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RECENT ADVANCEMENTS IN MASS TIMBER CONSTRUCTION TECHNOLOGIES IN CANADA

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ABSTRACT: Interest in mass timber is growing among designers, builders, developers and other stakeholders worldwide due to its environmental benefits as a low-carbon and sustainable building material. In Canada, several recent initiatives by industry and governments to expand the use of wood in construction have led to an increased number of mass timber buildings across the country and enhanced existing manufacturing capability. Supported by progressive building codes, a growing supply chain, and a rising number of designers and builders with mass timber expertise, mass timber construction is poised to continue to take off in Canada. To support this momentum, the Government of Canada launched the Green Construction through Wood (GCWood) program to expedite market acceptance and foster commercial uptake of mass timber products and systems in Canada.

This paper provides an overview of the GCWood program activities, showcasing the design and construction of several demonstration projects and the ongoing efforts to implement a national wood education roadmap. This is in addition to funding critical technical research to support the adoption of tall wood buildings in the Canadian building code and transitioning the code to become more performance based.

KEYWORDS: Tall wood buildings, demonstration projects, mass timber, building codes, advanced wood education

1 INTRODUCTION

The emergence of mass timber, and the use of engineered wood products in construction as a green building material, continues to gain traction in Canada and abroad. The Government of Canada recognized that in order to decarbonize the built environment and increase the acceptance of wood products and systems domestically, it is critical to showcase the use of wood in non-traditional applications. This led to several initiatives and programs being launched over the last 12 years. Funding demonstration projects, advancing wood education and training, and revising building codes to allow taller and larger wood buildings in Canada are the cornerstones of such initiatives.

2 DEMONSTRATION PROJECTS

In 2013, the Government of Canada launched the Tall Wood Building Demonstration Initiative (TWBDI), which supported the construction of two tall wood buildings in Canada (Figure 1). The first is an 18-storey hybrid mass timber student residence (Brock Commons - Tallwood House) located in Vancouver, which was the world's tallest hybrid wood building at the time of its completion. The second is a 13-storey residential building in Québec City (Origine). NRCan funded the critical incremental R&D activities required to design, approve, and construct the two demonstration buildings. This included fire, structural, and acoustics testing [1]. The success of the TWBDI led to new initiatives by the Government of Canada that further encouraged the design and construction of timber structures in non-traditional construction applications.

Figure 1: *Brock Commons on the left, and Origine on the right (Courtesy of Stéphane Groleau)*

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The Green Construction through Wood (GCWood) program was launched in October 2017 with the objective of increasing the use of mass timber as a green construction material in infrastructure projects. This included not just high-rise applications, but also low-rise non-residential and bridge construction. The Canadian federal government's budget in 2017 provided funding of $55 million over 5 years for GCWood under the *Pan-Canadian Framework on Clean Growth and Climate Change* to support the various GCWood program activities. GCWood program has three key components:

1) Mass timber and hybrid demonstration projects (e.g., high-rise, low-rise non-residential and bridges)
2) Building code revisions and supporting research (i.e., targeting 12-storey tall wood buildings by 2020 and performance-based in 2025 and 2030)
3) Technology transfer and advanced wood education (i.e., training courses, design and costing tools for architects, engineers and builders, and Life Cycle Assessment data and tools)

To expedite market acceptance of mass timber products and systems in Canada, three calls for proposals (CfP) were launched for innovative wood-based buildings and bridges between 2017 and 2018. To support the construction of these proposed projects, the GCWood program funded up to 100% of eligible incremental project costs associated with the design, approval, construction, and post construction activities of the selected demonstration projects.

Sixteen high-rise, low-rise non-residential wood buildings and timber bridges across Canada were funded under the GCWood program. These projects were selected based on specific criteria focused on design innovation, the expertise of the design and project team, replicability of the proposed wood-based systems, and the strength of the project business case, among a number of other criteria. All selected demonstration projects showcased advanced use of engineered wood-based products and systems in their design and construction. Several of the buildings are now completed, currently under construction, or at an advanced stage of design and approval across Canada.

2.1 TALL WOOD BUILDINGS

The first CfP was for tall wood buildings (minimum of 10 storeys) which targeted innovative use of advanced wood products and systems in high-rise applications. The choice for the number of storeys was based on a close consultation with the industry and based on market intelligence data. With the help of an expert evaluation panel, a handful of highly innovative projects that showcase advanced wood-based technologies in their design and construction were shortlisted for funding. The following are some examples of several tall wood buildings funded by the GCWood program.

2.1.1. George Brown College's Limberlost Place

One of these shortlisted projects was "Limberlost Place" (formally The Arbour), a 10-storey innovative tall wood building located at George Brown College's waterfront campus in downtown Toronto, Ontario (Figure 2). This academic building will serve as a learning space and a living laboratory for students. It will likewise house a mass timber research and testing facility to study renewable energy systems, fire performance, and durability.

The relatively thin structural system requires no use of conventional drop beams, which reduces the building height, volume, and material costs. The lateral load resisting system is composed of concentric steel braced frame core, which is being erected in tandem with the mass timber superstructure. The structural systems employ an innovative 7-ply timber-concrete-composite "slab band" to achieve the 9.2 m span (Figure 3). Extensive structural testing of the composite floor system was conducted at the University of Northeren British Coumbia (UNBC) to support the design. Huge glulam columns of 1,725 x 630 mm spanning three storeys tall will be used to support the gravity loads. Renewable energy systems, such as rooftop photovoltaic arrays, heat pumps, and rainwater recycling mechanisms are incorporated in the building design. The building is currently under construction and is scheduled for completion by the end of 2024. It will be Ontario's first tall wood, low-carbon institutional building with assembly occupancy.

Figure 2: *Limberlost Place (Courtesy of Moriyama & Teshima Architects)*

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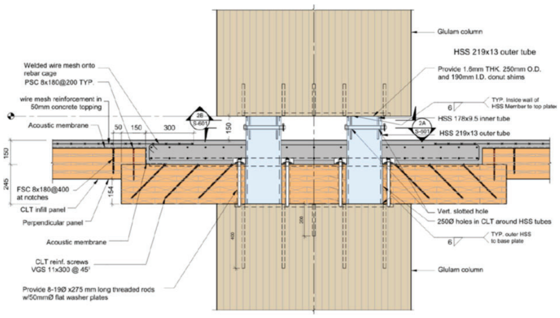

Figure 3: *Composite CLT/concrete slab and glulam floor system and connection (Courtesy of Fast+Epp)*

2.1.2. 2150 Keith Drive Tall Wood Building

Another shortlisted tall wood building was the 2150 Keith Drive project (Figure 4), a 10-storey mass timber tall wood building in Vancouver, British Columbia. This mass timber office building will be home to multiple office tenants from the technical and creative sectors. The design involves fully exposed mass timber elements, relying on charring to achieve a 2-hour fire-resistance rating.

The innovative design uses massive braced timber frame on the exterior as the main lateral load resisting system, complete with state of the art seismic dampers to improve the building's seismic resiliency. It likewise eliminates the need for a stiff interior concrete core by using four CLT shear walls in the interior which provide a design flexibility.

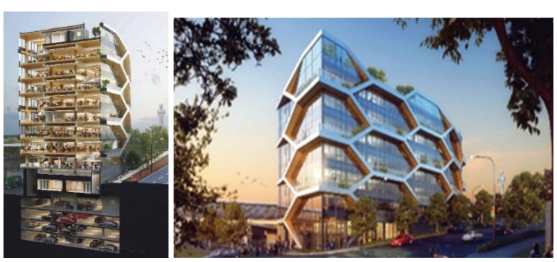

Figure 4: *2150 Keith Drive Office Building (Courtesy of DIALOG)*

2.1.3. University of Toronto's Academic Tower

Another project the GCWood program is providing funding to is the University of Toronto's Academic Tower (Figure 5). This 14-storey tower will be the tallest mass timber building in Ontario once completed, and will serve as an academic and research facility, as well as a living laboratory for the university.

The project is at the advanced design and approval stage with construction planned to begin in 2023. The top 10 storeys of this hybrid building will be made of glulam and engineered mass timber panels, with the four bottom storeys constructed of both timber and steel. One-way GLT slabs will be used for the deck to offer ample floor space, and to meet the required two-hour fire-resistance rating. The structural design uses wood super bracing as the lateral force resisting system against wind and seismic loads. Innovative connections engineered for off-site assembly will facilitate faster construction. The design involves partially exposed mass timber structural elements. Extensive engineering analysis and modelling including wind engineering studies has been conducted to support the design and approval of the building.

Figure 5: *Academic Tower (Courtesy of the University of Toronto)*

2.2 LOW-RISE NON-RESIDENTIAL BUILDINGS

The GCWood's second CfP targeted low-rise non-residential buildings including commercial, industrial, office, and institutional buildings of 4 storeys or less which demonstrate the innovative use of wood products or systems that could be easily replicated. Thirty applications were received and ten projects were short-listed for funding.

2.2.1. Toronto and Region Conservation Authority's (TRCA) New Administrative Office Building

One of the successful projects was Toronto and Region Conservation Authority's (TRCA) new Administrative Office Building. This is a 4-storey mass timber office building located in Toronto, Ontario and is part of the Canada Green Building Council's *Zero Carbon Building Pilot Program* (Figure 6*)*. The building is designed to achieve a low-carbon footprint through all lifecycle phases, with model simulations predicting a 50% reduction in operating emissions and over 75% reduction in embodied carbon compared to the average office building in Toronto. The mass timber structure is complete, and the remaining building construction will be completed by the end of 2023.

The structural system is composed of CLT mass timber floor panels supported on glulam beams and columns and uses a structural grid of approximately 6 m x 6 m. Metal steel strapping is installed on the top surface of the CLT floor/diaphragm where drag forces are concentrated to transfer the forces from the diaphragm to the shear walls. The lateral force resisting system for the office building utilizes a combination of stair and elevator cores constructed of CLT wit lateral glulam bracing. There is no structural concrete utilized above the main floor concrete slab. The LCA study that was originally submitted was completed before the open loop modelling, so the results reflect operating emissions based on the closed loop system. It is expected the open loop system to improve energy efficiency by an additional 10-15%, which will lower operating emissions accordingly. The final updated model will be completed in 2023 with an updated LCA report.

Figure 6: *Toronto and Region Conservation Authority Administrative Office (Courtesy of TRCA)*

2.2.2. KF Aerospace Centre for Excellence

KF Aerospace Centre for Excellence is a highly visible commercial 2-storey project that serves as a working and display hangars, a centre of expertise, an aviation history museum, and community gathering place at the Kelowna International Airport in British Columbia (Figure 7).

The project uses long span roofs, floors and tall walls, which is a unique application of wood for this type of building application. The primary and secondary structural elements are glulam beams and glulam and DLT trusses. Pre-fabrication of large integrated components helped minimize on-site erection time. Building assemblies for the projects' central hub and two working hangars incorporate long span roofs, floors, and tall walls components and assemblies. The project was completed in the summer of 2022, and the building is now occupied.

Figure 7: *Centre for Excellence (Courtesy of KF Aerospace Centre for Excellence)*

2.2.3. Yukon Street Office Building

The Yukon Street Office Building is a 4-storey hybrid mass timber and steel commercial office building built tightly on the property line as an infill project and serves as a living laboratory to gather data to evaluate the performance of the hybrid mass timber design (Figure 8).

The project used prefabricated mass timber components, offering strength and structural simplicity, while helping decrease construction time. The system allows for long spans without interior columns. Composite panels accommodate the large spans, providing exposed soffits, and hide required services for the building. The CLT shear walls, as well as elevator and stair core, are specially designed to resist earthquake forces using an advanced seismic resistance hold-down system from New Zealand (Tectonus). CLT walls were prefabricated with the exterior envelope and cladding to minimize access and construction along the tight property line. A 2-hour structural fire-resistance rating for the exterior wall is achieved through the application of non-combustible insulation.

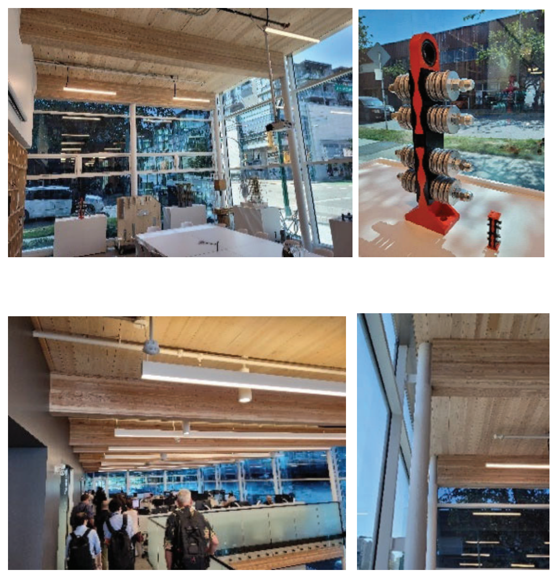

Figure 8: *Yukon Street Office Building with the Tectonus seismic hold-down system*

2.2.4. Bayview Elementary School

Bayview Elementary School is a 2-storey school in a high visibility location (Figure 9). It is one of the first schools to act on British Columbia's school seismic retrofit program. The design presents a large clear span roof using CLT panels and glulam webs, creating a "double T" design. The CLT shearwalls are installed throughout the building with multi-storey continuous shearwalls at the exterior to provide more efficient connections. There is CLT gravity walls at the upper level comprised of hybrid steel-CLT beams located at the second floor cantilevers over the ground level.

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__Figure 9:__ Bayview Elementary School (Courtesy of Bayview Elementary School)

2.2.5. wək̓ʷan̓əs tə syaqʷəm Elementary School

The wək̓ʷan̓əs tə syaqʷəm Elementary School, which in English means “the sun rising over the horizon”, is completed and has a very similar design to the Bayview school described above, and aims to achieve the same environmental targets such as LEED Gold certified (Figure 10). Extensive structural testing on the hybrid floor system and shear walls took place at the University of Northern British Columbia (UNBC) to support the balloon type shearwalls design used in this project (Figure 11).

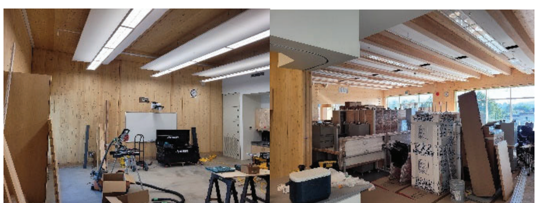

Figure 10: *wək̓ʷan̓əs tə syaqʷəm Elementary School*

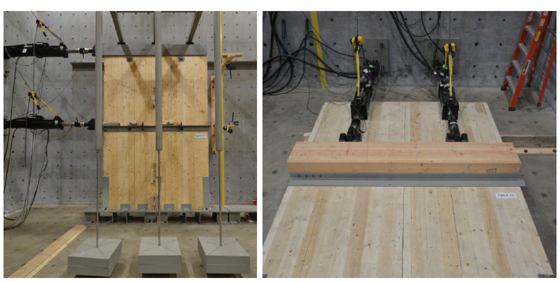

__Figure 11:__ Balloon Shearwall test setup (Courtesy of UNBC Wood Innovation Research Laboratory)

2.2.6. Canadian Nuclear Laboratories

A series of three mass timber buildings and one with partial mass timber is being constructed as part of a first of its kind project in Canada at the Canadian Nuclear Laboratories (CNL) in Chalk River, Ontario. The site is owned by Atomic Energy of Canada Limited (AECL), a Canadian Crown corporation, and operated by CNL. The mass timber buildings showcase the use of advanced design and construction technologies, both structurally and aesthetically, at a nuclear science and technology campus. The mass timber buildings include a site entrance building, support and maintenance facility, administrative building (Science Collaboration Centre), and a large nuclear research facility, the Advanced Nuclear Materials Research Centre (ANMRC). NRCan provided funding through the GCWood Program for the Support and Maintenance Facility, the Science Collaboration Centre and the ANMRC. All four of these buildings are being constructed to revitalize the campus, thanks to a $1.2 billion investment by AECL.

The Science Collaboration Centre is a hybrid building that will serve as a collaboration complex to house a new data centre with S&T computing capabilities, a university-style auditorium, a welcoming library space, a roof-top terrace, and office space and meeting rooms for approximately 450 employees (Figure 12). The design incorporates CLT slabs with glulam columns, beams, and purlins as the main gravity structural system. The structure consists of a reinforced concrete lower level, elevator, and stair core. Mechanical, electrical, fibre optics, and life safety distribution system are all concealed within mass timber elements. The lateral bracing system against earthquakes and wind is a hybrid system of concrete shear walls and timber braced frames, with CLT slabs acting as diaphragms to transfer lateral loads to shear walls. The building is currently under construction.

__Figure 12:__ Science Collaboration Centre (Courtesy of CNL)

The Support and Maintenance Facility is a 2-storey industrial use building which is home to various trades, transportation, and roads and grounds crews (Figure 13). The design includes a CLT elevator shaft, floors, and roof panels, which also act as diaphragms that are supported by glulam timber purlins, beams, and columns as the main structural system. The CLT mezzanine floors are suspended and supported by glulam beams. Glulam cross bracing is also provided to resist lateral loading. The construction of this building is complete.

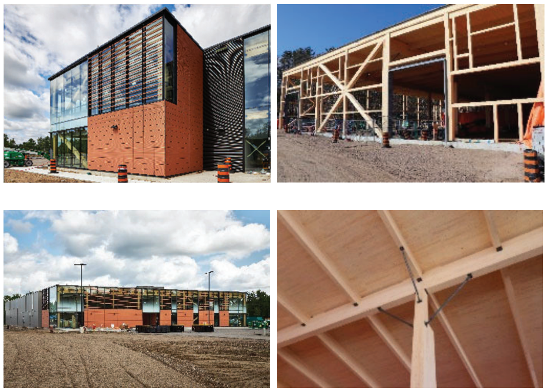

Figure 13: *CNL's Support and Maintenance Facility mass timber project (Courtesy of CNL)*

The Advanced Nuclear Materials Research Centre (ANMRC) is a hybrid wood/concrete design, which includes a two-storey mass timber office wing, a two-storey laboratory wing, and a two-storey concrete hot cells wing (Figure 14). The prefabricated CLT and glulam components will include columns, posts and beams, floor panels, diaphragm, bracing, and exterior walls. The building will have exposed soffits, eliminating the need for an alternative ceiling system. CNL will be taking a modular prefabricated approach for the construction of both the laboratory wing and the office wing. The building is at advanced stage of design. The building is at advanced stage of design/development.

An Integrated Project Delivery approach was broadly adopted in the design and construction of all of mass timber projects at CNL. The process brings together the manufacturers of the mass timber products, the full design team, trades, and the construction manager to work collaboratively to optimize the design, increase value to the owner, and maximize efficiency through all phases of design, fabrication, and construction.

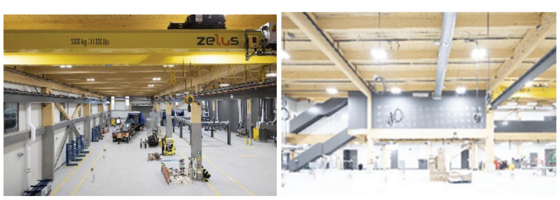

Figure 14: *Advanced Nuclear Material Research Centre (Courtesy of CNL)*

2.2.7. oN5 Office Building

oN5, a new 4-storey office building in downtown Vancouver was completed in 2022 and is being occupied by several engineering and architectural firms (Figure 15). The building uses CLT panels to demonstrate the potential for commercial mass timber. The structure utilizes a highly innovative self centering Lateral Force Resistance System (Tectonus) for resisting seismic loads. Prefabricated CLT panels were used in the design, from shearwalls to roof, and were produced by BC Passive House. The design aims to produce a replicable infill mass timber design for the construction industry. Exposed CLT panels offer great fire resistance and act as vertical supports, eliminating glulam or steel column requirements. Constructed at the property line, creative techniques were used to address the tight lot lines. The lightweight mass timber building elements were prefabricated and lifted into place quickly and efficiently (40-50% faster than typical construction).

Figure 15: *oN5 4-storey office building*

2.3 TIMBER BRIDGES

Industry and provincial and federal governments in Canada initiated several market and research efforts over the last 10 years to promote the use of timber in bridge applications. As a result, several modern innovative timber bridges have been built recently. The majority have been constructed in the provinces of Quebec, Ontario, and British Columbia. The Mistissini Bridge, built in 2014 and located at Uupaachikus Pass in Mistissini, Québec, is 160 m long and features four spans of straight girders supported by semi-continuous glulam arches (Figure 16). This is one of the longest modern timber bridges in Canada and was one of the first bridges to use CLT in the country.

The GCWood call for proposal for bridges (launched in the spring of 2018) builds on the success of previous efforts and projects, and ensures continued market momentum for timber bridges. The CfP received 13 applications for both vehicle traffic and pedestrian bridges that had a minimum clear span of 20 m. With the guidance of an expert evaluation panel, NRCan shortlisted several mass timber and wood-hybrid bridge demonstration projects for funding. Almost all selected demonstration bridges belong to provinces or municipalities, with many being a proposed replacement of an existing bridge. These bridges had been either closed to traffic, or their load carrying capacity reduced as they are showing signs of deterioration and require major maintenance.

The shortlisted timber bridges varied in length and complexity, but all demonstrated a high level of innovation in the engineering design, treatment, and the use of engineered mass timber products and systems. In

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the end, only two timber bridges advanced to the design and construction stage with funding from NRCan.

Figure 16: *Mistissini Bridge (Courtesy of Stantec)*

2.3.1. Duchesnay Creek Bridge

One of shortlisted projects is the Duchesnay Creek Bridge in North Bay, Ontario (Figure 17). The new bridge replaces the original which was closed by the Ministry of Transportation (MTO) in 2019 for safety reasons due to its poor condition. The original bridge had a timber deck truss and was constructed in 1937. Replacement of this 74 m long heritage deck truss bridge on the existing alignment imposed challenges. To avoid multiple timber pile bents in the approach spans, it was decided to select a bridge type sympathetic to the cultural heritage value of the original structure and a timber design that is efficient and reflects the key attributes of the original timber structure in modern form [2]. The redesign of the bridge was done with the intention to maintain the original timber aesthetic. The bridge design is an innovative three-span hybrid glulam girder bridge with precast concrete deck and arched glulam braces at the piers. The utilization of the glulam braces at the piers helps with the reduction of the shear loads experienced by the structure. The deck is attached to the main glulam girders using shear connectors to allow for the transfer of diaphragm forces. The bridge is 83 m long and 13 m wide with three spans and was opened for traffic in August 2021.

Figure 17: *Duchesnay Creek Bridge (Courtesy of MTO)*

3 EDUCATION AND DESIGN TOOLS

3.1 NATIONAL EDUCATION ROADMAP

Until recently, only a few Canadian engineering and architectural schools offered wood design courses at the undergraduate level. To address this gap, the GCWood program funded the implementation of a Canadian wood education roadmap, led by the Canadian Wood Council (CWC). The goal is to expand wood education at Canadian universities and colleges, and consequently, contribute to the development of the future timber design capacity in Canada.

The architectural and engineering community is always changing, and professionals need access to state-of-the-art tools, resources, and continuing education to ensure the wood products industry remains competitive. Innovation doesn't always start on the construction site, but often through the students and recent graduates who shape the next wave of design and construction. Therefore, expanding the wood education curriculum in Canada requires supporting an engaged network of enthusiastic educators, as they are essential to equip future professionals with a solid foundation of education and skillsets. The focus of the education Roadmap is to:

1. Build a network to support educators and institutions to increase availability of curricula and encourage students to study wood design and construction.
2. Develop up-to-date curriculum/manuals/ materials, presentations, lectures, learning modules, design exercises, sample calculations and more.
3. Develop several teaching modules, interactive case studies, hold site visits and tours, and host student competitions to engage students and trigger their interest in wood structures.

Three new sets of teaching manuals are being developed: Wood Design for Architects, a Wood Handbook for Builders, and an Advanced Wood Engineering Manual. So far, project activities have led to the addition of wood design and construction curricula at 11 accredited civil engineering, architectural and construction management programs across Canada which is a huge success.

3.2 STATE OF MASS TIMBER IN CANADA

Until recently, there was no comprehensive database of modern mass timber projects or production capacity in Canada. In order to fill this gap, NRCan worked closely with industry partners to develop a "The State of Mass Timber in Canada" (SMTC) report, which was the first of its kind (Figure 18). The SMTC report was released in May 2021, and established a baseline of data with the intent to measure future growth against and help inform decision making associated with he future of mass timber construction in Canada [3].

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Figure 18: *State of Mass Timber in Canada 2021 report*

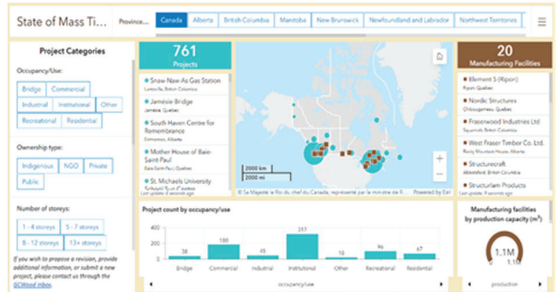

Figure 20: *SMTC map dashboard*

The report presented a baseline dataset that included over 480 projects completed or currently under construction since 2007 and represented nearly 1.5 million m^2 (or 16 million sf) of gross floor area. This is in addition to data on 20 mass timber manufacturing facilities in Canada (Figure 19). A web-based interactive map was also developed and is updated quarterly to provide users with information on the locations of all the mass timber projects and producers from across the country [4]. The following figure outlines the number of manufacturers for each type of mass timber elements in Canada.

Figure 19: *Number of Canadian manufacturing facilities by product*

Several updates to the SMTC dataset and map since its publication have now brought the total project number to over 750 projects. The web-based dashboard shows the location of the mass timber projects and manufacturing facilities across Canada. Users can zoom in and select individual projects, or filter by categories such as project type and use, year of completion, size, region, and other criteria (Figure 20). The SMTC map dashboard was recently included in the Living Atlas, the biggest collection of maps and geographical based data and information in the world! The Living Atlas offers a variety of contextual tools to visualize and analyze data, and now users will be able to access the SMTC map and dashboard on both the Mass Timber Construction in Canada Page and the Living Atlas.

3.3 DESIGN TOOLS

To support the deployment of mass timber construction in Canada, the GCWood program has been funding the development and deployment of several advanced design tools to assist designers, builders, and decision makers. Overall, the program supported the development of over 10 new design guides, tools, and datasets. This includes advanced wood design handbooks for engineers, architects and builders, carbon calculators, and Life Cycle Assessment (LCA) tools to help demonstrate the environmental benefits of building with wood. To further the governments' carbon accounting goals, GCWood provided funding to a major 4-year initiative called *Low-Carbon Assets through Life Cycle Assessment* (LCA^2) led by the National Research Council of Canada (NRC). This initiative focused on developing a national Life Cycle Inventory (LCI) database and whole building LCA guidelines.

The LCI data and LCA guidelines will be used to facilitate procurement policies at the federal and provincial levels, and by the design and construction industry. This work will expand opportunities to build with wood, open new markets for manufacturers and provide stimulus to the broader forest sector.

4 UPDATES TO CANADIAN BUILDING CODES

The 2015 edition of the National Building Code of Canada (NBCC) included some significant changes with respect to wood design as it permitted 5 and 6 storey tall wood frame buildings [5]. Building on the revolutionary acceptance of 12-storey mass timber buildings as a "pre-approved" Alternative Solution by the province of Québec in 2015 [6], a code change proposal for Encapsulated Mass Timber Construction (EMTC) was submitted in 2016 by the Canadian Wood Council to the NBCC Code Committee for their consideration targeting the 2020 edition of NBCC.

A Task Group and several Working Groups were established by the Standing Committee on Fire Protection (SC-FP) to discuss the proposed EMTC code change and identify potential issues and research needs to be

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addressed. Several research projects (mainly on fire and seismic performance) were conducted at the National Research Council (NRC), with funding from GCWood, to support the proposed code change provisions. The fire testing focused on the allowable percentage of exposed mass timber that should be permitted in EMTC buildings, and the effectiveness of water mist systems compared to conventional sprinkler systems that are commonly used in tall buildings.

The 2020 edition of the National Building Code of Canada (NBCC) was published in the Spring of 2022 and allows for EMTC up to 12 storeys. Several jurisdictions including British Columbia, Ontario, and Alberta have adopted the EMTC provisions in their respective codes. In addition, extensive efforts are being invested in transitioning the NBCC to become more performance-based in the future.

Additional research is ongoing to develop seismic design guidelines for mass shearwalls for tall wood buildings applications. A technical guide was developed recently by the Canadian Construction Materials Centre (CCMC) which will be used to support future code change provisions for tall wood buildings in the 2025 building code [7]. A series of design examples were also developed to validate and clarify how those guidelines will be used by engineers involved in the design and construction of tall wood buildings. The guidelines presented in the CCMC Technical Guide are being used to refine the current seismic design provisions in the 2024 edition of the Canadian Timber Design Standard CSA O86 [8].

NRCan has been funding critical research and development activities to support the NBCC code change process since 2010 and will continue to support future developments of the NBCC targeting a more performance-based code by 2030. Extensive efforts are currently underway to introduce performance-based design as one of the priorities for the current code cycle at the Canadian Commission for Buildings and Fire Codes (CCBFC) and its various standing committees.

4.1 MASS TIMBER FIRE DEMONSTRATION TEST

A national research program focused on demonstrating the fire performance of mass timber products in tall wood buildings was conducted in Canada over the past two years. The project was led by the Canadian Wood Council (CWC) and was jointly funded by the federal and provincial governments, including Natural Resources Canada, the provinces of Ontario, Quebec, British Columbia, and Alberta. The project's key objective was to encourage the acceptance of tall wood buildings in Canada and help inform the Authorities Having Jurisdictions (AHJs) about the performance of mass timber construction under various fire conditions. The fire tests were performed by the National Research Council of Canada.

The program comprised of two phases: Phase 1 involved conducting a series of pilot-scale fire demonstrations, which were carried out successfully in Vancouver in June 2021 (Figure 21). The tests represented typical construction fire scenarios. Phase 2 focused on testing a full scale 2-storey, 350 m^2, mass timber structure (Figure 22). Findings from Phase 1 pilot demonstration project were used to refine the design and testing approaches of the full-scale mass timber structure and supported the approval of several tall wood buildings in British Columbia.

In Phase 2, five different fire test scenarios were conducted on the full scale 2-storey mass timber structure designed and built at the Canadian Explosives Research Laboratory (CERL) in Ottawa. The tests investigated among other things, the fire performance of protected & unprotected mass timber, fire dynamics, and the behaviour of construction and garbage bin fires. The initial test conducted in Phase 2 was the world's largest mass timber demonstration fire presented to date. Preliminary observations have indicated that the fire performance of the mass timber structure was similar to that of non-combustible construction and have confirmed that mass timber performs well under the rare fire scenarios in which the sprinkler system fails, and the fire department is unable to respond.

One of the key objectives of the fire tests was to demonstrate to a host of decision makers (e.g., fire services, municipal building officials and regulatory authorities, insurance and finance industries, and other key construction stakeholders) that the fire performance of mass timber construction can meet, or even exceed, the performance achieved by non-combustible construction as permitted in the building code. Over 200 experts from across Canada, including fire officials, building regulators, insurance industry representatives, engineers, and architects (including some from governments), witnessed the tests to learn about the behaviour of mass timber construction under fire conditions.

Analysis and reporting of data collected from the tests will be used to support future code change proposals, including performance-based codes and the development of alternative solutions and new fire suppression systems.

Figure 21: *Vancouver Pilot Demonstration Test (Courtesy of GHL Consultants Ltd.)*

Figure 22: *Ottawa Mass Timber Fire Demonstration Test during and after the test as the fire died down*

5 CONCLUSIONS

The Government of Canada is making significant investments in expanding the use of wood as a low-carbon building material in Canadian building and infrastructure projects. Through demonstration projects and strategic activities focused on advancing wood design education and supporting science-based code revisions, the GCWood program is supporting greater market and regulatory acceptance of wood in non-traditional construction applications across Canada.

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