote locations like Northwest Ontario, where harsh weather conditions and limited access to resources can pose construction challenges.

Aesthetics and Comfort

Mass timber offers a warm and natural aesthetic that contributes to the well-being and morale of the mining camp's occupants. The use of wood in the interior spaces can create a calming and inviting atmosphere, promoting mental wellness and positive employee experiences.

Wood and natural materials have a profound impact on health and wellness, primarily through the concept of biophilia. Biophilia refers to the innate human connection with nature and natural environments. Incorporating wood and natural materials into architectural design can evoke feelings of tranquility and connection, reducing stress and promoting mental well-being. The visual and tactile qualities of wood create a warm and comforting atmosphere, contributing to a sense of coziness and relaxation. Exposure to natural elements also enhances indoor air quality and regulates humidity levels, promoting a healthier environment. These design choices, rooted in biophilia, can improve occupant satisfaction, productivity, and overall quality of life within the built environment.

Impact of Wood on Human Wellness

Addressing health and wellness in building design is of paramount importance in today's context due to several compelling reasons. First and foremost, people spend a significant portion of their lives indoors, whether at home, work, or other indoor spaces. Creating environments that prioritize health and well-being can directly impact occupants' physical and mental health, leading to increased productivity, better mood, and improved overall quality of life.

Moreover, the COVID-19 pandemic has underscored the importance of indoor air quality, ventilation, and infection control within buildings. Designing spaces that support proper air circulation, filtration, and sanitation measures has become crucial for safeguarding public health and preventing the spread of diseases.

In an era where environmental concerns are prominent, sustainable, and healthy building designs align with global efforts to reduce energy consumption, minimize waste, and lower carbon footprints. By integrating features that enhance natural lighting, incorporate green spaces, and utilize non-toxic materials, building designers can contribute to a more sustainable and resilient future.

Additionally, organizations and businesses are recognizing that investing in the health and well-being of their occupants can lead to tangible benefits such as increased employee satisfaction, reduced absenteeism, and improved employee retention rates. As a result, health-focused building design can have positive ripple effects on both individuals and organizations.
In essence, addressing health and wellness in building design reflects a holistic approach that considers not only the physical aspects of the built environment but also the well-being of its occupants, the surrounding community, and the planet as a whole.

Biophilia

The term biophilia means the love of life and living things. Humans have a deeply engrained love of nature, an intuitive and natural drive imprinted in our DNA.

Biophilic design is the movement that states that connecting humans to nature through design and natural elements, such as views of nature, natural light, plants, and natural materials, have benefited human health and well-being.

Many cultures have been using nature as restorative therapy.

Shirin-Yoku – "Forest Therapy" is a Japanese tradition of bathing in the forest light, which invites participants to slow down and enjoy the company of trees, lowering blood pressure and other stress-related conditions.

Another example is the Norwegian connection to **"Free Air Living" – Friluftsliv** believes that nature revitalizes the mind and body.

As well, multiple indigenous communities around the world have spiritual and physical relationships with ecology. On an emotional level, wood gives the impression of timelessness, generosity, and optimism. Every piece of wood is unique and engrained with its character.

In North America, we spend approximately 90% of our time indoors[1]; therefore, the quality of our built environment plays a significant role in our health and well-being.

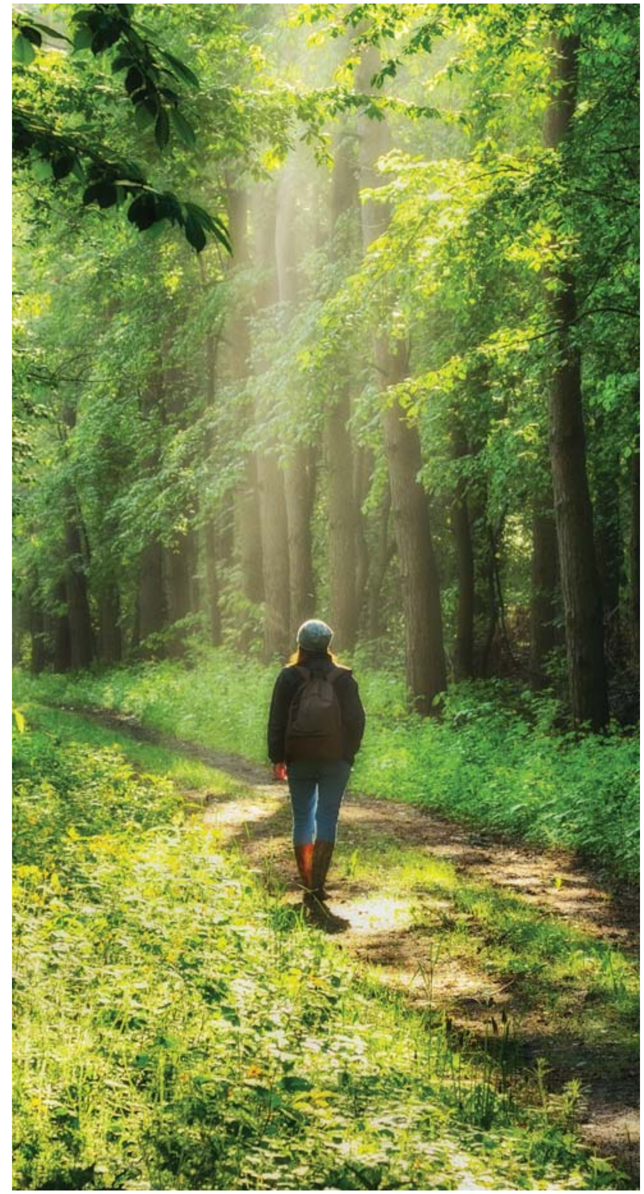
Given that many of us spend a significant portion of our day indoors, it is essential to design the indoor environment in a restorative and healthy way for our bodies and minds. Indoor Environmental Quality (IEQ) includes considerations for air quality, hygiene, humidity, temperatures, as well as the touch and feel of materials, and wood has beneficial qualities in all of these areas.

One of the biggest causes of health problems in modern society is stress, causing symptoms including anxiety and difficulty focusing or interacting socially.

An increasing amount of research is being conducted on the benefits of biophilic design and its impacts on human health and wellness. Studies from the US, Canada, Austria, and other countries found that humans can relax more quickly when elements from nature surround them.[2]

In addition, being in environments designed to connect to nature can reduce stress, blood pressure and heart rate and allow for more creativity and productivity.[3] Using wood in building designs plays an essential role in developing healthy environments for all.

1 Roberts, "We Spend 90% of Our Time Indoors. Says Who? | BuildingGreen."
2 Augustin, "Wood as a Restorative Material in Healthcare Environments."
3 Ikei, Song, and Miyazaki, "Physiological Effects of Wood on Humans: A Review."



Mass timber and natural materials offer numerous benefits to the health and wellness of people in various built environments

Improved Indoor Air Quality

Natural materials like wood can regulate humidity levels, leading to better indoor air quality. Mass timber, with its low emissions and minimal use of chemicals, contributes to healthier indoor environments by reducing the presence of indoor air pollutants.

Biophilic Connection

Both mass timber and natural materials contribute to biophilic design principles, which emphasize the innate human connection to nature. Biophilic elements in buildings, such as wood finishes and textures, have been shown to reduce stress, improve cognitive function, and enhance overall well-being.

Incorporating natural materials in building design fosters a stronger connection to the natural world, even in urban settings. This connection is associated with improved mental health, reduced stress, and increased overall happiness.

Thermal Comfort

Mass timber has natural insulating properties, providing efficient thermal performance. This helps maintain consistent indoor temperatures, leading to improved comfort and reduced energy consumption for heating and cooling.

Acoustic Benefits

Wood's sound-absorbing properties can reduce noise levels within buildings. This leads to quieter and more peaceful indoor environments, which can positively impact mental health and concentration.

Aesthetic Pleasure

The warm and natural aesthetics of mass timber and other natural materials create visually pleasing and calming spaces. Aesthetic satisfaction contributes to positive emotional experiences and overall well-being.

Stress Reduction:

Exposure to natural materials has been linked to stress reduction and improved mood. Wood's natural appearance and texture can evoke feelings of relaxation and comfort.

Holistic Approach:

The use of natural materials aligns with a holistic approach to building design that considers the well-being of occupants alongside environmental sustainability. This approach acknowledges the interconnectedness of human health and the natural world.

Wood Innovation Design Centre, by Michael Green
Photo Credit: Ema Peter

Environmental Benefits

Climate Change and Carbon

Climate change is defined as a crisis of our time and is increasing at an unprecedented rate. The United Nations report that rising temperatures fuel environmental degradation, natural disasters, weather extremes, food and water insecurity, economic disruption, and conflict. The environment is at a critical juncture with human-induced climate change, resulting in more frequent and intense extreme events, causing adverse impacts and related losses and damages to nature and people.

Carbon emissions are recognized as a leading cause of climate change.

The Architectural, Engineering and Construction (AEC) industry is identified as one of the main contributors to environmental decline causing climate change.

As the industry seeks strategies to reduce the impact of buildings on the environment, we must consider a holistic approach structured around net-positive benefits on all systems that impact communities, including economic, social, and cultural values. It is therefore critical that now and over the coming years, architects and engineers develop building design strategies that will deliver climate resilience, form stronger communities, and realize a positive cultural and social built environment.

Globally, carbon emissions from the building industry are a significant contributor to greenhouse gas emissions, even larger than the transportation and industrial sectors.

Globally, buildings are currently responsible for 39% of global energy-related carbon emissions: 28% from operational emissions, from the energy needed to heat, cool and power them, and the remaining 11% from materials and construction.

In 2022, the Government of Canada released data that 24% of Canada's total GHG emissions come from the oil and gas sector, 22% from transportation, 12% from buildings and 10% from the heavy industry sector. Although Canada's share of the total global GHG emissions is less than 2%, it remains one of the highest per capita emitters.

The impacts of climate change are also being widely felt in the country, particularly in northern Canada, with rising temperatures, melting ice caps, and more frequent severe extreme weather events impacting the vitality, health and wellness of people and communities.

In "Bringing Embodied Carbon Upfront: Coordinated action for the building and construction sector to tackle embodied carbon," World GBC has issued a bold new vision that:

By 2030, all new buildings, infrastructure and renovations will have at least 40% less embodied carbon with significant upfront carbon reduction, and all new buildings are net zero operational carbon.

By 2050, new buildings, infrastructure and renovations will have net zero embodied carbon, and all buildings, including existing buildings, must be net zero operational carbon.

Biogenic Carbon

Forests are a key factor in naturally capturing carbon.

Biogenic carbon is the carbon that is stored in biological materials, such as plants or soil. Carbon accumulates in plants through photosynthesis; therefore, bio-based products can contribute to reducing the levels of carbon dioxide in the atmosphere and help mitigate the challenge of climate change. Biogenic carbon within a building product can be considered a "negative emission." This means that carbon is stored in the material during the growth stage of bio-based materials.

In the context of wood construction products, the carbon sequestered by the tree as it grows continues to be stored in the wood product over its lifetime.

Responsibly managing forests in a way that balances harvesting and replanting and provides a sustainable source of wood products that continue to store carbon and offset the use of fossil fuels can significantly reduce the amount of carbon in the atmosphere over the long term.

As trees grow, they clean the air we breathe by absorbing CO2 from the atmosphere. They release oxygen and incorporate the carbon into their twigs, stems, roots, leaves, needles, and surrounding soil. Young, vigorously growing trees take up carbon dioxide quickly, slowing down as they reach maturity. As trees mature and die, they decay and slowly release the stored carbon back into the atmosphere. Carbon is also released more quickly when forests succumb to natural hazards such as wildfires, insects, or diseases.

Wood is comprised of about 50 percent carbon by dry weight. So the wood in a building provides physical storage of carbon that would otherwise be emitted back into the atmosphere.

The forest regenerates, whether trees are harvested for products or decay naturally. When trees are manufactured into products and used in buildings, a new phase of carbon mitigation can begin.

One cubic meter of wood stores one ton of carbon dioxide.

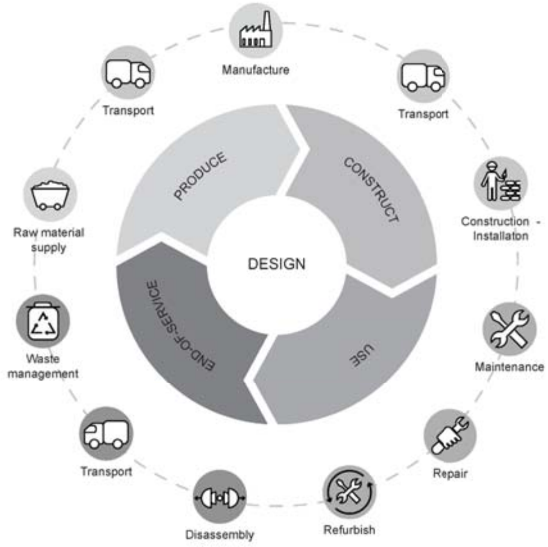


Diagram of the Circular Economy of Construction.
Image Credit: TUDelft, Course: Circular Economy for a Sustainable Built Environment

Embodied Carbon

Wood products have much lower embodied fossil energy content than concrete or steel because they require significantly less energy to produce.

In the building Industry, the current focus on Energy Efficiency is further defined into considerations of reducing both Operational and Embodied carbon.

Energy efficiency is an umbrella term for a wide range of strategies to reduce the overall energy we use. This involves designing, constructing, and upgrading buildings to make the most of their energy and prioritizing waste, stranded, or non-renewable energy wherever possible.

This is known as operational carbon - the greenhouse gasses emitted by a building while it's in use, from when it opens to when it is closed for demolition. It includes all carbon emissions from the building's heating, cooling, electricity usage, ventilation, manufacturing, industrial processes, etc.

As the industry becomes more equipped to design for energy efficiency, the focus will quickly shift to embodied carbon.

Embodied carbon is the greenhouse gas emitted associated with materials and construction methods. This includes the extraction of raw materials, manufacturing and processing, transportation, and installation of building materials. Also, embodied carbon is considered the maintenance and repair of the building and end-of-life deconstruction and waste of a building.

Unlike operational carbon emissions, which can be reduced over time with energy upgrades and renewable energy, embodied carbon is locked into place as soon as the building is built.

The amount of carbon sequestered in wood is typically more than the amount of carbon emitted to make the wood into a building product, resulting in a net negative embodied carbon footprint.

Additionally, embodied carbon accounting represents biogenic carbon as a negative number. The critical benefits of reducing embodied carbon are immediately achieved when a building is constructed.

Workforce Design Principles & Prototype Building Design

Prototype Site Location

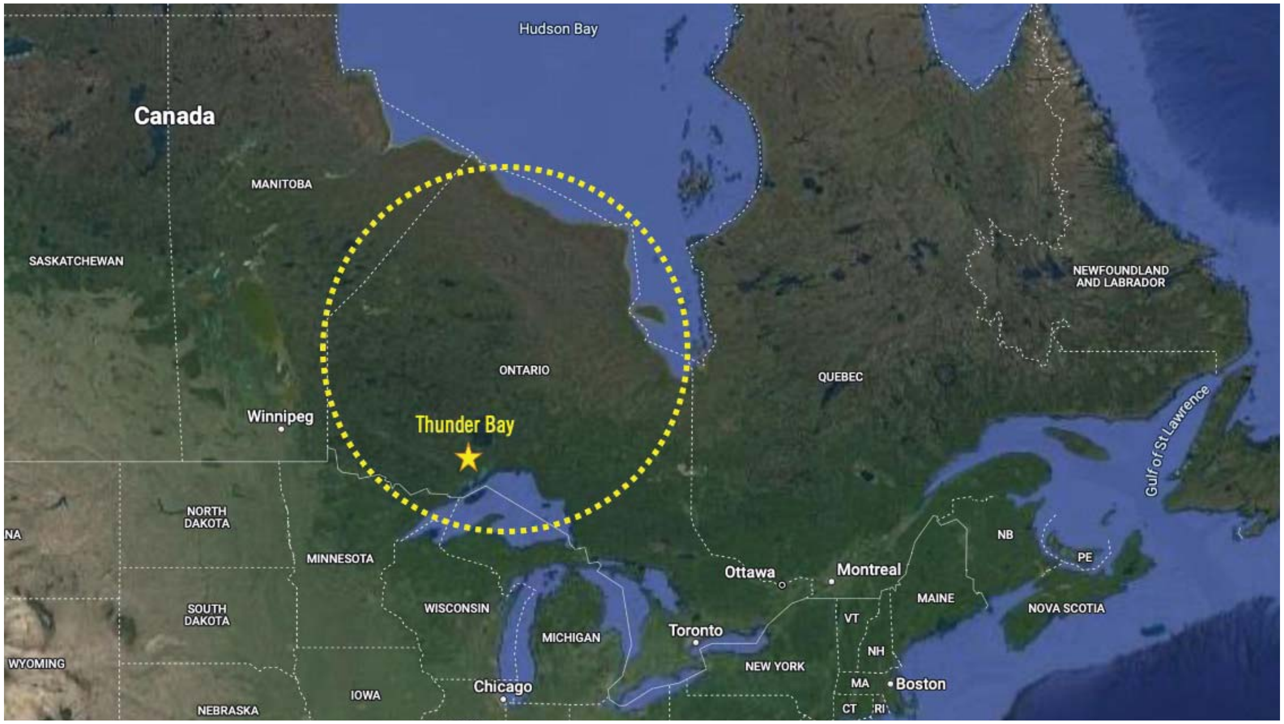
The location for the proposed prototype remains speculative and undefined, though it is generally assumed to be in Northwestern Ontario. Given this uncertainty, several key considerations shape the design strategy. The site's presumed remote nature poses significant challenges, particularly concerning the supply of materials and labor. To counter these logistical hurdles, a cornerstone of the design approach focuses on off-site fabrication of modules in a Thunder Bay-based factory. The remote nature of the speculative site makes daily transportation of materials and workers impractical, thus making off-site prefabrication a critical element in the overall design and execution strategy.

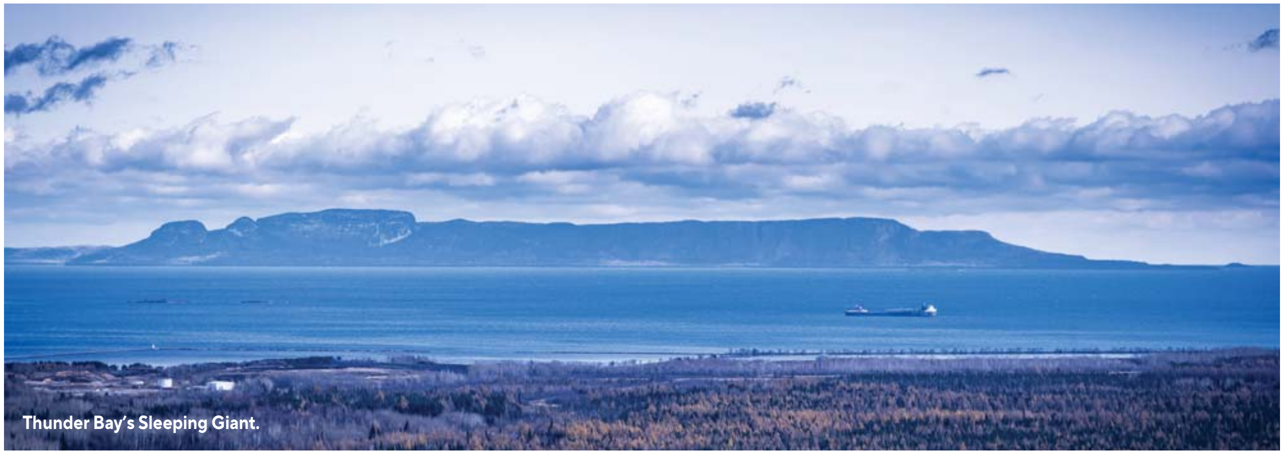
The assumed site's limited connectivity to the systems grid underscores the significance of integrating passive techniques to optimize energy efficiency and reduce external resource dependence. The prevailing northern climate further emphasizes the need for a high-performance building approach that enhances energy conservation and occupant comfort. Water supply sourced through a well drill initiates the exploration of sustainable water management practices, while the project's commitment to environmental consciousness drives the exploration of low-carbon energy sources to minimize its ecological impact.

To navigate the challenges posed by the remote setting, the design strategy pivots towards off-site prefabrication of complete modules, aligning with efficient transportation and assembly methods. The envisioned scenario involves off-site volumetric modular buildings, using prefabricated components and assembled in a factory in Thunder Bay. The units will be transported fully assembled to the site, accounting for the complexities of remote road conditions.

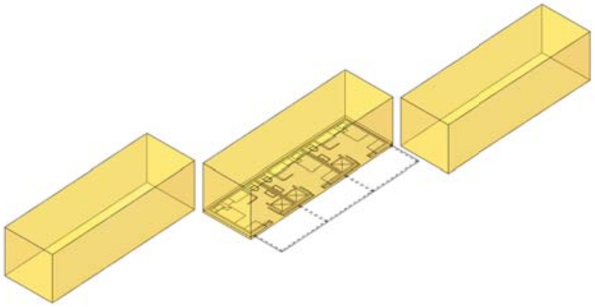
Given the scope and timeline of the study, certain aspects such as site services, connection, and site-specific design details are not included due to insufficient information regarding exact location, servicing, geotechnical conditions, and soil analysis. Consequently, the foundation design is not encompassed within the design package; however, the concept of a temporary foundation system serves as the foundational premise.

The site location's unique attributes and constraints serve as guiding principles for the project's design, ensuring an innovative and contextually responsive approach that maximizes efficiency, sustainability, and adaptability to the remote environment.




Thunder Bay's Sleeping Giant.

Program Breakdown

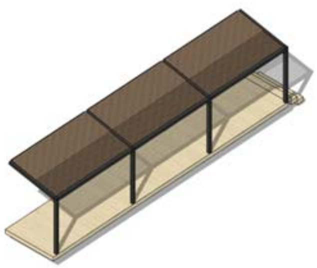


Living Quarters:

250 people occupancy during construction
110 people occupancy during operations

Single Occupancy with Ensuite
Three to four units per modular
Each modular to fit on a semi-trailer and shipped to site
Units must be transportable once the mine is decommissioned or scaled down
Acoustic and noise considerations important for wellbeing

Alternative Plan Layouts:
Double bed occupancy



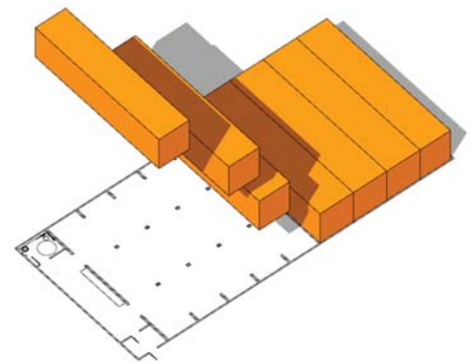
Porch

Game changer into providing personal outdoor space
Open door to the outside
Investigate opportunities and cost impacts
Option 1 (Basis of Design) - Includes porch
Option 2 (Four unit module) excludes

Arctic Corridor

Corridor connection between all buildings

Provide shelter against harsh winters and rain



Community Buildings

Centrally located
Create a sense of community

Dining Hall & Kitchen
Comfortable dining
Kitchen facilities
Loading

Office Building
For site office function

Dry House
Lockers
Showers
Laundry

Male to Female Ratio
10% during construction
15% during operations

Focused Barrier Free Integration

General

Improving living condition to increase recruitment and retention of workers
Investigate opportunities to reduce carbon and energy usage
Solar panels as a separate price
Consider durability and high performance envelop, high R Value

Flexibility of building being repurposed
Consider remote location and constructability challenges
Decentralized mechanical - allow for disassembly of parts to scale up or scale down camp

Climate Undersatnding - Northwestern Ontario Zone 7B (northern tip), Cold Climate Thermal Design

Canada's climatic zoning map divides the country into various climate zones based on factors such as temperature, precipitation, and other climatic characteristics. This map is essential in understanding and categorizing the diverse range of climatic conditions across different regions of Canada. It helps architects, engineers, builders, and designers make informed decisions about building design, materials, and energy systems that are appropriate for specific climatic conditions.

Considering the climatic zoning map is crucial for several reasons:

Building Design: Different climate zones have varying temperature ranges, humidity levels, and weather patterns. Designing buildings that are adapted to the local climate can improve energy efficiency, occupant comfort, and overall building performance.

Energy Efficiency: Building designs tailored to the local climate can optimize energy use. For instance, in colder climates, strategies to capture solar heat gain can reduce heating demands, while in warmer regions, designing for natural ventilation and shading can decrease cooling needs.

Material Selection: Climate influences the performance and durability of construction materials. Using materials suitable for the local climate can extend the lifespan of buildings and reduce maintenance costs.

Insulation and Thermal Performance: Different climate zones require different levels of insulation to maintain comfortable indoor temperatures. Proper insulation can prevent heat loss in cold climates and heat gain in warm climates.

HVAC Systems: Heating, ventilation, and air conditioning (HVAC) systems need to be optimized for the climate to ensure efficient and effective temperature control.

Resilience to Extreme Weather: Considering the local climate helps in designing buildings that are resilient to extreme weather events such as heavy snowfall, hurricanes, or heatwaves.

Environmental Impact: Designing buildings that respond to their climate can reduce greenhouse gas emissions by optimizing energy use and reducing the need for artificial heating and cooling.

Building Codes and Regulations: Many building codes and regulations in Canada incorporate the climatic zoning map to set standards for energy efficiency and building performance.

Climate Zone 7B in Canada corresponds to regions with specific climatic characteristics.

Key considerations for Climate Zone 7B include:

Temperature Range: Climate Zone 7B typically experiences cold winters with average annual minimum temperatures ranging from -12.3°C to -15°C (10.1°F to 5°F).

Heating Demand: Due to the cold temperatures, buildings in Climate Zone 7B have a significant heating demand during the winter months. Ensuring proper insulation and energy-efficient heating systems is crucial.

Cooling Demand: While the cooling demand in Climate Zone 7B is relatively lower compared to warmer climates, buildings still require cooling solutions for the short summer season. Efficient cooling systems and strategies like natural ventilation can help manage indoor temperatures.

Winter Precipitation: Regions in this zone often experience significant snowfall and winter precipitation. Designing roofs to handle heavy snow loads and ensuring proper drainage systems are essential.

Building Envelope: A well-insulated and air-sealed building envelope is essential to prevent heat loss during the cold winters and maintain indoor comfort.

Glazing and Solar Gain: Proper placement of windows and glazing can optimize solar gain during winter months to reduce heating demands. However, attention should be paid to prevent excessive heat gain during the summer.

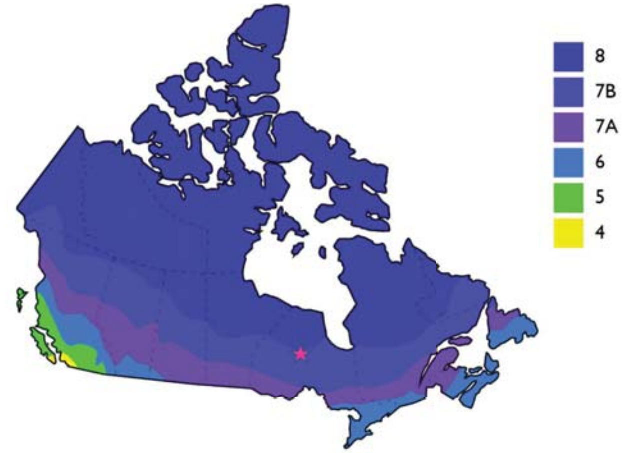
Ventilation: Effective ventilation systems are important to maintain indoor air quality while minimizing heat loss during colder months.

Renewable Energy: Given the heating demand, renewable energy sources like solar panels can be considered to offset energy consumption.

Insulated Foundations: Insulated foundations help prevent heat loss through the ground, improving energy efficiency.

Weather-Resistant Materials: Exterior building materials should be durable and weather-resistant to withstand winter conditions.

Passive Solar Design: Incorporating passive solar design principles can harness natural heat from the sun to reduce heating costs.



Weatherization: Ensuring proper sealing and weatherization of the building is vital to prevent air leakage and heat loss.

Considering these factors when designing and constructing buildings in Climate Zone 7B helps create energy-efficient, comfortable, and resilient structures that can withstand the specific climatic challenges of the region.

Thermal Performance Targets

Walls	**R35 - R50**
Roof	**R60**
Exposed Floor Slab	**R31-R45**

Although minimum energy performance for workforce camps in the Ontario Building Code are not prescribed, the prototype design will target high thermal performance values in the envelop design to reduce energy and carbon consumption, as well as add to the comfort of the users.

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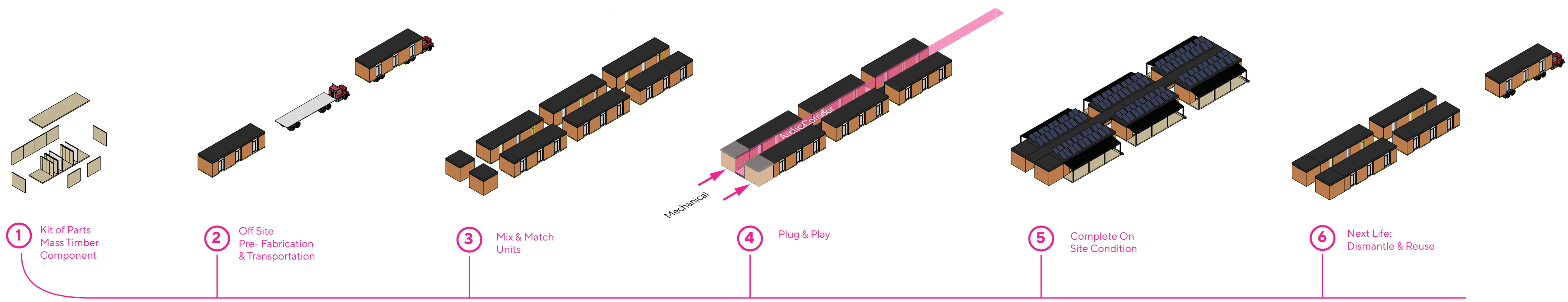
Off-Site Prefabrication



Transportation Logistics and Impact on Design

Transporting modular buildings presents a unique set of challenges and considerations that play a pivotal role in shaping the overall design strategy. As modular construction gains momentum for its efficiency and sustainability, understanding the logistics of transportation becomes crucial to ensure successful and cost-effective project execution.

First and foremost, the dimensions and weight of modular units are key factors. These modules need to adhere to transportation regulations, especially when being transported on roads. Width, height, and weight restrictions dictate the maximum size of modules that can be transported without special permits or accommodations. This consideration often influences the design process, as modular units need to be structurally sound yet compact enough to meet transportation limitations.

Secondly, the mode of transportation itself is a critical consideration. Modules can be transported by road, rail, sea, or air, each with its own set of requirements and limitations. The design needs to account for loading and unloading methods, securing the modules during transport, and potential challenges posed by various modes of transit.

Logistics also extend to the route planning. Road conditions, clearance heights, weight-bearing capacities of bridges, and potential obstacles must be considered to ensure a smooth and safe journey. Modules may need to be disassembled or designed with detachable components to navigate narrow roads or tight turns.

Additionally, transportation timelines and costs play a significant role in the overall project budget and schedule. Delays or unexpected challenges during transportation can have a cascading effect on the construction timeline and subsequent project phases. As such, designers must coordinate closely with transport companies to align the modular building's dimensions and characteristics with the available transportation options.

In summary, the logistics of transporting modular buildings are intricately tied to the design strategy. The dimensions, weight, transportation mode, route planning, and timing considerations all shape the modular unit's design. Successful integration of these logistical factors not only ensures the safe and efficient transportation of modules but also impacts project timelines, costs, and the overall success of the modular construction project.

It is critical to individual consider all design, construction and transportation parameters for each site.

*** Review critical requirements with local Highway Act and other jurisdictions.**

Typical Loads for Northern Communities

Typical Width 12'-0" (3.7 m)
Typical Length 60'-0" (18.3 m)
Typical Heigth 11'- 6" (3.5 m)

In conversations with local companies specialized in moving buildings, it was advised to design the prefabricated modules according to these dimensions to manage rural and remote road conditions.

Cross Laminated Timber (CLT) Panel typical to Element 5

Max Width (exposed panel) 3.1 m
Max Width (unexposed panel) 3.45 m
Max Legth 15.8 m

Althought it is possible to ship longer lengths, it was critical to the design to optimize the efficiency of the CLT panel.

Modular Buildings - Regulations and Standards

In Canada, modular construction is subject to various standards and codes that ensure the safety, quality, and performance of modular buildings. Some of the key standards and codes related to modular construction include:

National Building Code of Canada (NBCC)

The NBCC sets out the minimum requirements for the design, construction, and occupancy of buildings in Canada. It includes provisions that are applicable to modular and prefabricated construction methods.

Provincial Building Codes: In addition to the NBCC, provinces and territories in Canada have their own building codes that may include specific regulations and requirements for modular construction based on local conditions and considerations.

Currently, in Ontario the Ontario Building Code (OBC) is the defined regulation for most buildings.

It's important to note that these standards and codes may evolve over time, and it's essential for designers, manufacturers, and builders involved in modular construction to stay updated with the latest regulations to ensure compliance and the safety of the constructed buildings.

** The contents of this document are developed at a conceptual level, and the author assumes no liability for any errors or omissions. This document is not a substitute for a comprehensive and detailed design process, and it is essential to engage a qualified team, including engineers and code consultants, for thorough design development.

CSA A277 Standard for Factory-Assembled Buildings

This standard outlines the requirements for the design, manufacturing, and installation of factory-assembled buildings, including modular construction. It covers structural design, materials, quality assurance, and transportation considerations.

CSA Z240 MH Series of Standards

These standards pertain specifically to factory-built modular homes. They cover various aspects of modular construction, including design, materials, construction, transportation, and installation.

CSA Z241 Park Model Trailers Standard

This standard applies to the design, construction, and safety requirements for park model trailers, which are a type of factory-built modular structure.

CSA Z362 Prefabricated Accessible and Adaptable Housing Units:

This standard addresses the design, construction, and accessibility requirements for factory-built housing units that are designed to be accessible and adaptable for individuals with disabilities.

Modular Mass Timber construction with Swiss Kono Board, https://www.swisskrono.com

Crane lifting a wooden building module to its position in the structure. Construction site of an office building in Berlin. The new structure will be built in modular timber construction.

Building Codes

The Ontario Building Code (OBC) governs the design and construction of buildings in Ontario. The OBC provides the minimum standards for health, safety and other matters related to public welfare.

Changes to the OBC

Building codes are rapidly evolving when considering mass timber construction. In 2015, the Ontario Building Code permitted combustible construction up to six storeys. More recently, in 2022, Encapsulated Mass Timber Construction up to twelve storeys were included in the OBC. Internationally, mass timber is being used in buildings over 18-storeys and beyond.

Encapsulated mass timber construction (EMTC) is a type of construction in which a degree of fire safety is attained using encapsulated mass timber elements with an encapsulation rating and minimum dimensions for the structural timber members and other building assemblies. This direction requires that most of the mass timber components be encapsulated in a fire-protected assembly, such as a fire-rated gypsum board.

Combustible construction generally refers to wood, and non-combustible relates to concrete and steel. Wood is a combustible material, but there are several ways that combustible materials can be used in a non-combustible building.

Currently, Mass Timber construction is considered combustible according to the OBC and can be considered to be synonymous with heavy timber requirements. In a Group A-2 assembly, combustible construction is permitted to a maximum of 2-Storeys. A maximum building area of 2400 SM is also allowed when the budling is sprinklered.

To go beyond two storeys, an Encapsulated Mass Timber Construction solution or an application for Alternative Solution is possible. An Alternative Solution is a proposal to allow an alternative design in place of the prescriptive requirements under Division B of the Building Code.

Mass Timber and Char Effect

Even though mass timber is considered a combustible material, a fire rating can inherently be achieved through the thickness of the member. This is due to the charring ability of wood. Once wood begins to burn, it will char to self-extinguish the fire and create a protective coating to prevent further burning. To achieve a fire rating of a mass timber assembly, the structural members are oversized, including a char thickness plus the structural section. Char theory has been widely researched.

In 2022, North America's largest Mass Timber Fire Demonstration test was performed, providing valuable research on the safety of Mass Timber during a fire.

https://firetests.cwc.ca/

Mass timber and low-carbon design solutions in building design are rapidly evolving in Canada. Due to the constantly changing nature of this topic, primarily related to building codes in various jurisdictions, all information in this report should be independently verified through the local Authorities Having Jurisdiction (AHJ).

Collaborative Methods of Project Delivery

As the construction industry moves towards greener building methods, many owners, developers, and architects are returning to wood as a primary structural material. As a result, the industry is developing new products and construction processes that will increase efficiency, reduce waste, and reduce overall carbon.

Today, the use of prefabrication and modular construction is being seen on many levels as the industry adopts industrialization and automation. As a result, the construction of buildings is moving away from onsite methodologies to off-site prefabrication. Prefabrication is seen in both lightweight wood-frame and mass timber systems and is integrated into several building types, including housing, commercial and institutional. Modular construction varies in scale, from parts of buildings, such as bathroom packs and structural components, to complete living suites and even entire buildings. As the knowledge of prefabrication and mass timber increases, the scale of these buildings is quickly moving into mid-rise and even tall building heights. As the industry adapts to these changes, building codes and standards are quickly adopting provisions to allow for larger and taller buildings in wood.

Changing Methodologies of Wood Construction

There are varying degrees of prefabrication and modular construction, from kit-of-parts to three-dimensional volumetric units. Deciding on the degree of prefabrication and modularity will depend on program requirements, site conditions, skills knowledge, and manufacturer capabilities, to name a few. Developing a design that includes modular components requires a unique framework for project development by all parties to ensure quality and efficiency of design and construction. Early adoption and commitment to prefabrication and modular construction will lead to cost and schedule efficiencies and greater quality control.

As more knowledge and experience are gained in modular building products, it has been reported that prefabrication and modular construction can result in a twenty to fifty percent reduction of construction schedule, compared to traditional on-site builds.

In addition, modular construction can:

- Reduce overall build costs
- Accelerate build schedules
- Greater certainty on build times and costs
- Improve the quality of the building, including better energy and seismic performance

The Integrated Design Process and Co-operative Project Planning

Buildings that include prefabricated or modular systems require a collaborative and Integrating Design Approach (IDP). To optimize successes, an integrated or cooperative design process is adopted early in the project planning process to ensure careful consideration of building use, site considerations, structure, systems integration, and construction sequencing. The time investment early in the design and planning process, will benefit the construction process by allowing the schedule to be accelerated through the sequencing of construction and reduction of on-site changes or coordination issues. As a result, the industry is recognizing the importance of bringing the expertise of builders and contractors in early in the design process.

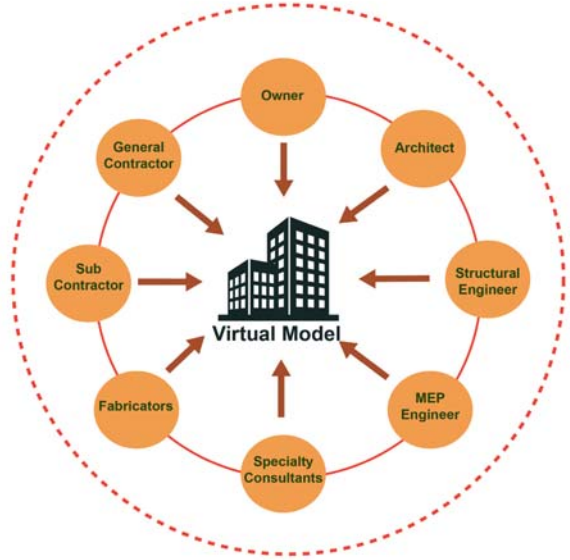
The Integrated Design Approach is a multidisciplinary strategy to building planning that prioritizes a whole systems approach. Implementing an IDP process is a critical step for achieving high-performance building design. The IDP process seeks to bring all key experts and stakeholders together to facilitate a collaborative design process. The best results are achieved when this process is implemented early on in a project and as early as the predesign stage.

Collaborative Methods of Project Delivery - Integrated Design Process

The type of contract procurement between the owner, builder and design team will have a significant impact on the project is executed. If the project follows a collaborative approach, such as in Construction Management (CM) or Design-Build (DB) contract, greater considerations between design decisions and construction efficiencies can be established. A traditional Design-Bid-Build linear style of contract can limit opportunities for efficiencies and savings as there is limited interaction, if any, between the design and building team during the design stage. The results of a collaborative model can render higher quality, efficient, sustainable, and cost-effective buildings.

The Integrated Design Process (IDP) is an interdisciplinary, whole-system thinking approach emphasizing early collaboration. It is a comprehensive process focusing on the building's design, construction, operation, and overall life cycle. Through this process, all stakeholders, including owners, consultants, and builders, cooperatively participate early in the project development.

Many project delivery models have been developed that have IDP at the core of the process. Construction Management and Design-Build models were designed to maximize team collaboration and optimize construction efficiencies to reduce material waste and save time and costs. The Integrated Project Delivery method is a more recent project delivery system adopted in Canada where all members have a contractual obligation to each other. The main objective of these contract types is to take advantage of the knowledge of all team members to maximize the project outcome, and it becomes a critical methodology for green buildings moving forward.



The Integrated Design Process is key to the success of a Mass Timber, Low Carbon building design.

Kit-of-Parts

A "Kit of Parts" refers to a modular design approach where building elements and components are pre-designed, standardized, and fabricated in a way that allows them to be easily assembled or combined to create various structures. This method emphasizes flexibility and efficiency by breaking down the design into reusable modules that can be adapted and assembled to suit different contexts and functions. A Kit of Parts approach simplifies the construction process, reduces design time, and enhances construction speed while maintaining consistent quality. This approach is often used in architecture and construction to streamline the building process and enable the efficient creation of diverse structures using a standardized set of components.

This kit of parts address address the unique requirements of mining camps in Northern Ontario while adhering to the overarching principles of modular construction.

Optimized Modular Fabrication:

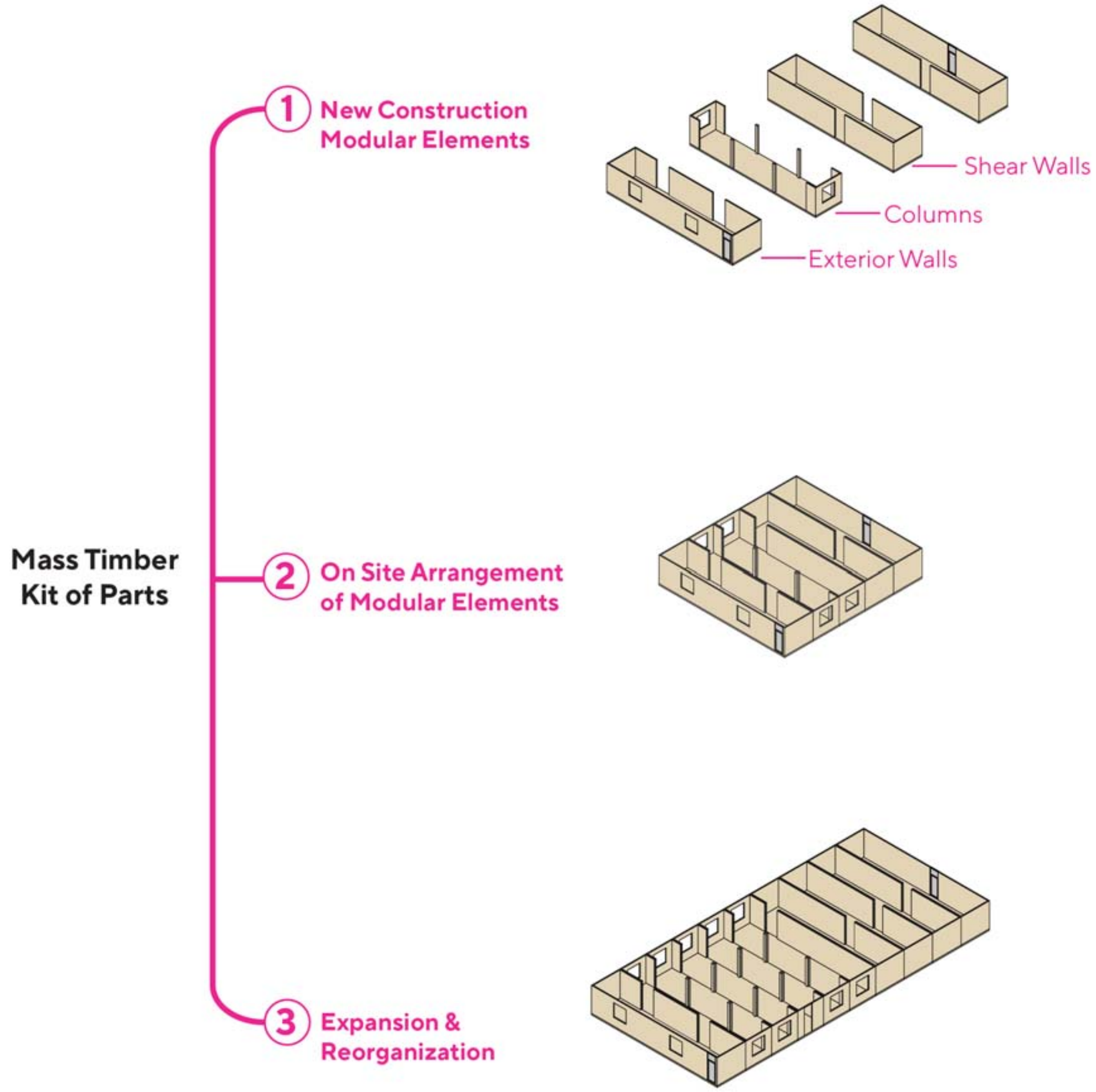
The kit of parts approach prioritizes the optimization of modular elements and components through factory-based construction. This method ensures efficient and high-quality fabrication, streamlining the building process. Additionally, the modular elements are meticulously designed to cater to various geographical locations. This design consideration encompasses both material availability and the demand for skilled labor, resulting in a harmonious balance between efficiency and craftsmanship.

Tailored Onsite Arrangement:

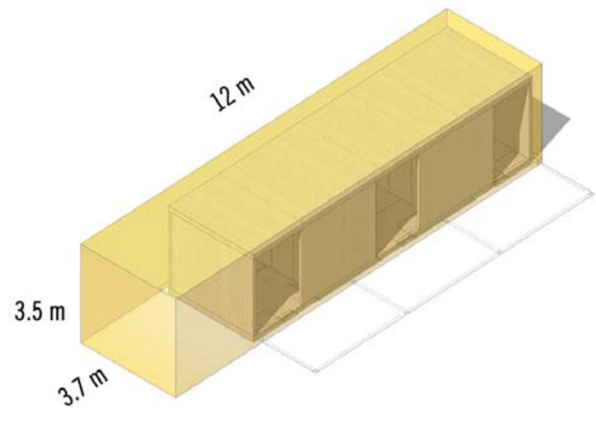
The approach extends its focus to the onsite arrangement of modular elements. Here, the foundations are designed to align with the specific requirements of each site. This customization ensures structural stability and performance, enhancing the overall quality of the modular building. By catering to site-specific needs, this aspect of the approach maximizes the practicality and adaptability of the construction.

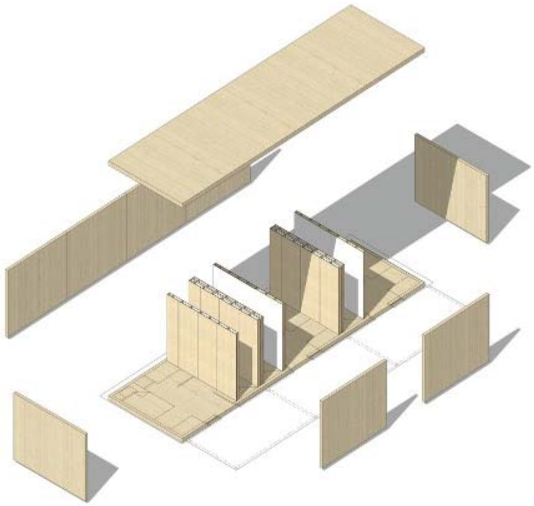
Long-Term Resilience and Circular Economy:

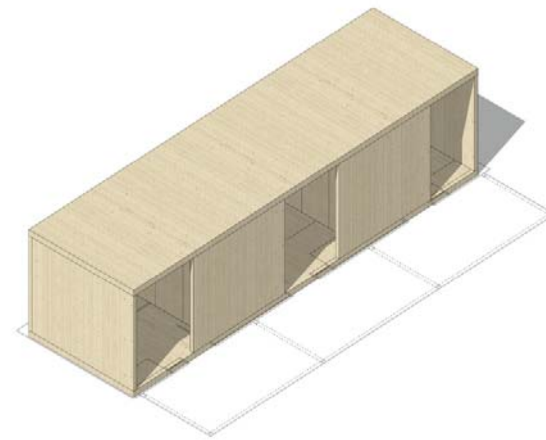
Looking toward the future, the kit of parts approach underscores the importance of expansion, reorganization, and long-term resiliency. This entails designing for flexibility and adaptability, allowing for the reuse and relocation of modular elements. The strategy aligns with principles of material circularity, contributing to sustainability by minimizing waste and optimizing resource utilization. In emphasizing both longevity and environmental responsibility, this approach sets the stage for resilient and eco-conscious building practices.



Planning Framework - Modular Elements Factory Made







Logistic Framework Integration

The planning process is intricately linked with the logistical aspects of fabrication and construction. This includes careful consideration of lifting, hoisting, and maneuvering, as well as establishing optimal dimensions for the framework. By aligning the design with logistical requirements, the process becomes streamlined and more seamless.

An Integrated Design Process is critical to the success of a mass timber, low-carbon building.

An Integrated Design Process is a systems-based approach that considers many elements simultaneously to optimize efficiencies and minimize carbon and energy consumption. It is a critical consideration for all buildings moving forward.

The Integrated Design Process requires all key team members to be included in the early design decisions. This may include owners, architects, structural engineers, mechanical engineers, and sustainability experts. This should also include builders and mass timber fabricators in the case of mass timber. An integrated approach is the best way to minimize waste and maximize the efficiencies of all systems.

For the prototype building design, the consultant team took an Integrated Design Approach where all members collaborated frequently and closely to determine efficiency and best value.

Mass Timber Efficiency Maximization

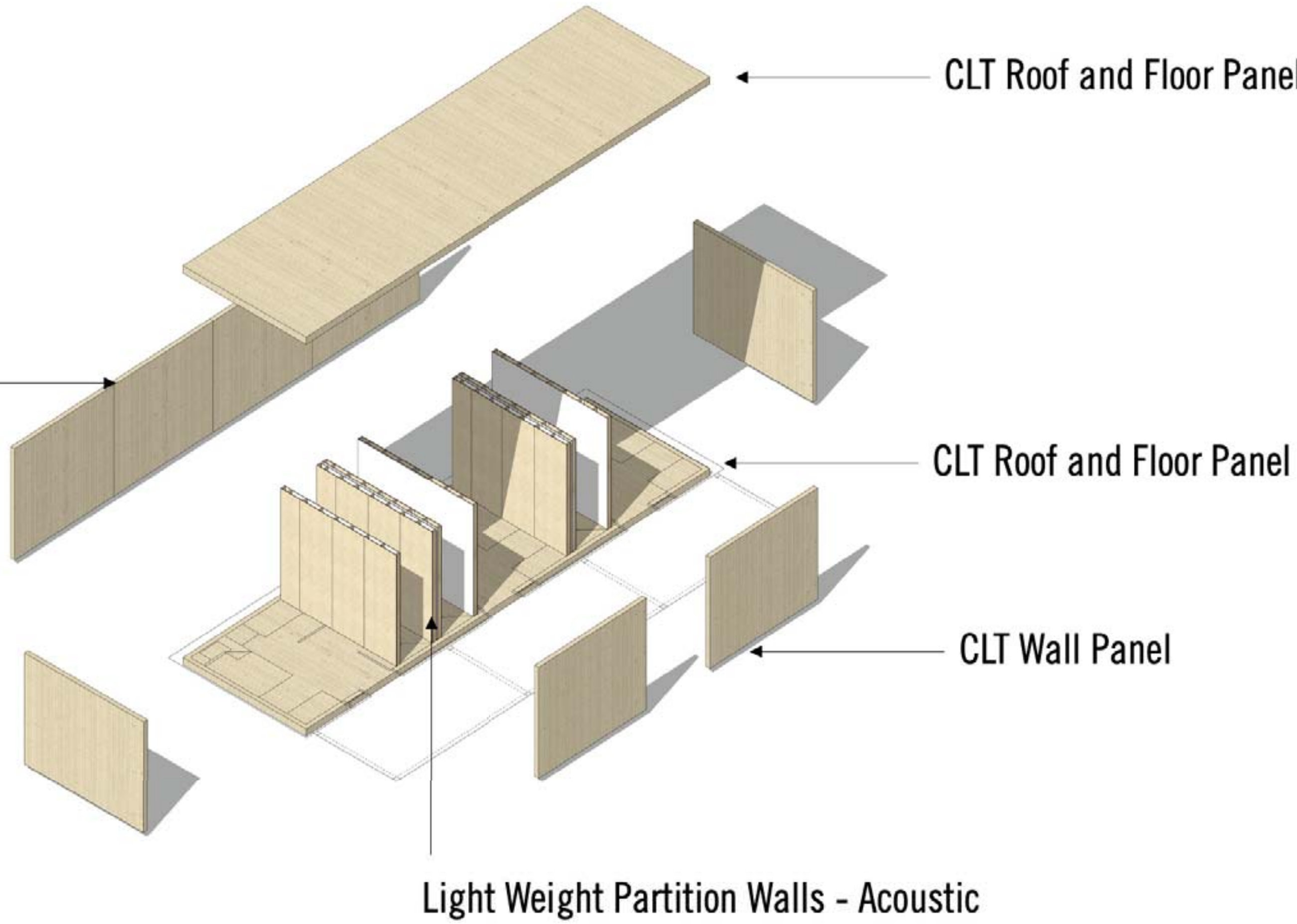
To optimize material usage and reduce waste, the width, length, and strength ratios of Cross Laminated Timber (CLT) are maximized. The incorporation of CLT floor and roof plates ensures exceptional rigidity, allowing for multiple moves without compromising structural integrity. Lightweight framed partitions are employed for interior spaces to minimize weight, and acoustic insulation is integrated to dampen sound transmission between units.

Assembly Optimization

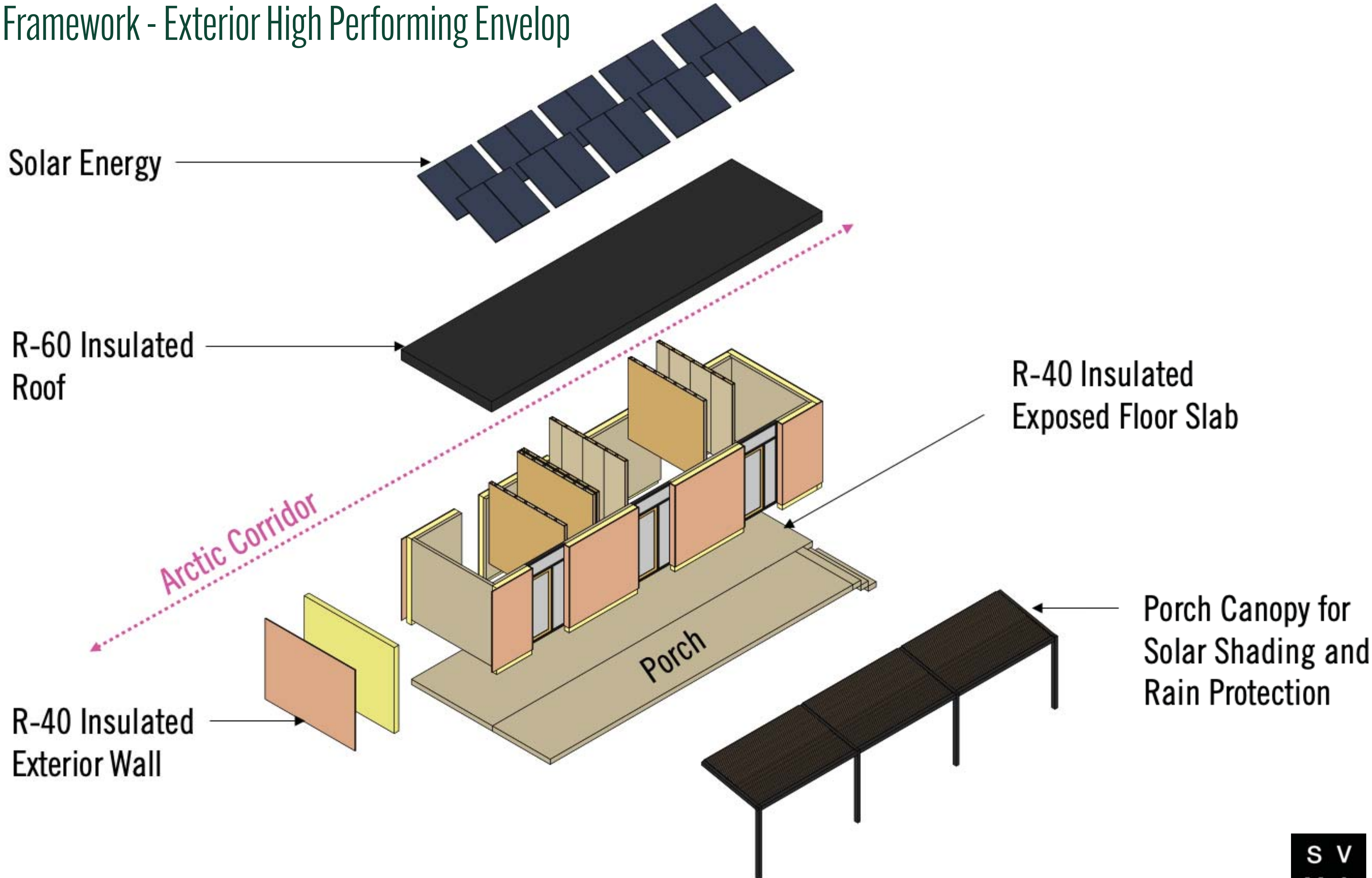
The assembly phase is carefully orchestrated to minimize crane operations and enhance speed. The strategic reduction of CLT panels simplifies and accelerates the assembly process. The design's simplicity, including the judicious reduction of Computer Numerical Control (CNC) elements—such as omitting headers above doorways—not only accelerates construction but also curtails waste generation.

Streamlining the process, the CLT panels are simplified and intricate CNC integration minimized. Certified factories, like Element 5 in St. Thomas, Ontario, can supply CLT billets which are then transported to a Thunder Bay-based factory for machining and finishing. This approach not only ensures efficient production but also generates employment, economic growth, and skills development within the local communities.

Planning Framework - CLT Structure



Planning Framework - Exterior High Performing Envelop



Conceptual view of one Living Quarter modular.

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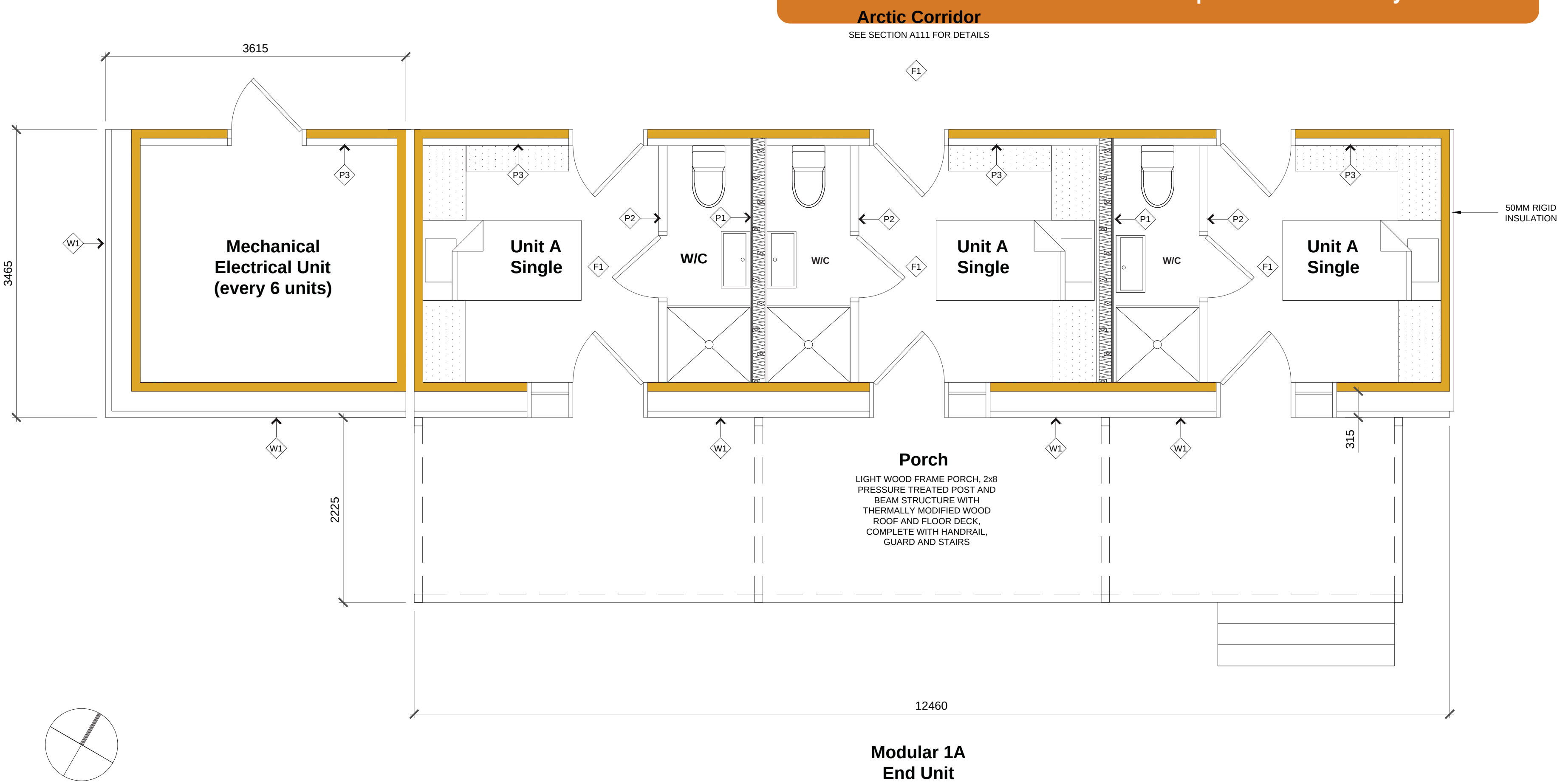
Living Quarter Module A with M/E (Service Unit)

Floor Plan

The Costing Report includes for two living quarter options, Module A (3 units) and Module B (4 units) per module.
Each module contains an end unit, centre unit and an end unit with mechanical and electrical unit to make up a cluster dormatory.



LIVING QUARTER MODULE A - THREE UNIT WITH ACCESS TO PORCH AND ARCTIC CORRIDOR
1:50

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NW MINING COMMUNITY CLT STRUCTURES
FEASIBILITY STUDY

22019 NW MINING COMMUNITY
ISSUED FOR: COSTING
REVISION:
09 AUG 2023

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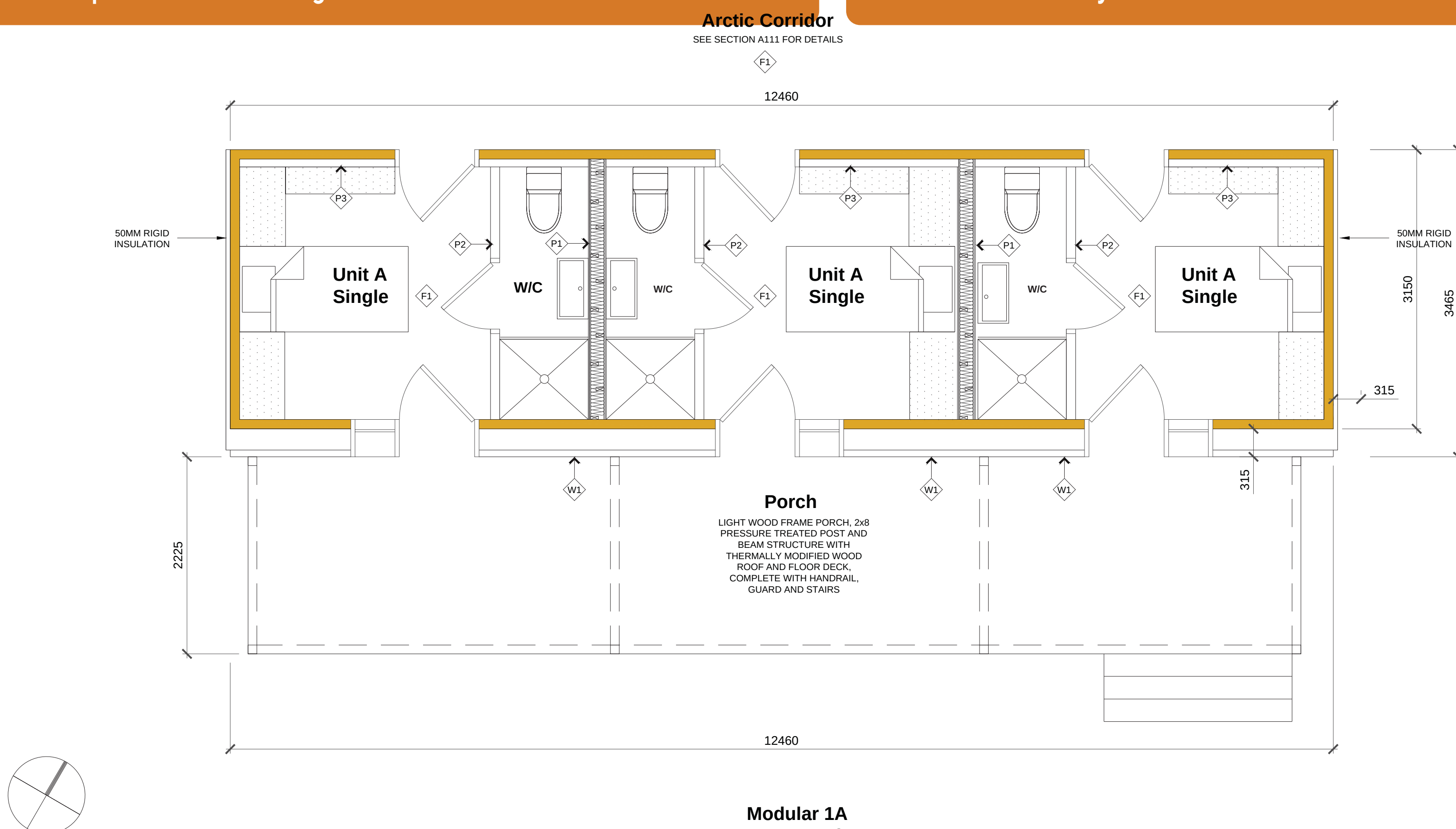
Living Quarter A includes an option for an outdoor porch (includes as an optional price), and connection to the Arctic Corridor.
The porch was described as a nice to have, and game changer in the landscape of Canadian mining communities.

The porch provides an space for workers a semi-private outdoor space as well acts as an extension to the indoor living space. Althought it can be cold in Northwestern Ontario, the porach can be enjoyed for at least 9 months of the year.



Modular 1A
Centre Unit

LIVING QUARTER MODULE A - THREE UNIT WITH ACCESS TO PORCH AND ARCTIC CORRIDOR
1:50

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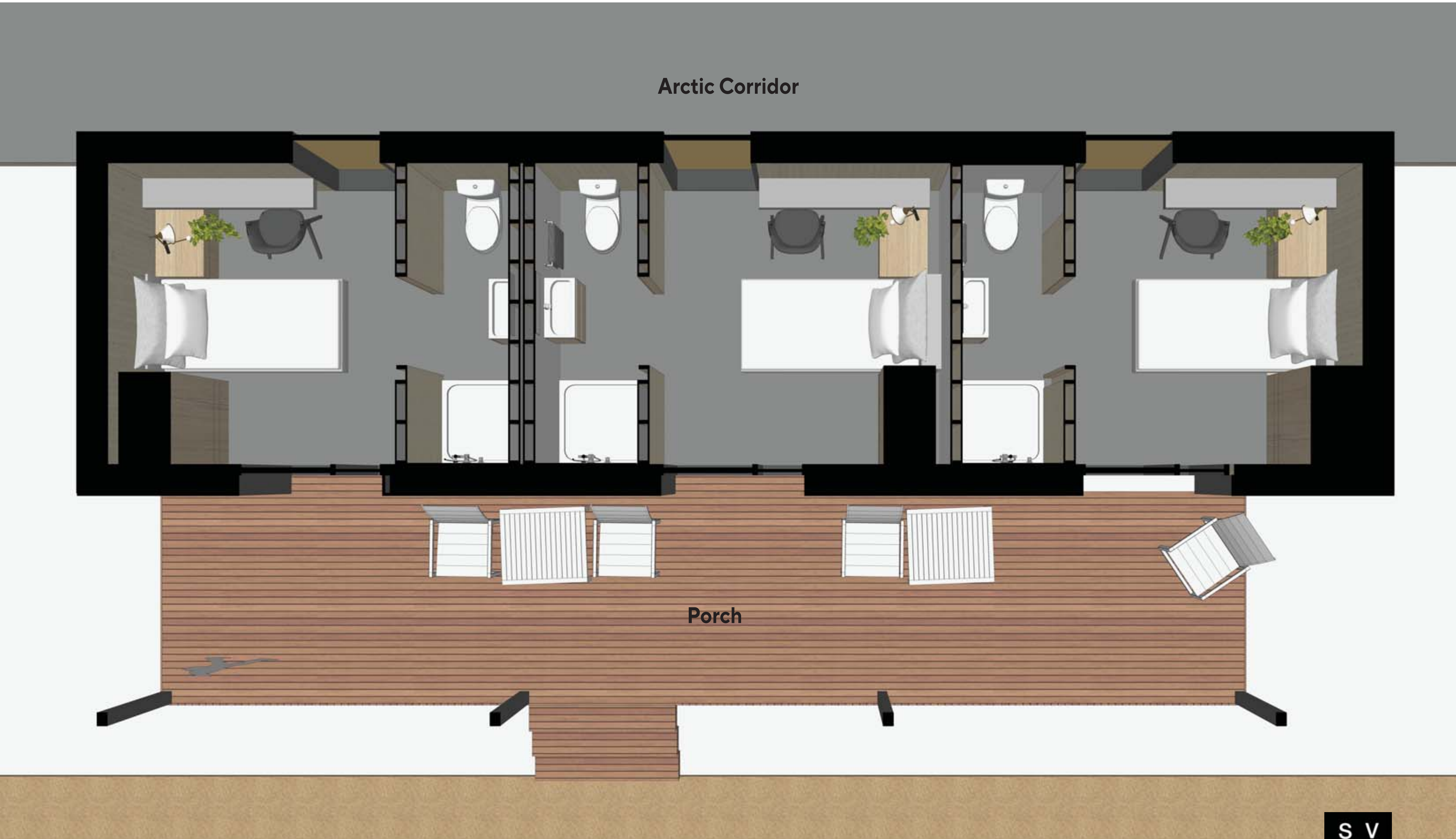


Axonometric Plan view of Living Quarter Module A (porch option), illustrating three person dorm with integrated ensuite in each.

Interior view of Living Quarter Modular A (porch option), illustrating the warm and calming effect of the exposed mass timber on the walls and ceiling. Each unit includes access to the porch and arctic corridor, as well as integrated storage space, desk and tv.

System-Based Approach

An Integrated Design Process is critical to the success of a mass timber, low-carbon building.

An Integrated Design Process is a systems-based approach that considers many elements simultaneously to optimize efficiencies and minimize carbon and energy consumption. It is a critical consideration for all buildings moving forward.

The Integrated Design Process requires all key team members to be included in the early design decisions. This may include owners, architects, structural engineers, mechanical engineers, and sustainability experts. This should also include builders and mass timber fabricators in the case of mass timber. An integrated approach is the best way to minimize waste and maximize the efficiencies of all systems.

For the prototype building design, the consultant team took an Integrated Design Approach where all members collaborated frequently and closely to determine efficiency and best value.

Optimizing the Mass Timber System

The design adopts a system-based approach to optimize the mass timber structure, employing a Cross Laminated Timber (CLT) panel system for the exterior walls, roof, and floor. Complementing this, lightweight wood framing is used for interior partitions. By utilizing this configuration, carpenter trades can efficiently install both the mass timber structure and the lightweight wood frame infill walls, thus minimizing the number of trades required on-site and mitigating the potential for schedule disruptions. Additionally, the lightweight framing integrates prefabricated

techniques, further enhancing efficiency and construction speed.
The key to reducing cost and optimizing flexibility in a mass timber structural system is to reduce the volume of wood and maximize the efficiency of the Cross Laminated Timber Structure.

Achieving cost reduction and maximizing flexibility within a mass timber structural system hinges on minimizing wood volume and optimizing the efficiency of the Cross Laminated Timber (CLT) structure. This involves streamlining complex connections and CNC machining processes. In the context of modular buildings, the durability of components gains significance due to the anticipated movement of the structures over time. Mass timber, renowned for its lightweight yet robust nature, emerges as an ideal material for transportation and lifting purposes.
During the initial stages of devising the prototype building's design solution, a pivotal discourse was held with structural engineers to determine the most suitable spacing for the Cross Laminated Timber. Collaborating with Element 5, it was determined that a derivative of the 3.1m x 15.8m (maximum for exposed surfaces) CLT panel would optimally span the mass timber structure while effectively managing factors like vibration, dead loads, and live loads. This dimensions was adopted as the typical module for various areas.

For spaces requiring a slightly broader bay, such as wet areas, a 3.45m wide unfinished CLT panel provided by Element 5 was strategically employed. This design approach significantly reduced the complexity of components and cuts, contributing to an efficient and streamlined construction process. The result is a carefully calibrated system that maximizes the benefits of mass timber, enhances durability, and simplifies the assembly of the modular building.

Plug and Play Approach to the System Design

A "plug and play" mechanical system refers to a self-contained and pre-engineered system that can be easily integrated into a larger structure or system without requiring complex installations or custom adjustments. This type of system is designed to be modular and standardized, allowing it to be quickly connected and operated without the need for extensive on-site assembly or specialized technical expertise. The term "plug and play" suggests that the components of the mechanical system are akin to plug-in devices that can be easily connected to a power source or interface, making installation and integration more efficient and user-friendly. This concept is often used in various industries, such as technology, construction, and manufacturing, to streamline the implementation of complex systems and reduce installation time and costs.

Incorporating a holistic approach to comfort and functionality, each individual living quarter unit will come equipped with pre-engineered heating, cooling, and ventilation systems. These integrated systems are designed to provide seamless and reliable climate control, ensuring the well-being and comfort of the occupants. This standardized configuration serves as the cornerstone of the heating, cooling, and ventilation distribution strategy employed in this design.

To ensure adaptability and flexibility, these mechanical systems will be structured for a "plug-and-play" setup. This design philosophy allows for the effortless relocation of the modular units to alternative suitable sites, without compromising the efficiency and functionality of the integrated systems. This modular flexibility not only enhances the long-term viability of the structures but also facilitates efficient logistics and deployment, especially in remote or challenging environments.

In fostering a sense of community and shared resources, a practical approach is adopted for clusters of living quarters. For every grouping of 6 living quarter clusters, two smaller mechanical modules will be installed. These central modules will serve as hubs, providing a shared and centralized system that caters to the heating, cooling, and ventilation needs of the connected living quarters. This smart utilization of resources not only streamlines maintenance and operation but also contributes to a more energy-efficient and sustainable living environment.

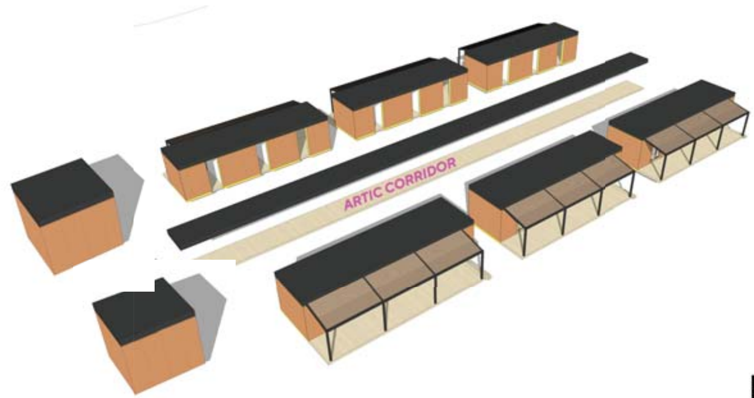
The Arctic Corridor concept plays a crucial role in this modular design, offering a sheltered passage between clusters of living quarters, which proves essential in safeguarding occupants from the harsh winter conditions. Beyond its protective function, the Arctic Corridor also serves as the central distribution spine for various services. This integration minimizes the footprint of services within individual living quarters, thereby optimizing the available space and ensuring a more spacious and comfortable interior environment.

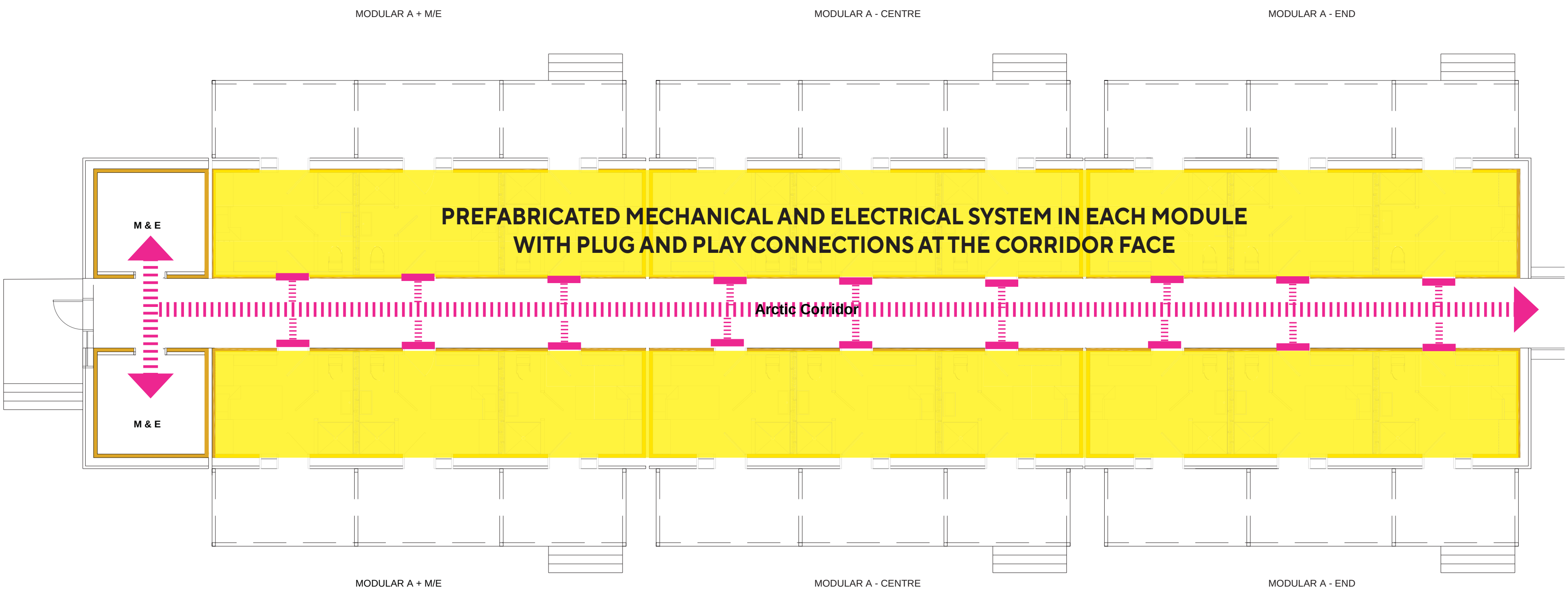
Furthermore, the interior services within each module are pre-installed, ensuring that they are ready for use upon arrival at the site. This design approach significantly reduces on-site construction time and minimizes the complexities associated with system integration. The result is a seamless and efficient assembly process that maximizes convenience and minimizes disruptions.

The innovative integration of plug-and-play mechanical systems within a modular living quarter design not only underscores the commitment to occupant comfort and well-being but also highlights the adaptability and resource efficiency that characterize this forward-looking approach. By seamlessly combining these elements, the design offers a comprehensive solution that is both practical and future-oriented.

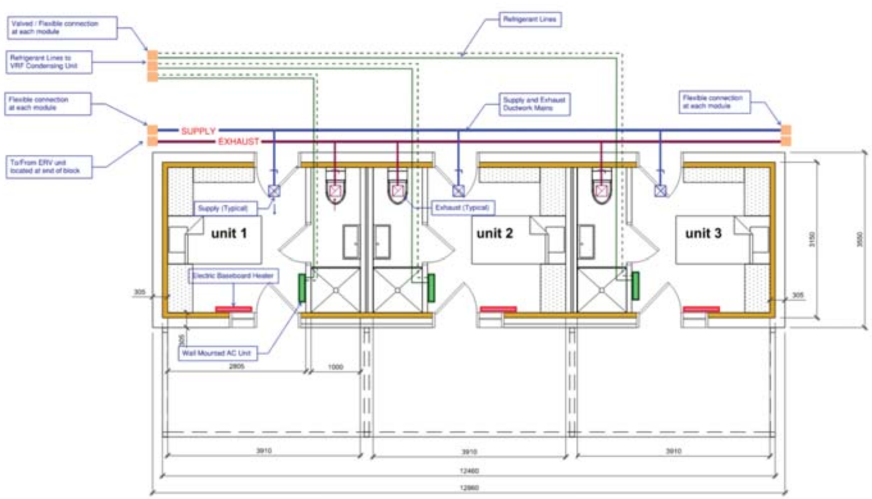
The design integrates a "Plug and Play" system approach. Each living quarter module is prefabricated with all mechanical, electrical and plumbing fit outs with a connect at the Arctic Corridor, where the main system branches are routed from the M & E service module. This allows each living module to be disconnected and move without impact.

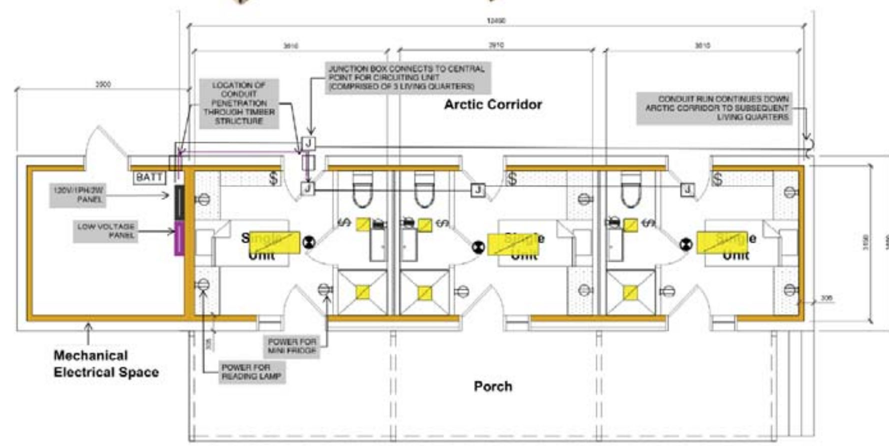
Each M&E (mechanical and electrical) room provides service to six living quarters, maximizing efficiency of the system, and saving space within each module.





Mechanical Schematic of M&E Service Room





Birds eye view of the proposed mass timber Living Quarter dormatory with optional porch and solar panels.
The living quarters are connected by an internal Arctic Corridor to protect workers from harsh winters.

Conceptional street elevation, mass timber Living Quarter dormatory with optional porch and solar panels.

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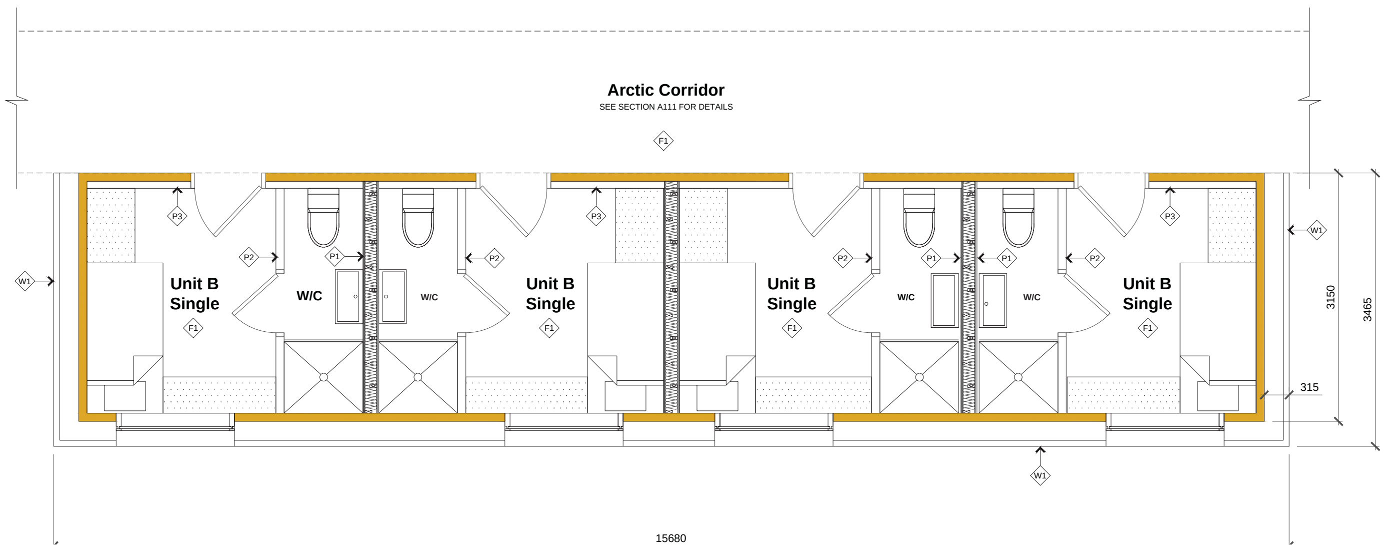
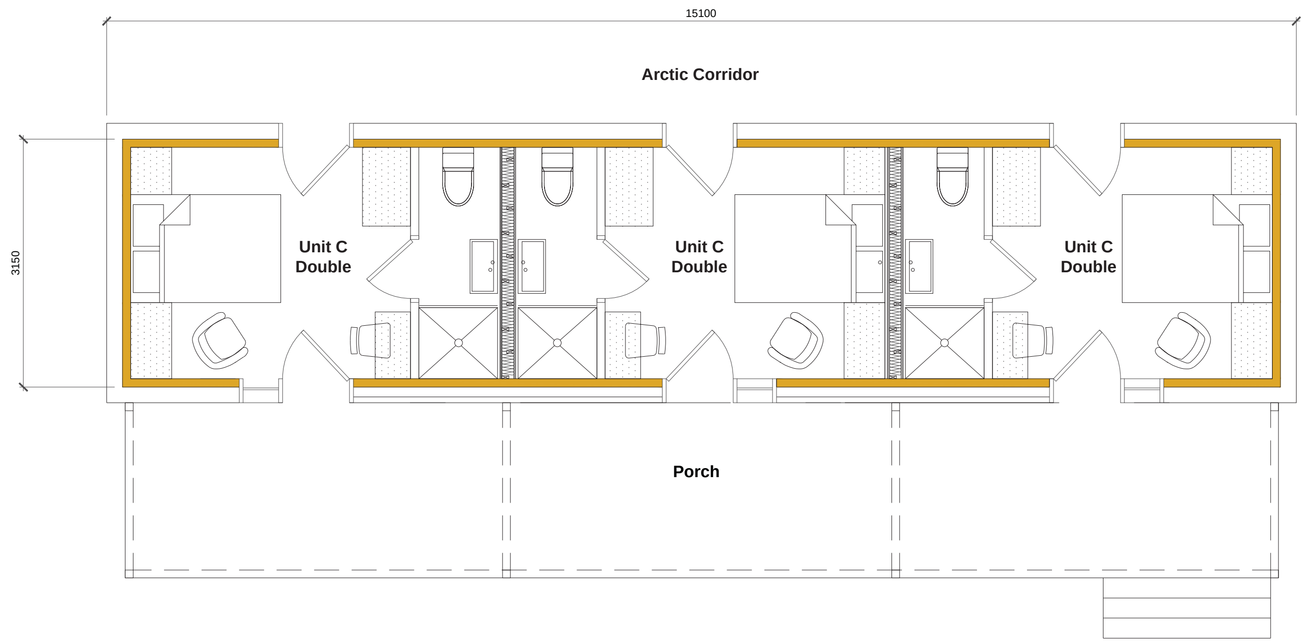
Option Floor Plans

Living Quarters Module B Option includes 4 units with integrated ensuite, and a single connect to the Arctic Corridor only.

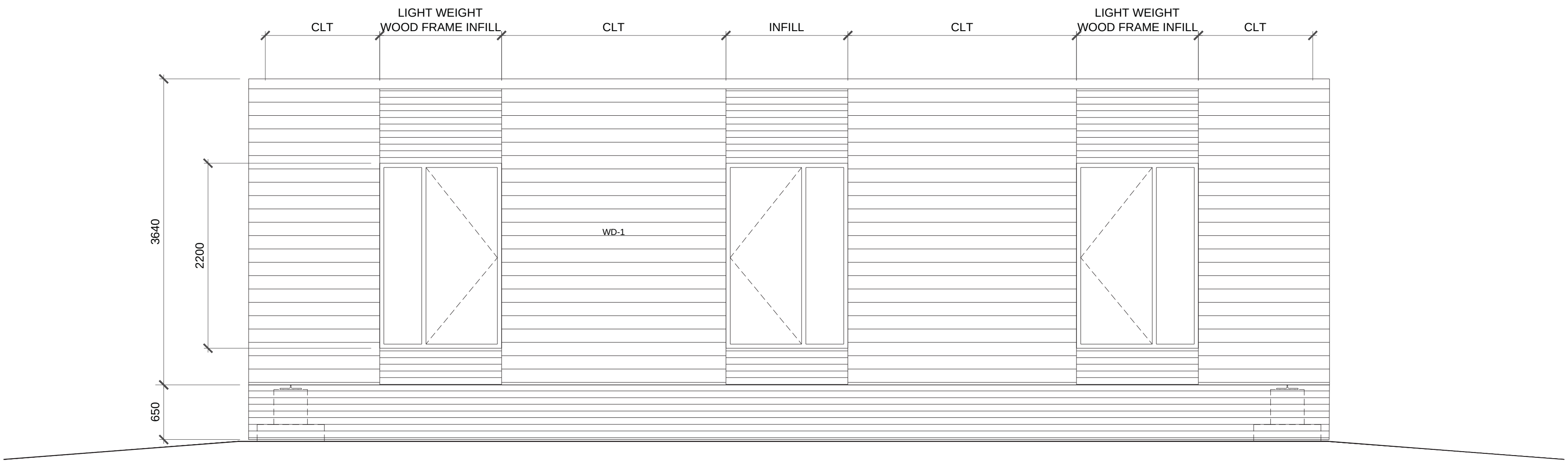


Double occupancy includes a double bed for family visits, or VIP. This option is not priced, however, would be similar costs to Living Quarter Module A option.



Living Quarter Module A with M/E (Service Unit)

Elevation



LIVING QUARTER MODULE - ELEVATION 1
1:50

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NW MINING COMMUNITY CLT STRUCTURES
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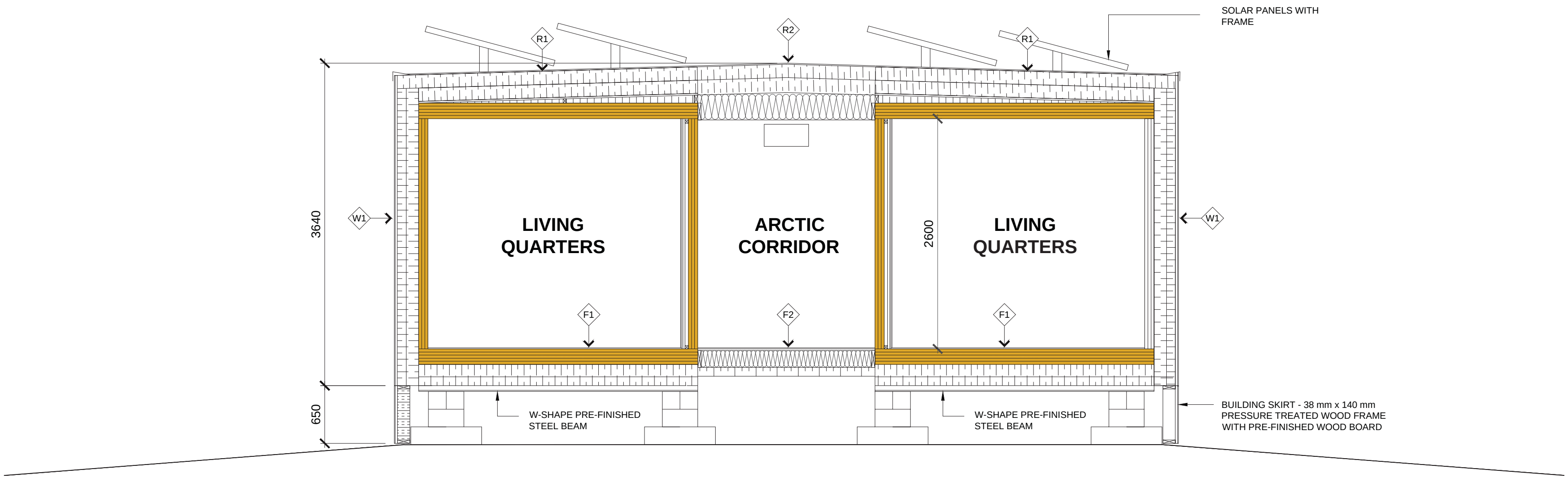
Living Quarter Module A with M/E (Service Unit)

Building Section

The design strategy includes a high performing envelop system. Although workfoce camps in the OBC do not prescribe minimum thermal performance, the design follows thermal performance for residential contruction in this cimate zone to achieve low energy design and thermal comfort.



LIVING QUARTER MODULE - SECTION THROUGH ARCTIC CORRIDOR
1:50

Thermal Performance Targets

Walls	**R35 - R50**
Roof	**R60**
Exposed Floor Slab	**R31-R45**

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North-West Ontario Mass Timber Mining Workforce Communities

Assembly Schedule
July 4, 2023

P1 - Interior Partition Assembly – Living Quarter Demising Walls (Stc 55+)

2 – 38mm X 89mm Wood Studs Spaced 406mm or 610mm o.c. staggered
With Absorptive Material **(INS-2)**
2 Layers – 13mm Gypsum Board on Each Side with Rothoblaas Silent Wall
Soundproofing and Waterproofing Membrane Bituminous Membrane between layers

Note: Use Waterproof Cement Board, Interior Side of Washroom

P2 – Interior Partition Assembly

13mm Gypsum Board
38mm X 89 mm Wood Studs
13mm Gypsum Board

P3 – Interior Partition Arctic Corridor (Stc 53)

2-Layers, 13mm Type X Gypsum Board
Resilient Channels @ 600mm o.c.
38mm X 38mm Wood Stud @ 600mm o.c. with Sound Batt Insulation

W1 – Exterior Wall Assembly (R-40)

Wood Siding **(WD-1),** Thermally Modified, Tongue and Groove
25mm Air Space with Vertical Wood Baton
240mm (9.5") Total, Rigid Stone-Wool Insulation **(INS-1),** 2- Layers, Staggered Joints,
Rockwool Comfortboard 80 (R-40), or equal
Self-Adhered Continuous AVM Barrier
105mm Cross Laminated Timber **(CLT),** 3-Ply, Spruce-Pine-Fir (SPF)

F1 – Floor Assembly Type 1 on CLT

Resilient Floor on Acoustic Matt Underlayment on
175mm Cross Laminated Timber **(CLT),** 5-Ply, Spruce-Pine-Fir (SPF)
Mechanically Fastened Continuous AVM Barrier
240mm (9.5") Total, Rigid Stone-Wool Insulation **(INS-1),** 2- Layers, Staggered Joints:
Rockwool Comfortboard 80 (R-40), or equal

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F2 – Floor Assembly Type 1 on Wood Frame

Resilient Floor on Acoustic Matt Underlayment on
19mm Plywood
38 mm x 184 mm Wood Frame with Mineral Wool Batt Insulation **(INS-5)**
Mechanically Fastened Continuous AVM Barrier
240mm (9.5") Total, Rigid Stone-Wool Insulation **(INS-1),** 2- Layers, Staggered Joints:
Rockwool Comfortboard 80 (R-40), or equal

R1 – Roof Assembly Type 1

Liquid applied roofing membrane system complete with rigid cover board: Sikalastic, or equal
150 mm Rigid Stone-Wood Insulation **(INS-4)**
150 mm Polyisocyanurate Insulation **(INS-3)**
19 mm Plywood Sheathing
2% Wood Frame Sloped at 2%
Continuous AVM Barrier on
175 mm Cross Laminated Timber **(CLT),** 3-Ply, Spruce-Pine-Fir (SPF)

R2 – Roof Assembly Type 2

Liquid applied roofing membrane system complete with rigid cover board: Sikalastic or equal
150 mm Rigid Stone-Wood Insulation **(INS-4)**
150 mm Polyisocyanurate Insulation **(INS-3)**
19 mm Plywood Sheathing
2% Wood Frame Sloped at 2%
Continuous AVM Barrier on
38 mm x 184 mm Wood Frame with Mineral Wool Batt Insulation **(INS-5)**
Prefinished wood plank (ceiling finish)

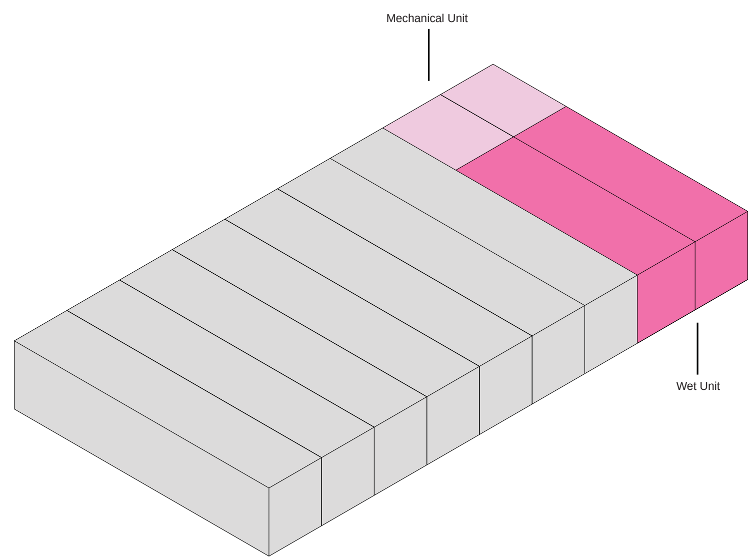
Office Building Diagram

The support buildings are designed with similar modular dimensions as the living quarters. Each CLT module is shipped to site complete and connected in a linear arrangement.

This "Kit of Parts" approach allows various configurations of the modules to allow for various uses, such as recreational facilities.

Each support building is strategically planned to consolodate the wet areas (areas of plumbing), to reduce the run of lines within the configuration, as well as contain all areas with water together.

This is beneficial for disassembing the building, as well contain areas that may require extra waterproofing.



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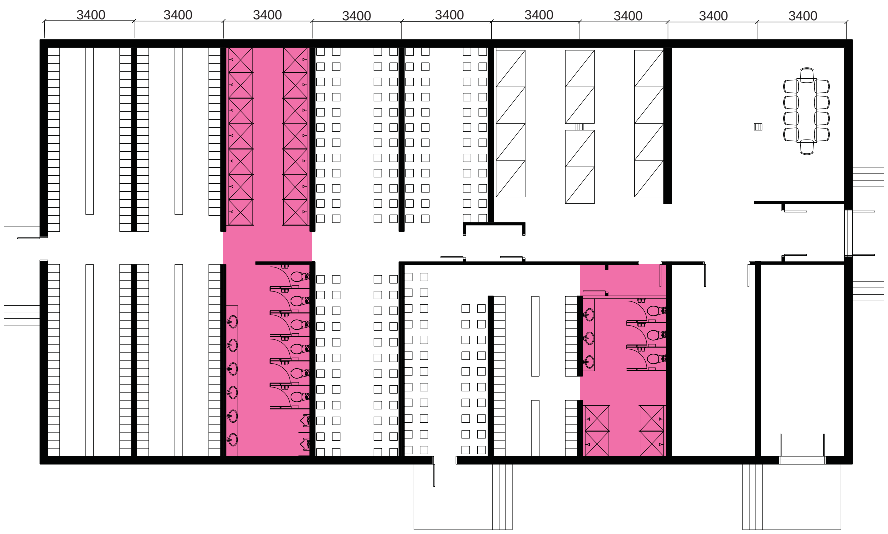
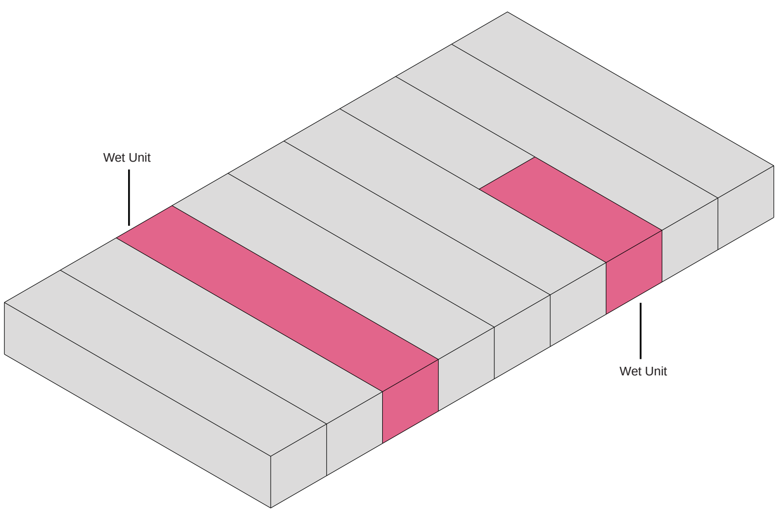
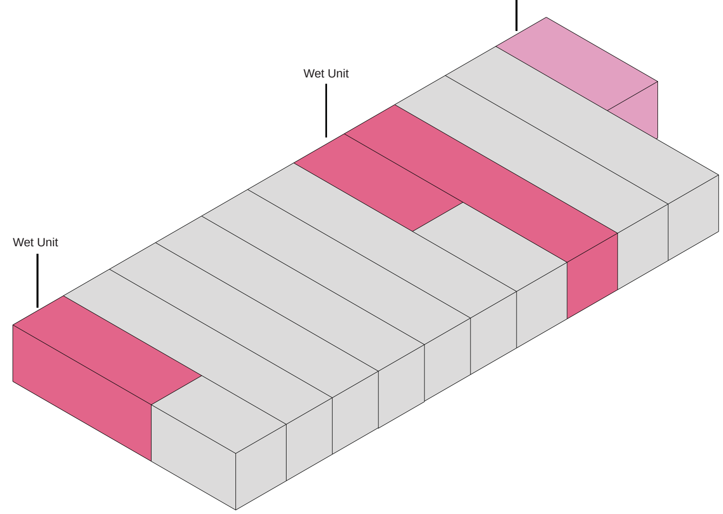
Dry House Diagram

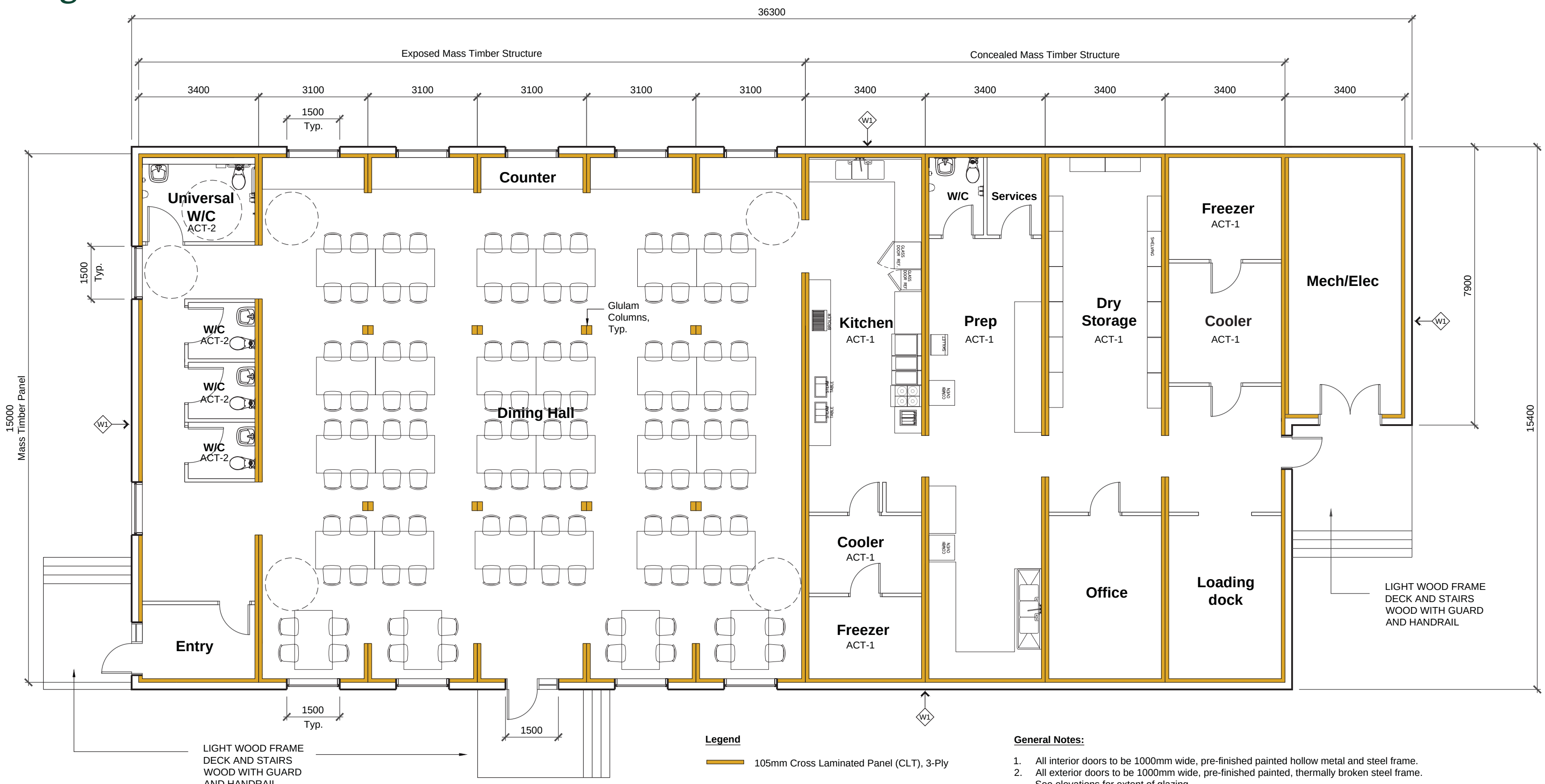




Dining Hall Diagram



Dining Hall - Floor Plan



Legend

- 105mm Cross Laminated Panel (CLT), 3-Ply
- 2 - 105mm Cross Laminated Panel (CLT), 3-Ply
- Partition Type 2, unless otherwise noted

General Notes:

1. All interior doors to be 1000mm wide, pre-finished painted hollow metal and steel frame.
2. All exterior doors to be 1000mm wide, pre-finished painted, thermally broken steel frame. See elevations for extent of glazing.
3. Resilient floor finish throughout.
4. Exposed CLT ceiling unless otherwise noted.
5. ACT-1: Anti-microbial, water repellent ceiling tiles: KITCHEN ZONE by Armstrong, or equal.
6. ACT-2: Anti-microbial, water repellent ceiling tiles: CERAMAGUARD by Armstrong, or equal.
7. ACR-1: Acrylic Solid Surface Wall Panel as wall covering in wet rooms.

DINING HALL AND KITCHEN PLAN
1:125

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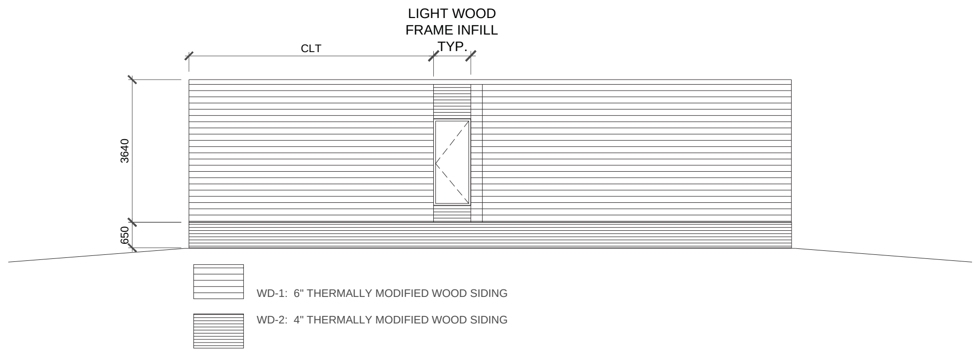
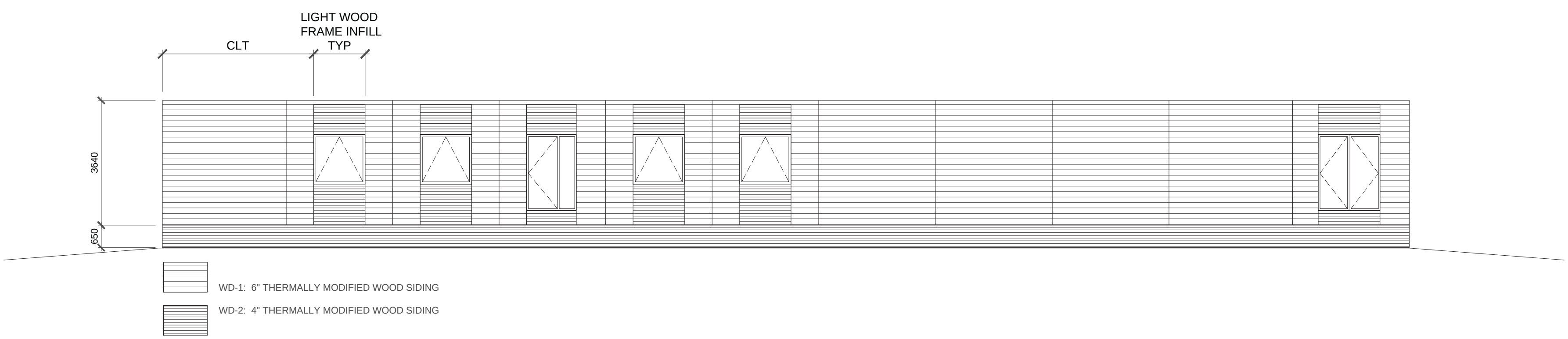
Dining Hall - Elevations



DINING HALL AND KITCHEN ELEVATION - EAST
1:125



DINING HALL AND KITCHEN ELEVATION - SOUTH
1:125

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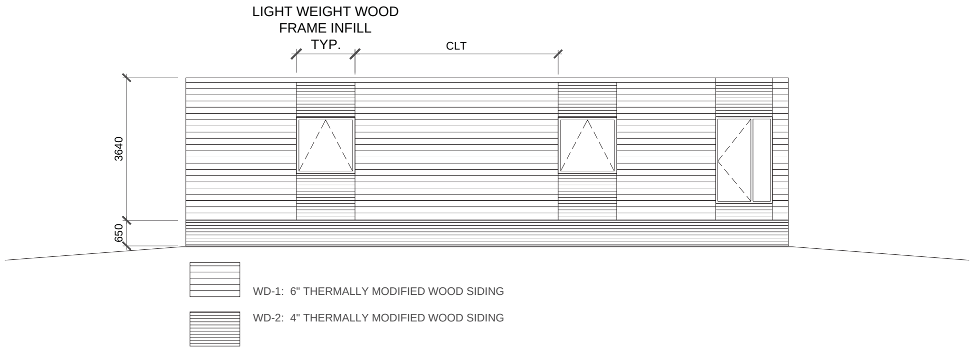
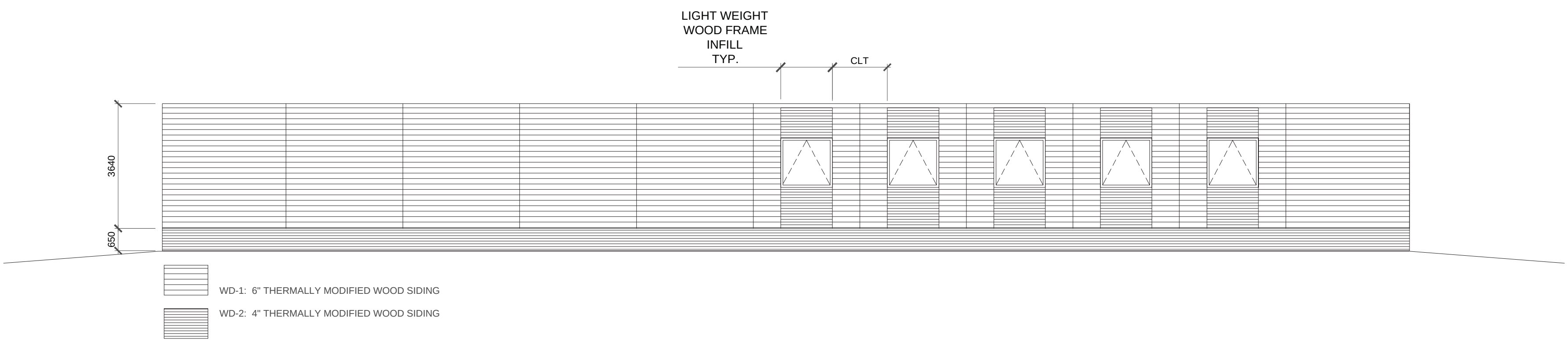
A210

Dining Hall - Elevations



DINING HALL AND KITCHEN ELEVATION - WEST
1:125



DINING HALL AND KITCHEN ELEVATION - NORTH
1:125

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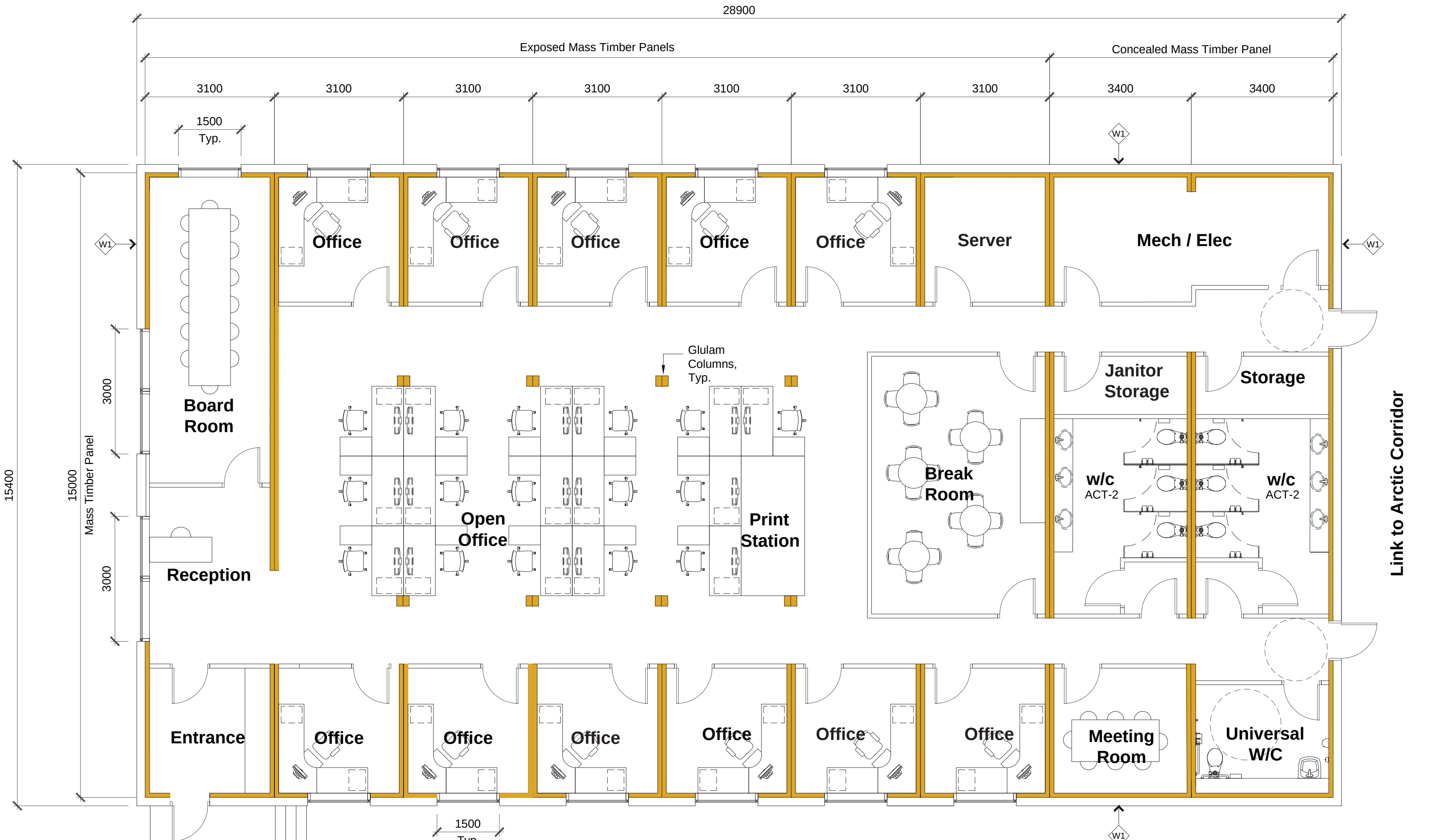
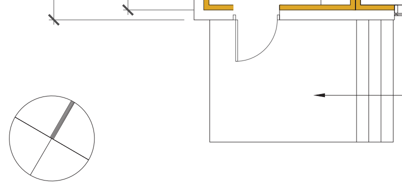
Office - Floor Plan





Legend

- 105mm Cross Laminated Panel (CLT), 3-Ply
- 2 - 105mm Cross Laminated Panel (CLT), 3-Ply
- Partition Type 2, unless otherwise noted

General Notes:

1. All interior doors to be 1000mm wide, pre-finished painted hollow metal and steel frame.
2. All exterior doors to be 1000mm wide, pre-finished painted, thermally broken steel frame. See elevations for extent of glazing.
3. Resilient floor finish throughout.
4. Exposed CLT ceiling unless otherwise noted.
5. ACT-1: Anti-microbial, water repellent ceiling tiles: KITCHEN ZONE by Armstrong, or equal.
6. ACT-2: Anti-microbial, water repellent ceiling tiles: CERAMAGUARD by Armstrong, or equal.
7. ACR-1: Acrylic Solid Surface Wall Panel as wall covering in wet rooms.

OFFICE PLAN
1:100

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NW MINING COMMUNITY CLT STRUCTURES
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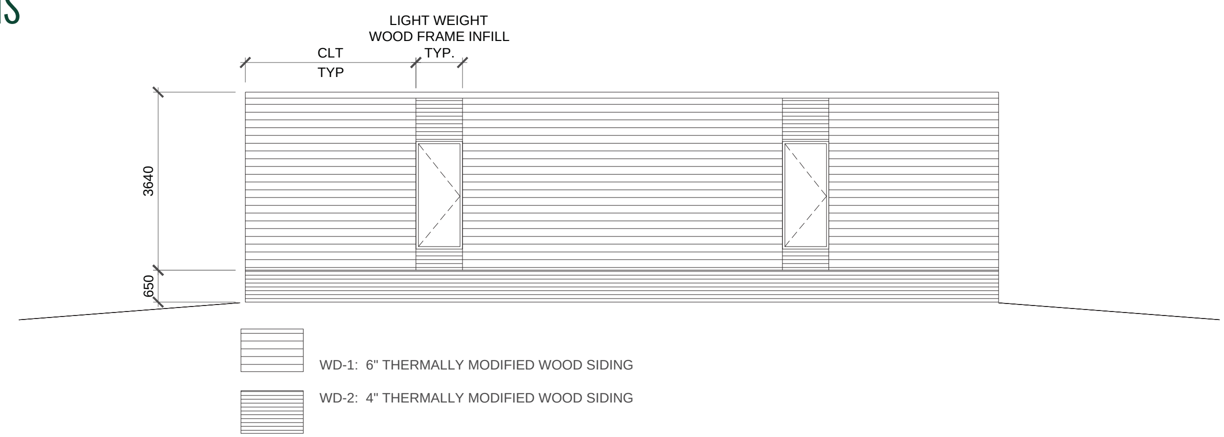
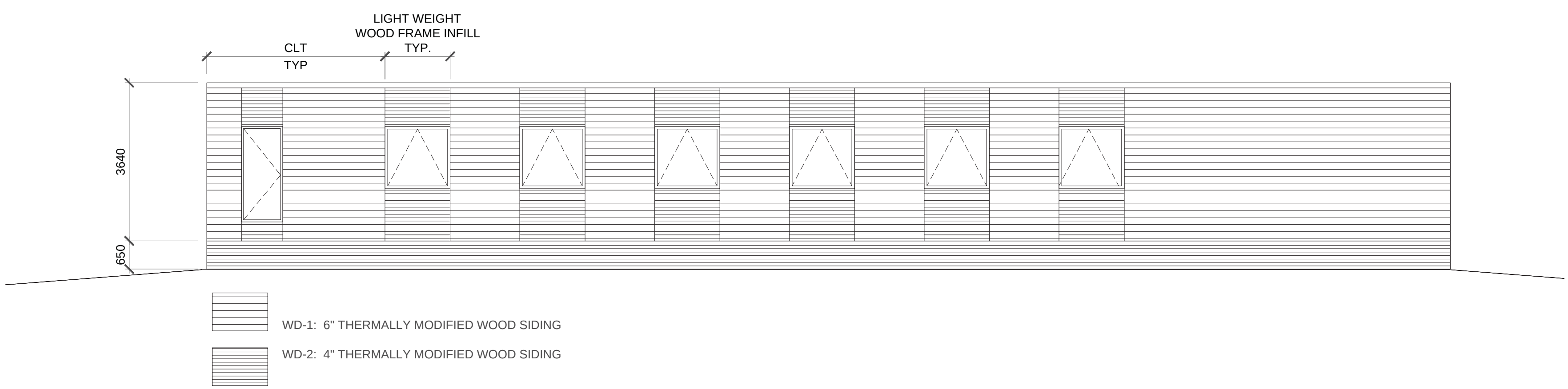
Office - Elevations



OFFICE ELEVATION - EAST
1:100



OFFICE ELEVATION - SOUTH
1:100

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NW MINING COMMUNITY CLT STRUCTURES
FEASIBILITY STUDY

2219 NW MINING COMMUNITY
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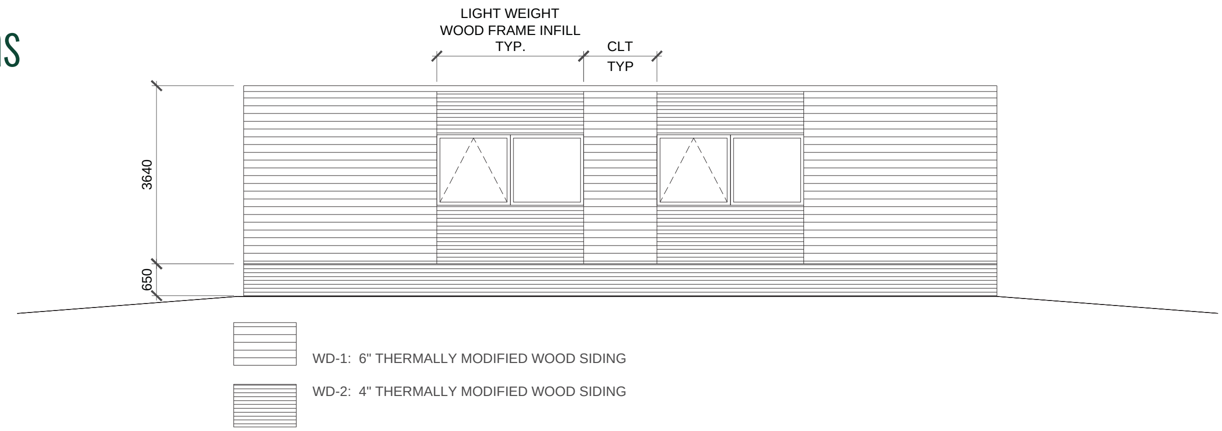
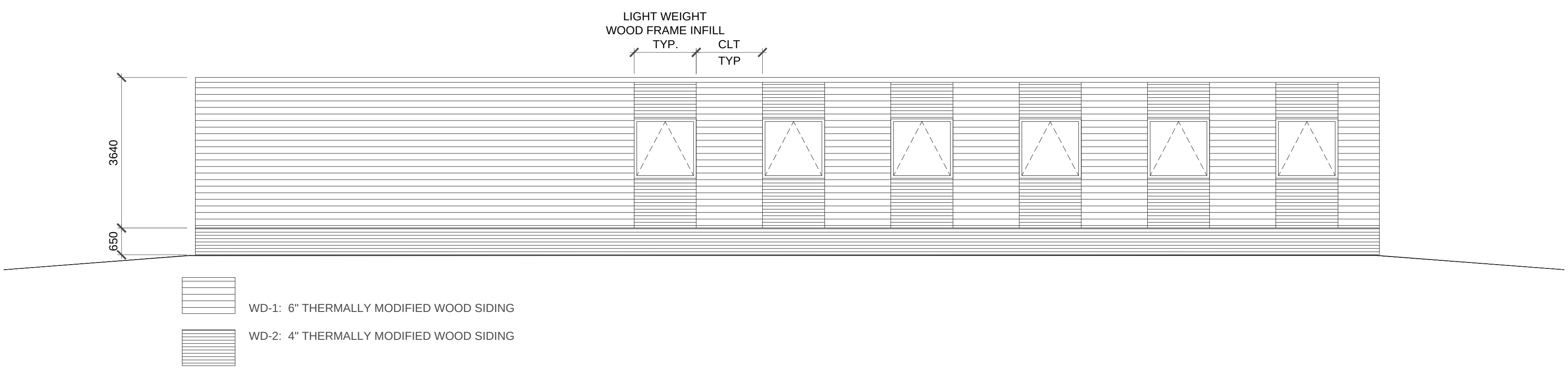
A310

Office - Elevations



OFFICE ELEVATION - WEST
1:100



OFFICE ELEVATION - NORTH
1:100

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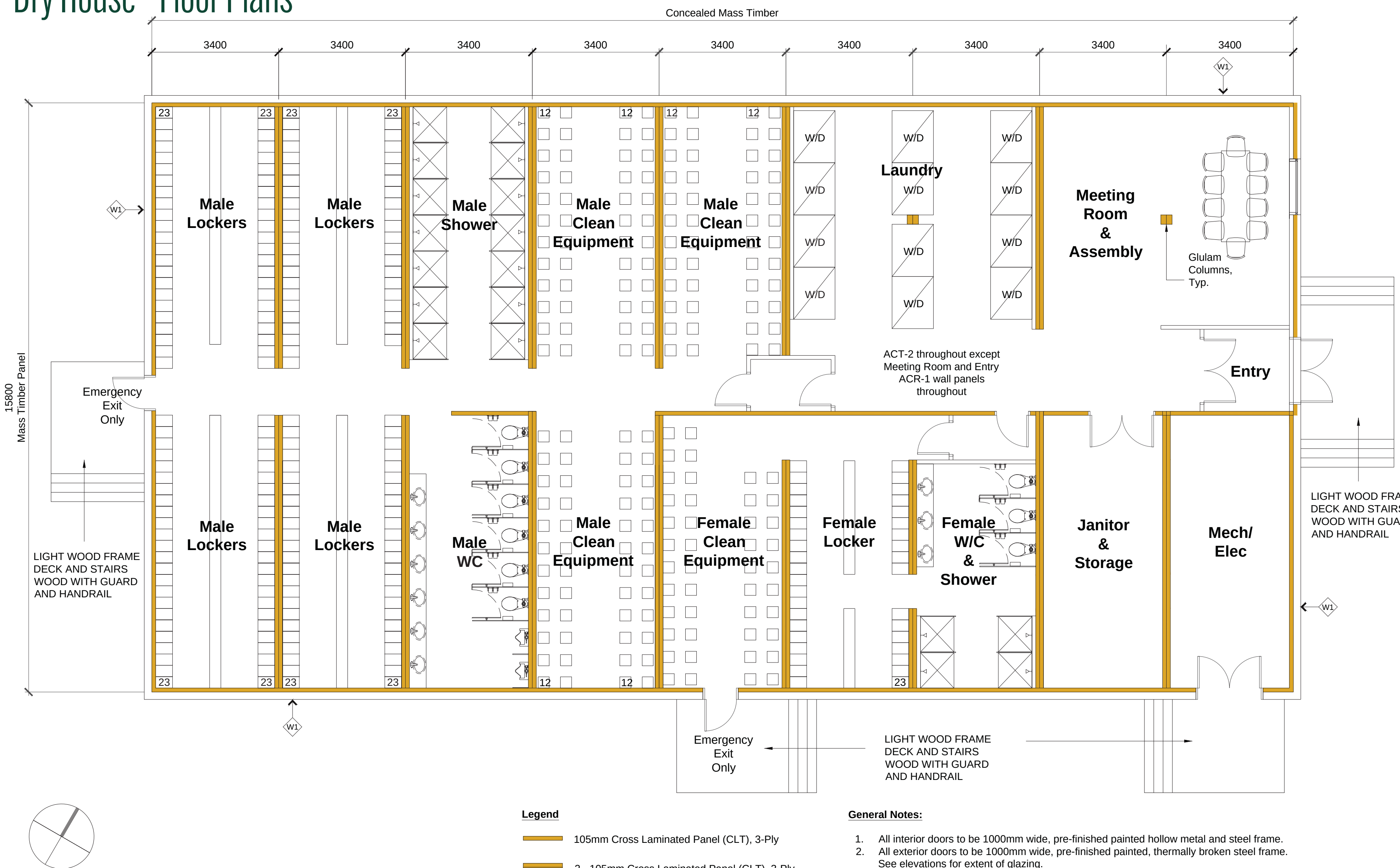
Dry House - Floor Plans



DRY HOUSE PLAN

Legend

- 105mm Cross Laminated Panel (CLT), 3-Ply
- 2 - 105mm Cross Laminated Panel (CLT), 3-Ply
- Partition Type 2, unless otherwise noted

General Notes:

1. All interior doors to be 1000mm wide, pre-finished painted hollow metal and steel frame.
2. All exterior doors to be 1000mm wide, pre-finished painted, thermally broken steel frame. See elevations for extent of glazing.
3. Resilient floor finish throughout.
4. Exposed CLT ceiling unless otherwise noted.
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NW MINING COMMUNITY CLT STRUCTURES
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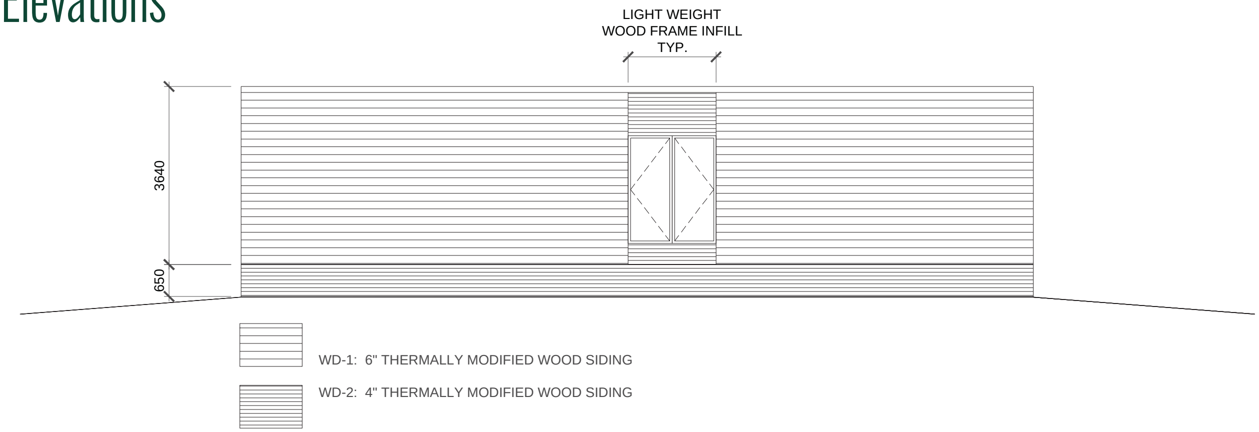
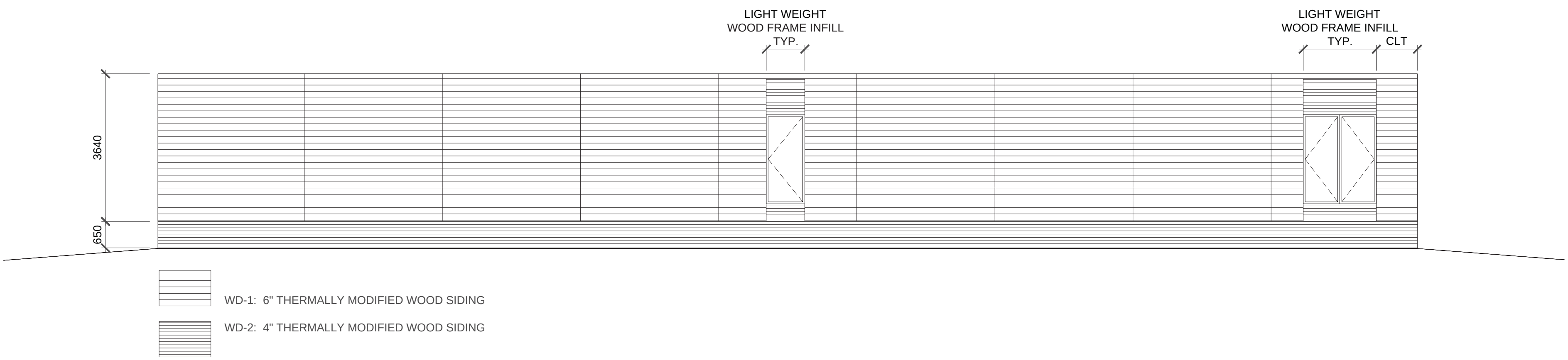
Dry House - Elevations



DRYHOUSE ELEVATION - EAST
1:100



DRYHOUSE ELEVATION - SOUTH
1:100

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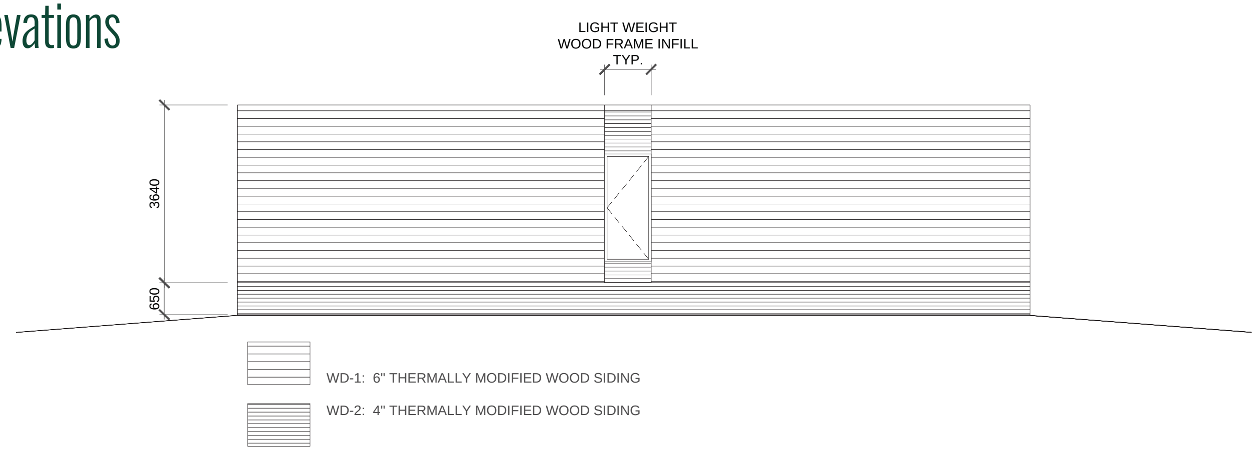
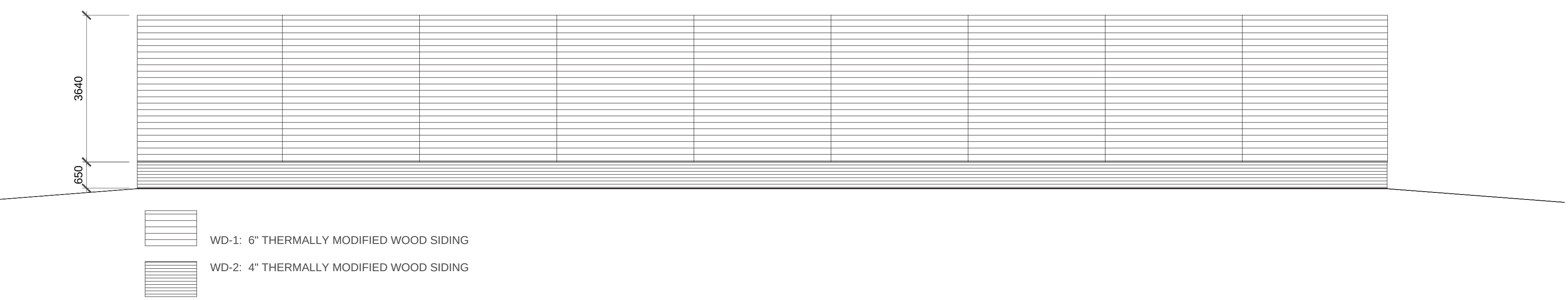
Dry House - Elevations



DRYHOUSE ELEVATION - WEST
1:100



DRYHOUSE ELEVATION - NORTH

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Cost Analysis

Class D and Costing Summary

Living Quarter Module Option A - Three Unit Module

Total Modules = 84 (Three units in each module)
Occupancy = 252 people

Total Offsite Thunder Bay Costs	$ 27, 969, 200
Average Cost per Unit:	$ 332, 966
Transportation Cost	$ 1, 814, 400
Onsite Camp Costs	$ 2, 917, 600
Total Cost for 84 Modules	**$ 32, 701, 200**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Living Quarter Module Option B - Four

Total Modules = 63 (Four units in each module)
Occupancy = 252 people

Total Offsite Thunder Bay Costs	$ 26, 065, 200
Average Cost per Unit:	$ 413, 733
Transportation Cost	$ 1, 476, 300
Onsite Camp Costs	$ 2, 505, 300
Total Cost for 84 Units	**$ 30, 046, 800**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Porch

Total Modules = 84
Onsite site fabrication

Total Onsite Cost for 84 Units	**$ 2, 923, 200**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Arctic Corridor

Assuming 200 LM at 2m wide
Onsite site fabrication

Total Onsite Cost for 84 Units	**$ 5, 738, 240**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Dining Hall - 11 Modules (1 building)

Total Offsite Thunder Bay Costs	$ 2, 651, 700
Transportation Cost	$ 237, 900
Onsite Camp Costs	$ 361, 000
Total Cost for 84 Units	**$ 3, 250, 600**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Office Buildling - 9 Modules (1 building)

Total Offsite Thunder Bay Costs	$ 2, 306, 600
Transportation Cost	$ 194, 700
Onsite Camp Costs	$ 342, 500
Total Cost for 84 Units	**$ 2, 843, 800**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Dry House - 9 Modules (1 building)

Total Offsite Thunder Bay Costs	$ 2, 654, 500
Transportation Cost	$ 194, 700
Onsite Camp Costs	$ 315, 200
Total Cost for 84 Units	**$ 3, 164, 400**

(includes Ancillary Work, General Requirements & Fee, and Allowances)

Costing Conclusion: Prioritizing Long-Term Value and Performance

The pursuit of long-term value and sustained performance stands as a central consideration within this study. Emphasizing durability and future adaptability of modular units, particularly the prospect of relocating these units over time, holds significant importance. During the mine's construction phase, the site's population may extend to approximately 250 individuals, while operational periods could see a reduction to around 110 people. A noteworthy observation is that nearly 50% of the living units could be rendered inactive within five years, underscoring the necessity for structures that can be efficiently reused or repurposed within a short timeframe.

To effectively address these dynamics, the design strategy embraces key elements:

Utilizing mass timber as the primary framing material, harnessing its rigidity, resilience, and capacity to withstand multiple relocations without compromising structural integrity.

Crafting units for seamless disassembly, ensuring that all components remain intact and functional.

Employing plug-and-play mechanical and electrical systems that can be detached with ease at the connection point to the arctic corridor, facilitating maintenance and adaptability.

The intrinsic value of mass timber

Its long-term salvage value surpasses that of conventional light frame construction.

The inherent rigidity of mass timber engenders a robust structure capable of withstanding diverse conditions.

The integration of a high-performance envelope contributes to conforming to stringent occupancy standards, reducing energy consumption, and augmenting long-term value through life cycle considerations.

Moreover, the longevity of these units is notable:

With proper maintenance practices, mass timber structures can endure for more than 50 years, extending their life cycle and enhancing the economic and sustainable impact of the project.

Total Estimated Construction Costs

252 occupancy
Option: Module A with Porch and Support Buildings
(includes Arctic Corridors attached to Living Quarters)

Total Off Site Thunder Bay	**$ 35, 582, 000**
Transport Modules	**$ 2, 441, 700**
On Camp Site	**$ 12, 643, 740**
Total	**$ 50, 667, 440**

Itemized Costs Excluded from Base Cost

Additional 200 LM Arctic Corridor	$ 1, 550, 500
Solar Panels (Modular A)	$ 5, 334, 000

Assumptions:
* We assume that project will be tendered as a single contract
** Escalation allowance is excluded in this estimate
*** Construction allowance is excluded in this estimate

Cost Comparison between CLT Modular Construction, Traditional Stick-Built Wood Frame Construction Rental Option

CLT Modular Construction (Module 1A)	$ 50, 667, 440
CLT Modular Construction (Module 1B)	$ 44, 773, 040
Traditional Stick-Built Wood Frame	$ 40, 029, 265
Rental Option over 25 years	$ 38, 200, 000

Costing does not include:

This Order Of Magnitude Estimate does not provide for the following, if required

- Site Works (Site Preparation, Development and M/E Site Services)
- Earth Works
- Foundation Works
- Utility Service Tie-ins to Modular Building Facilities
- Residential and Commercial Kitchen Equipment
- Equipment beyond that identified in this estimate
- Window Treatment
- Special audio, visual, security equipment or installation other than carried in
- electrical division
- Financing costs
- Loose furniture, furnishings and equipment
- Value-added tax (e.g. Harmonized Sales Tax, Goods and Services Tax, or other)
- Premiums associated with Public-Private Partnership procurement model
- Trade tariffs
- Third party commissioning costs
- Cash allowance
- Overtime premiums for work done outside normal working hours
- Phased construction premium
- Construction Contingency Allowance
- Escalation Contingency Allowance
- Soft Costs
  - Building permit
  - Development charges
  - Easement costs
  - Fund raising costs
  - Land acquisition costs and impost charges
  - Legal fees and expenses
  - Owner's staff and associated management
  - Preventative maintenance contracts
  - Professional fees and expenses
  - Relocation of existing facilities, including furniture and equipment
  - Right of way charges
  - Value-added tax (e.g. Harmonized Sales Tax, Goods and Services Tax, or other)
- unexpected labour unavailability and productivity disruptions leading to delays and added costs
- supply chain disruptions leading to delays and added costs

Refer to Appendix A, for full costing report and details

Embodied Carbon Analysis

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North-West Ontario Workforce Communities
Whole Building Life-Cycle Assessment Report

Prepared By:
Studio VMA Inc.
Toronto, Ontario

Prepared For:
Thunder Bay Community Economic Development Commission (CEDC)

August 25, 2023

STUDIO VMA INC.

1 Project Description

The Workforce Community for North-Western Ontario is a visionary project comprising a series of Mass Timber, Low Carbon buildings, conceptualized in North-Western region of Ontario, north of Thunder Bay. This initiative is a crucial component of a study aimed at assessing the feasibility of mass timber-based buildings for mining communities. The primary focus of this development will be on providing living quarter spaces, complemented by essential support structures such as a dining hall, office, and dry house.

To facilitate a comprehensive Whole Building Life Cycle Assessment (LCA), our analysis concentrated on a single Living Quarter unit, allowing for a comparative assessment against a conventional building design based on traditional methodologies. The primary objective of this LCA is to compare the embodied carbon emissions between the customary building typologies employed in mining and other workforce communities and the proposed mass timber, low carbon architectural approach.

The single living unit module was designed to accommodate three people. It is the understanding that the Workforce Community will be approximately 200-250 people. For simplicity, scaling up the outcome of this LCA exercises is a matter of multiplying the outcomes by the required number of units to accommodate the occupancy. While this approach simplifies the scaling process, it provides a practical way to estimate the larger environmental implications of choosing one building option over another for the entire Workforce Community.

In pursuit of this assessment, preliminary digital drawings played a pivotal role in quantifying the components of the buildings. The foundation of our LCA model relies on industry-standard or generic data applicable to the North American region, provided through the OneClick LCA platform. Whenever feasible, we incorporated specified products or utilized generic Canadian resources. In cases where Canadian data was unavailable, we resorted to using generic data from the United States to estimate emissions associated with building materials.

2 Whole Building Life Cycle Assessment

2.1 Intent

The intent of conducting Whole Building Life Cycle Assessments (LCAs) is to comprehensively evaluate the environmental impact of a building throughout its entire life span, from construction and operation to eventual or disposal. This assessment aims to quantify and understand the various aspects of a building's environmental footprint, including resource use, energy consumption, emissions, and waste generation. By conducting a Whole Building LCA, stakeholders can make informed decisions to optimize building design, construction methods, and operational practices to minimize environmental harm and promote sustainability. This process helps identify opportunities to reduce embodied and operational carbon emissions, conserve resources, and create more sustainable and environmentally friendly buildings.

2.2 Background

The holistic assessment of a building material's embodied carbon footprint considers the cumulative greenhouse gas emissions stemming from its entire lifecycle. This encompasses various stages, including extraction, transportation, refining, processing, assembly, installation, ongoing operations, decommissioning, and eventual disposal.

While there has been notable progress in understanding and mitigating operational emissions in recent years, a substantial portion of embodied carbon emissions still remains unaddressed. These emissions, and their contribution to climate change, currently constitute a relatively minor segment of the overall carbon footprint of an average building. However, their significance is expected to increase as operational emissions decrease in buildings over time.

3 Life Cycle Assessment Methodology

3.1 About Life Cycle Assessment for Construction Industry

As awareness of environmental concerns grows among businesses, governments, and the public, the spotlight increasingly falls on industries with the most significant environmental footprints. The construction sector is a prime example, accounting for 40% of global carbon emissions. It's also a leading consumer of raw materials, responsible for half of all raw material extraction, and a major contributor to mass displacement and transfer activities. Consequently, there's a pressing need for the industry to not only lower its carbon footprint but also to minimize resource depletion, particularly of non-renewable materials, through circular economy practices.

Life Cycle Assessment (LCA) offers a scientific approach to evaluating environmental performance. This methodology adheres to globally recognized standards and utilizes well-defined, public frameworks to quantify environmental impacts. These impacts are expressed in terms of their potential damage to ecosystems, including air, soil, and water. The measurements are usually presented in normalized units, such as the equivalent of one kilogram of carbon dioxide for global warming potential.

LCA takes a comprehensive view, examining the environmental impact throughout a building's entire life cycle—from material production and transportation to usage and eventual disposal. This provides a holistic understanding of how resources are consumed, and emissions are generated over the complete life span of a building.

The most commonly assessed impact in LCA is Global Warming Potential (GWP), often referred to as a building's carbon footprint. This quantifies the effect of greenhouse gas emissions on global temperatures, providing a focused measure of the construction industry's contribution to climate change.

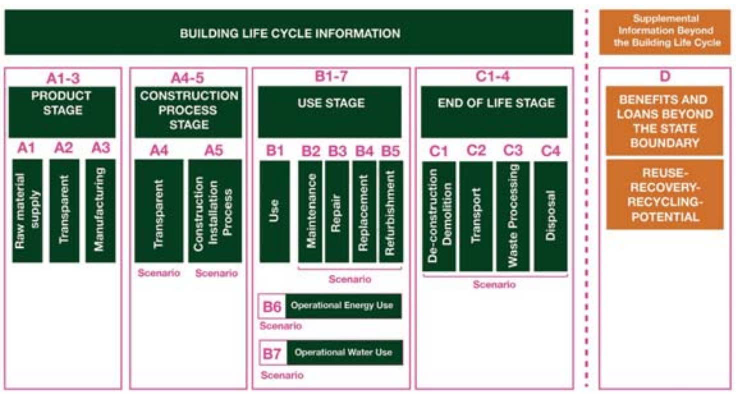
3.2 Applicable International and European Standards

All Life Cycle Assessments for building and civil engineering projects conducted through the One Click LCA platform adhere to the subsequent international standards:

- ISO 14040: Principles and Framework for Environmental Management and Life Cycle Assessment
- ISO 14044: Environmental Management and Life Cycle Assessment - Requirements and Guidelines
- ISO 21930: Core Rules for Environmental Product Declarations in Buildings and Civil Engineering Works

3.3 System Boundary

The International Standard ISO 21930 standard and the European EN 15804 standard establish a unified life-cycle model for projects in the building and construction sectors. This model features modular sections for each stage of the life cycle, enabling stage-by-stage comparisons with other projects. In building-level assessments, the product stage data (A1-A3) is typically aggregated, as are the end-of-life stages (C1-C4) in most instances. Depending on the specific objectives of the Life Cycle Assessment, some stages might be excluded or substituted with hypothetical scenarios if detailed information is lacking.



3.4 Impact Categories

The findings from Life Cycle Assessments (LCAs) are derived through a process known as characterization, which quantifies the environmental impact of specific emissions. One Click LCA employs a variety of such characterization methods. For North American clients, when no particular method is required, One Click LCA utilizes the TRACI 2.1 methodology as established by the United States Environmental Protection Agency.

Impact Category	Unit (s)	Description
Global Warming Potential	kgCO_2eq	The term "carbon footprint" refers to the impact of greenhouse gas emissions on local, regional, or global surface temperatures. These emissions primarily result from burning fossil fuels and lead to an increased concentration of greenhouse gases in the atmosphere. The emissions are closely linked to other environmental issues, such as acidification and smog formation.

4 Study Parameters

4.1 Building Description

Utilizing the OneClick LCA platform, a foundational model was developed that reflects the design specifications of the Mass Timber, High Performance Living Quarter. This model ensures consistency in key parameters such as building geometry, total square footage, and directional orientation between the Baseline and the Mass Timber, Low Carbon design.

Quantity take-offs for building components were conducted using AutoCAD and 3D model drawings of the building's design. The Life Cycle Assessment (LCA) model adheres to industry standards and utilizes generic data relevant to North American regions. Wherever specific materials were indicated, they were incorporated into the model as much as possible. In cases where such specific data was unavailable, generic resources based on Canadian standards were used as the next best option. If Canadian data was also not accessible, generic data from the United States was employed to account for the material emissions.

4.2 Description of the Mass Timber, Low Carbon Building

To enable a fair comparison of material impacts and building assemblies, both the Mass Timber and the Baseline Building were analyzed using identical parameters—specifically, the same orientation, size, and function.

To streamline the study, a single, standalone unit of the Living Quarter module was examined.

4.2.1 Mass Timber, Low Carbon Module

The Mass Timber module features a structural frame made of Cross Laminated Timber (CLT) for the walls, as well as the roof and floor assemblies. Considering the climatic conditions of the region, a high-performance envelope designed to an R-40 insulation value was incorporated. This included fire-resistant and water-resistant, outboard insulation. Additionally, thermally modified wood cladding was used.

The roof's insulation is situated above the CLT structure and has an R-value ranging from 55 to 60, while the floor assembly is designed with an R-40 insulation value.

Interior finishes were kept to a minimum to maximize the exposure of the mass timber. This design choice aligns with the objective of leveraging the biophilic benefits of mass timber for enhancing health and wellness.

4.2.2 Baseline Module

The common understanding is that prefabricated module units are frequently employed in workforce communities. Due to the proprietary nature of the manufacturing process, the specific construction methodology for these units remains undisclosed. Nevertheless, we relied on available research, data, and our own professional expertise to develop an informed model for the material and assembly particulars of the Baseline Module.

The Baseline Module is designed with a light wood frame for the wall, roof, and floor structures. The envelope incorporates packed wool insulation within a 2x6 light wood frame, with an assumed thermal performance rating of R-20 for the walls.

For the exterior, profiled metal cladding is assumed, while the interior is expected to feature finishes made of vinyl-clad gypsum board.

4.2.3 Timing

The duration of a building's useful life is a key factor in its Life Cycle Assessment (LCA). Buildings with longer lifespans generally present a more positive environmental profile when evaluated on an annualized basis. This is because the environmental expenditures related to construction and materials are spread over an extended period, making construction approaches and materials that offer durability more attractive in LCA calculations where lifespan is taken into account.

While the Mass Timber option is projected to have a durability of over 50 years, this study opted for a more conservative estimate based on research suggesting that modular buildings commonly have a lifespan of around 30 years. Therefore, the Mass Timber option was evaluated assuming this 30-year lifespan.

Conversations with mining companies revealed that traditional building types, which serve as the basis for the Baseline option, typically have a lifespan ranging between 10 to 15 years. Consequently, this study considered both a 15-year and a 30-year scenario for the Baseline building to provide a comprehensive comparison.

4.3 Exclusions

Certain elements were deliberately excluded from this study to focus specifically on the comparison between Mass Timber construction and the baseline design. Foundations for both building options were not considered, as the specific site information is unavailable.

Mechanical and electrical components were also left out to simplify the understanding of the core structural impacts. In addition, site elements weren't considered as the site itself has not yet been defined.

Transport-related emissions were also not accounted for; the study assumed construction in a Thunder Bay factory, and as no specific site location was provided, it was assumed that both the Baseline and Mass Timber options would incur similar transport-related impacts.

Lastly, optional exterior elements like porches and canopies were excluded from the study, as they are considered add-ons designed for health and wellness benefits, rather than fundamental components of the building structures.

5 Scope of Analysis and Data Sources

5.1 Scope of the Study

This study adheres to LEED guidelines for its scope, but diverges in terms of building lifespan assumptions. The Mass Timber module is assessed with a 30-year lifespan, while the Baseline Building is evaluated under two different scenarios: 15 years and 30 years.

The elements examined in this study include:

- Building envelope and exterior finishes
- Vertical structural components
- Horizontal structural components
- Floor and ceiling systems
- Interior surface finishes

The scope excludes operational energy and water use, as well as transportation and construction impacts.

5.2 Data Sources

The analysis has been performed relying on the following data sources for building information:

Data Type	Data Source
Material quantities (A1-A3)	Extracted manually from digital drawings.
Material transportation distances (to factory) (A4)	Region-specific transportation scenarios from One Click LCA are utilized in this study. These scenarios reflect the typical transportation distances and modalities for various product types within the given region. This is particularly useful when supplier decisions have not yet been finalized, allowing for a more accurate representation of likely transportation-related environmental impacts.
Construction installation (factory only) (A5)	Impacts are based on conservative default values from One Click LCA.
Material impacts in use (B1-B5)	The service lives of materials are grounded in typical values pertinent to the materials being examined, and these have been vetted for their applicability to the project. Adjustments to these values have been made as needed. It's important to note that the study's scope does not encompass material maintenance and repair activities. Instead, the assumption is that materials will be entirely replaced once they reach the end of their designated service lives.
Use phase energy consumption (B6)	Impacts are omitted from the analysis.
Use phase water consumption (B7)	Impacts are omitted from this analysis.
End of life impacts (C1-C4)	The end-of-life impacts in this study are derived from scenarios provided by One Click LCA. These scenarios are designed to reflect typical end-of-life treatment processes for various material types and follow the standards set forth in EN 15804+A1.

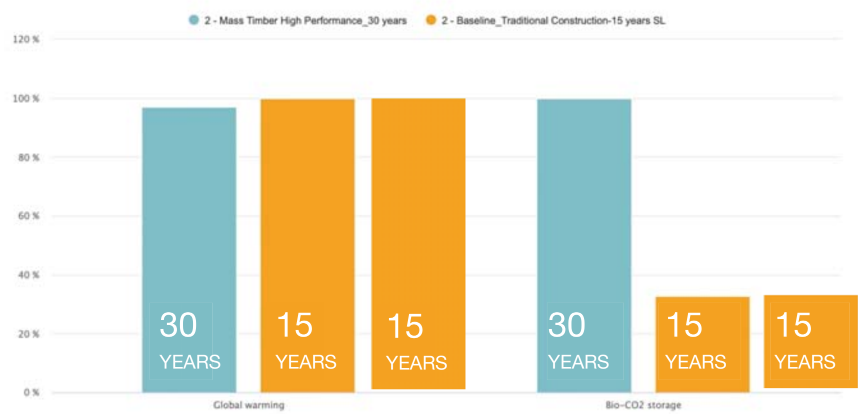
6 Results

The following graphs and tables present a comparative analysis of the environmental impacts between the Baseline and Mass Timber buildings. For a more detailed breakdown of the environmental effects attributable to individual materials and building components in each structure, please refer to Appendices A and B.

6.1 Impact Categories Reductions

The graph that follows clearly demonstrates a notable reduction in Global Warming Potential (GWP) over a 30-year span for the Mass Timber Module when compared to the Baseline building. This suggests that the Mass Timber Module is more environmentally sustainable in the context of long-term climate impact.

Comparison of Global Warming Potential and Biogenic Carbon Over 30 Years



The above graph illustrates a substantial decrease in Global W rming Potential (GWP) over period of 30 years for the Mass Timber Module, as compared to the Baseline uilding. This indicates that the Mass Timber Module offers greater environmental sustainability with respect to long-term contributions to climate change.

Category	Mass Timber Design	Base Building (15 years)	Base Building at 30 years including replacement at 15 years	% reduction of mass timber at 30 years
Global Warming Potential (kg CO_2e)	**10,975**	**11, 303**	**22,606**	**51%**
Biogenic Carbon Storage (kg CO_2e bio)	**21,527**	**7,050**	**14,100**	
Carbon difference	**-10,552 (Carbon Negative)**	4,253	8,506	

Global Warming Potential: When the quantity of greenhouse gasses in the atmosphere increases, the atmospheric layers near the earth are heated up, resulting in climate change.

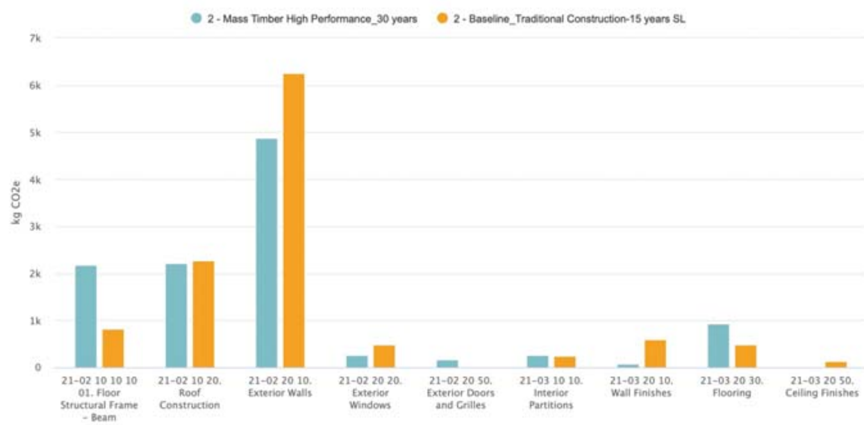
Biogenic Carbon Storage: Biogenic carbon sequestered in materials (in case of A1-A3) or in growing vegetation (in case of B1), expressed as CO2-equivalent. This biogenic carbon may or may not be preserved after the asset lifetime depending on the end-of-life process for said materials. This impact category is separate from accounting of the fossil GWP.

Carbon Negative: Carbon negative refers to an activity or process that removes more carbon dioxide (CO2) from the atmosphere than is emitted into it. In other words, a carbon-negative operation not only reduces its own carbon footprint but also offsets the emissions of other activities, ultimately reducing the overall levels of atmospheric CO2.

6.2 Building Elements Comparison

The subsequent graphs illustrate the differences in Global Warming Potential (GWP) among the various building components of the two designs. The most significant reductions are evident in elements like beams, columns, exterior walls, floor structures, load-bearing walls, and the roof. This highlights where the most substantial environmental benefits can be gained in the Mass Timber design.

Building Elements GWP Comparison



The graph above provides side-by-side comparison of the Global Warming Potential (GWP) of various building elements in the Mass Timber design t 30 years and the Baseline option at 15 years. It's worth noting that the GWP for the Baseline option, represented in orange, would essentially double over 30-year span due to the need for building replacement t the 15-year mark. This underscores the long-term environmental advantages of opting for the Mass Timber design

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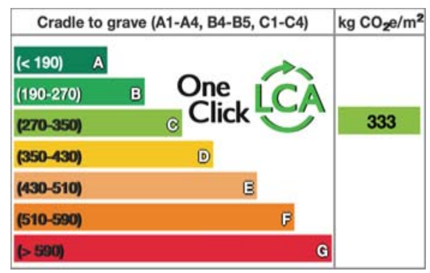
7 Summary and Recommendations

7.1 Summary and Interpretation of the Results

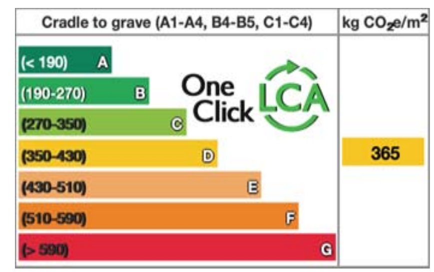
Comparing the Mass Timber and Baseline options isn't exactly a like-for-like evaluation. Firstly, the Mass Timber design has a minimum life expectancy that exceeds the Baseline option by at least 30 years. This greater durability is largely attributable to the Cross Laminated Timber (CLT) structural systems, as opposed to the light wood frame used in the Baseline.

Additionally, the Mass Timber construction is particularly robust, designed to withstand the stress associated with relocating the modular buildings multiple times over its life.

Based on this analysis, the Mass Timber building has a lower embodied carbon impact compared to the Baseline. While the accompanying illustration may show only a marginal reduction in embodied carbon for the Mass Timber option, it's important to factor in its extended lifespan. Given that the Mass Timber option is expected to last at least twice as long as the Baseline, the effective reduction in carbon emissions could be assumed to be double as well.



30 YEARS



15 YEARS

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The lifespan of a building plays a significant role in its Life Cycle Assessment (LCA). A longer-lasting building often has a more favorable environmental impact when assessed on a per-year basis, as the environmental costs associated with construction and material use are amortized over a longer period. This may make durable construction materials and methods appear more favorable in an LCA when longevity is considered.

Here are some specific ways in which the life duration of a building impacts its LCA:

1. **Resource Efficiency**: Longer-lasting buildings can be more resource-efficient over their entire lifecycle, reducing the frequency of resource-intensive activities like renovation or reconstruction.
2. **Operational Energy Use**: A longer lifespan may allow a building more time to "pay back" the energy and resources spent in its construction through more efficient operation, especially if it's designed with sustainability in mind.
3. **Maintenance and Renovation**: The need for maintenance and renovation materials and activities can differ depending on the lifespan of the building, affecting its overall environmental footprint.
4. **End-of-Life Stage**: A building that lasts longer delays the environmental impacts associated with demolition and waste processing. This also gives more time for developing better recycling or repurposing technologies that can mitigate end-of-life impacts.
5. **Replacement Cycle**: Shorter-lived buildings require more frequent replacement, which entails additional environmental burdens from manufacturing, transportation, and construction activities more often.
6. **Adaptive Reuse**: Longer-lasting buildings are more likely to be repurposed or renovated for new uses, which can significantly lower their lifetime environmental impact compared to a building that is demolished and replaced.
7. **Technological Advances**: A longer building lifespan provides more opportunities for incorporating energy-saving retrofits and other technological advances that can improve its LCA profile over time.
8. **Material Degradation**: On the downside, some materials may degrade in a way that makes the building less efficient over time, potentially offsetting some of the benefits of a long lifespan.

Understanding the likely duration of a building's useful life is crucial for a more accurate and meaningful LCA. It allows for a better-informed comparison between different construction methods and materials, helping stakeholders make decisions that are more sustainable over the long term.

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Another key factor to consider is the thermal performance of the exterior envelope. While the Ontario Building Code doesn't set minimum energy requirements for temporary Workforce buildings, the project's mandate emphasized the need for a high-performing envelope to minimize energy consumption and improve occupant comfort. Consequently, the Mass Timber module was designed with superior thermal resistance values: an R-40 envelope, an R-55 roof, and R-40 floor systems—twice the insulating value of the Baseline option.

This enhanced thermal performance is directly related to the use of more durable building materials, increased insulation values, and reduced air infiltration. However, it's important to note that the construction industry has limited choices when it comes to types of insulation that are both high-performing and low in embodied carbon. Many of the available insulation materials that meet the thermal performance criteria also come with high embodied carbon values. Therefore, the Mass Timber module, despite its superior thermal performance, does have a higher carbon footprint due to the thicker insulation used.

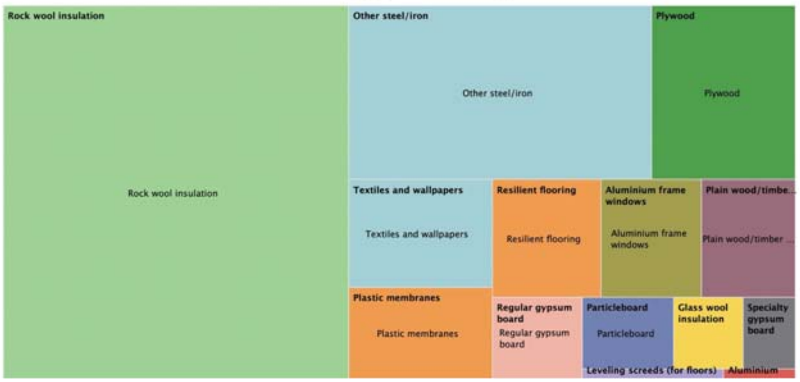
This isn't a straightforward comparison between the two scenarios and highlights the industry's need for further material research—specifically, materials that deliver high thermal performance with low embodied carbon. To gain a more comprehensive understanding of the carbon reduction potential of the two different thermal performances, an energy analysis factoring in operational energy would be beneficial. This would provide a more nuanced view of the long-term carbon impact of each option.

8 Appendix

8.1 Baseline Module

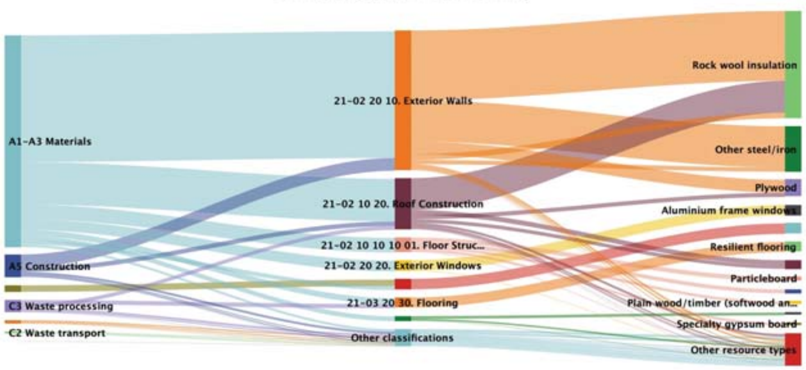
GWP Impact Based on Resources Type

Global warming kg CO2e - Resource types



GWP Impact Based on Building Element

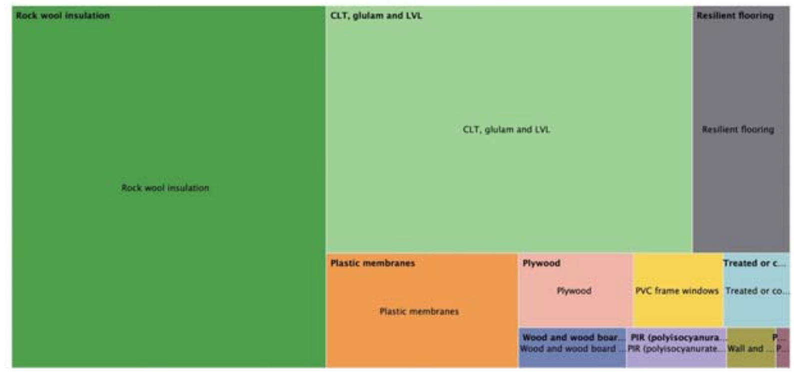
Sankey diagram, Global warming



8.2 Mass Timber High Performance Module

GWP Impact Based on Resources Type

Global warming kg CO2e - Resource types



Building Elements GWP Impact

Sankey diagram, Global warming