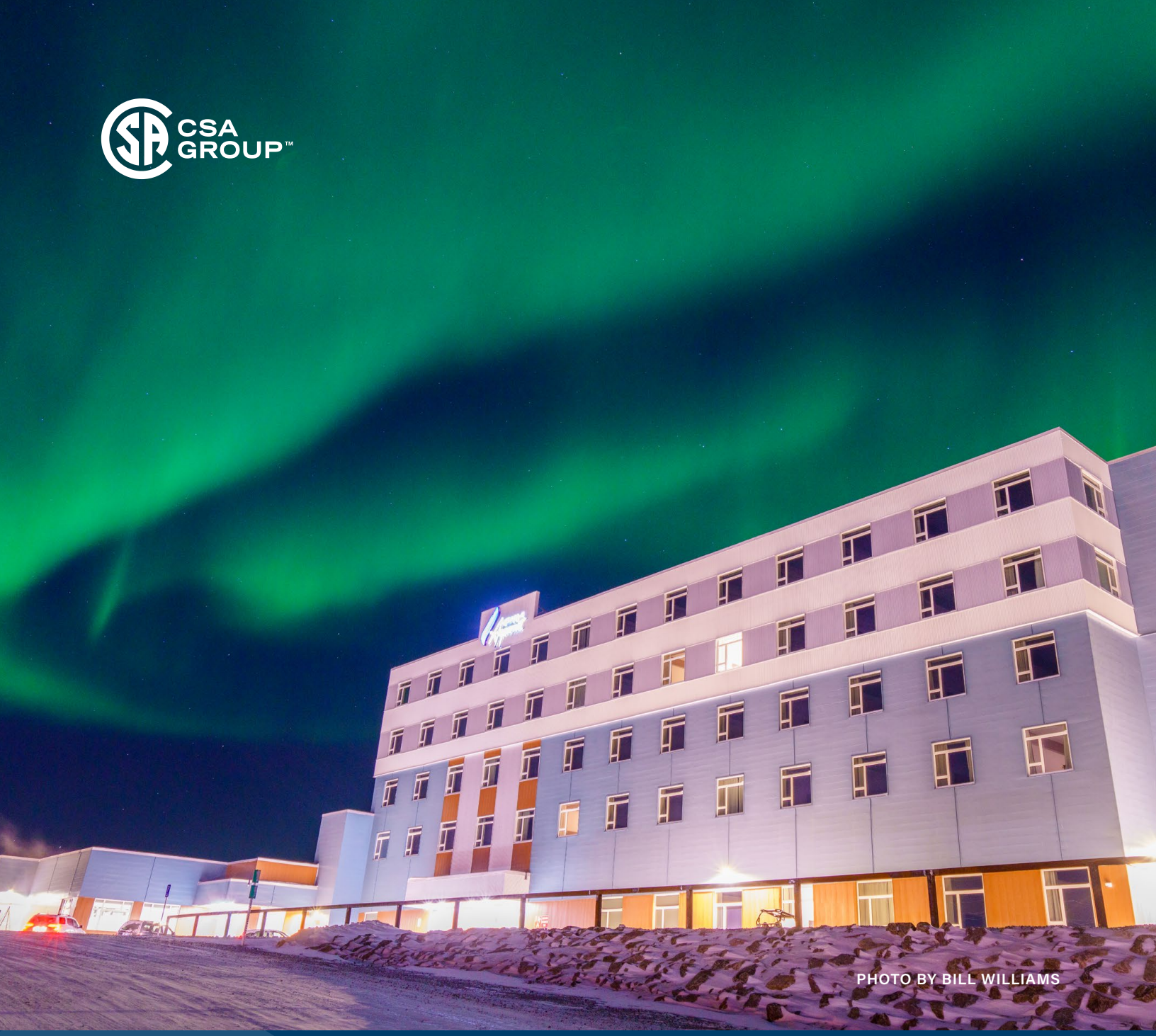

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STANDARDS RESEARCH

Exploring the Existing Regulatory Framework for Modular Construction in Canada

July 2021

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Executive Summary

There are many roles in every modular project – from the design team to the off-site manufacturers through transportation and the on-site installation and construction members – each representing an essential link in the modular construction process. Successful projects, particularly in the construction industry, require excellent communication amongst everyone involved, as well as a thorough understanding of the process and the roles and responsibilities within that process. Additionally, Canada is a large country with multiple jurisdictions, each implementing different regulations for the construction sector. This presents challenges for regulatory officials working with modular projects and necessitates a nationally minded, best practices approach for manufacturers operating in this industry.

Consistent, reliable evaluation practices and communication methods between constructors and regulatory officials are required to ensure that every modular construction project is executed efficiently. This report explores opportunities to improve various aspects of the modular construction process, examining different perspectives and approaches that may be used to help ensure modular construction is meeting building codes, adhering to standards, and passing inspections with efficiency and ease every step of the way.

A more uniform approach for all stakeholders, including regulatory officials, concerning the processes of permitting, inspections and approvals, and codes and standards as they apply to modular construction would greatly assist the industry. A thorough understanding of the roles and responsibilities of each link in the project chain also holds the potential to lessen the workloads of Authorities Having Jurisdiction (AHJ) by improving these processes.

This report explores the current regulatory landscape and, based on interviews and consultations with key stakeholders in the modular industry, identifies key opportunities to support modular construction through new guidelines that address:

- The modular construction process: who is involved, at what stage, and who is responsible for ensuring code compliance through building practices, inspections, and approvals at each step;
- What modular construction building permit applicants must include in their application package;
- What AHJs should expect to see in such a building permit application package;
- Details that the drawings and documents of a modular construction project must include;
- Standards and codes that are applicable and at what stages of construction they apply;
- How certification programs, certification bodies, and third-party inspection agencies operate; and
- Best practices in off-site and on-site inspections procedures.

This report aims to contribute to creating a clearer understanding of the regulatory landscape pertaining to modular construction. A continued analysis of modular construction practices and procedures will provide a better understanding of the processes currently in place and of the opportunities for the further enhancement of those processes, allowing both the public and stakeholders to feel more confident in modular construction as an effective, efficient building process.

Terminology

Alternative solution refers to a building system that complies with all applicable building codes, but does so in a way that is not specifically set out by the acceptable solutions in the applicable building code; therefore, an alternative solution must be proven to achieve at least the minimum level of performance which is already defined for the current code requirement for acceptable solutions in the applicable building codes.

Audit refers to a planned, systematic verification activity by an accredited certification body to evaluate one or more aspects of the quality system that is put in place to determine compliance with code and standards requirements.

Authority Having Jurisdiction (AHJ) refers to the national, provincial, territorial, municipal, district, or on-reserve First Nations agency with authority over a specific aspect or aspects of a building's design, construction, and/or operation/use.

Building envelope refers to all the building components that enclose a structure to maintain an interior and exterior environment; the building envelope includes exterior walls, foundations, roofs, windows, and doors.

Building system refers to elements that combine to create a complete major division of construction that is intended to be used as part of a building or building design.

Certification refers to the confirmation by a certification body (CB) that a product complies with all applicable requirements. Certified products are authorized by the CB to use a designated certification marking as long as they continue to comply with all requirements.

Certification body (CB) refers to a nationally recognized testing and inspection agency that has been deemed acceptable to the applicable regulatory authority or an organization accredited by the Standards Council of Canada or another body acceptable to the applicable regulatory authorities.

Certification program refers to a program that can assist consumers and those responsible for regulating products to confirm compliance with requirements.

Component refers to an element manufactured as an independent unit, subsystem, or subassembly that can be joined or blended with other elements to form a more complex item.

Factory refers to a manufacturing facility that provides protection of construction materials, components, equipment, and products against adverse environmental effects during storage and fabrication.

Inspection refers to a random on-site verification activity to evaluate one or more aspects of a product design or characteristics of a product to determine compliance with applicable technical or administrative requirements.

Jurisdiction refers to the territory or area where a certain person or group of authority extends.

Mateline refers to the location or joint where two modules meet.

Intermodule connection refers to any connection (structural, mechanical, electrical, plumbing, etc.) between the shared boundaries of two or more modules.

Manufacturer refers to the company that primarily engages in the transformation of materials or substances into new products.

Modular construction is a construction technology that refers to the construction of modules at an off-site factory. These modules, when complete, would then be shipped to their final location/site and assembled to form a complete building.

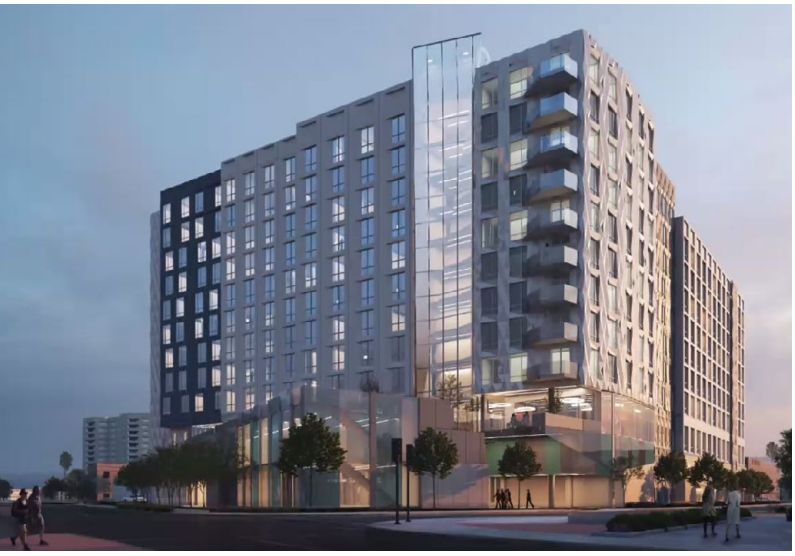
Module refers to a 3D-section of a building designed to be constructed off-site and transported to its final location. Modules are constructed in-factory to various levels of completion.

Off-site refers to the location(s) where modules are constructed.

On-site refers to the site where the completed module or modules are transported to be installed and finished.

Scope of Work (SOW) refers to a document that acts as a guide covering all the agreed-upon tasks for a project. SOWs provide a matrix showing individual tasks or groups of tasks and which party will be responsible for the execution.

Third-party inspection agency (TPIA) refers to a qualified party that inspects a building or portions of a building to assess its compliance with the applicable codes and standards.



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"Benefits of modular construction are its potential ability to meet a rising demand for housing, the ways in which modular construction uses sustainable, environmentally friendly building practices, its potential for accelerated and potentially cost-saving project schedules, and its potential for increased worker safety."

1 Introduction

1.1 Background and Objectives

This research report follows an earlier report, issued in June 2020 by the Canadian Standards Association (CSA Group) titled "High-Rise Modular Construction" [1]. The June 2020 report reviewed the benefits of modular construction, such as its potential ability to meet a rising demand for housing, the ways in which modular construction uses sustainable, environmentally friendly building practices, its potential for accelerated and potentially cost-saving project schedules, and its potential for increased worker safety.

The June 2020 report also investigated growth, barriers, design, approvals (primarily off-site approvals), and construction throughout the modular process. It offered recommendations based on a review of the current landscape of modular construction in Canada and a codes and standards gap analysis of codes and standards related to modular construction. The top four recommendations were as follows:

1. Develop a new standard for off-site/modular construction.[1]
2. Increase and expand adoption of CSA Standard A277 by the provinces.
3. Review and update CSA Standard A277.
4. Develop guidance for AHJs for off-site/modular buildings.

The fourth recommendation in the list primarily resulted from the finding that most Canadian Authorities Having Jurisdiction (AHJs) have limited experience with modular construction. Presently, modular construction is an underutilized building process in Canada, comprising only 3% of North American new builds; however, globally, modular construction is seeing an increase in use [2]. AHJs could benefit from more exposure to the practices and procedures used in modular construction.

The June 2020 report identified that AHJs would benefit from codes and standards better addressing several aspects of modular construction, including structural aspects, building systems, and off- and on-site construction practices. It also identified that communication between all parties, roles and responsibilities clarification, and on-site inspections as primary areas where AHJs were in need of additional guidance [1].

Foreseeing a potential rise in the use of modular construction methods and products in Canada, the June 2020 report determined that one of the first necessary steps to support modular construction as a growing industry is to develop guidance for AHJs pertaining to modular construction. The current report builds on the findings of the June 2020 report and begins to address this recommendation by examining the current inspection and approvals process for AHJs across multiple jurisdictions. It identifies potential

1 A new standard is currently under development in an effort to address this recommendation. An overview of that standard is provided in Section 5.6 of this report.

challenges in the approvals processes and examines potential best practices through literature and case study review, as well as expert opinions from industry stakeholders.

While this second report's primary purpose was to identify areas of greatest impact to the AHJ community, research was expanded to provide a roadmap for AHJs, constructors, manufacturers, and providers navigating the regulatory landscape of modular construction in Canada. This report highlights key actions that can be taken by stakeholders in every stage of construction, from preplanning to on-site installation. The recommendations aim to facilitate smoother inspection and approvals by AHJs, supporting the industry's growth through adoption of best practices throughout the modular construction process. Recommended actions in modular construction practices, procedures, building codes and standards, as well as other areas of development to strengthen the industry are provided in Section 9.0 and Section 9.1.

1.2 Methodology

The research was conducted in five stages as described below.

Stage 1: Review literature and case studies to understand the current landscape of modular construction strategies, both nationally and internationally.

Stage 2: In-depth review of applicable Canadian building codes, standards, and guidelines currently in place for approvals processes.

Stage 3: Interviews with stakeholders in the following interest categories: modular consultants, designers, providers, project leads, specification writers, and building officials.

Stage 4: Comparison of information gathered through interviews against previous research.

Stage 5: Analysis of information collected and development of recommendations.

Fifteen stakeholders were consulted, some of whom had acted in multiple roles in the modular construction industry. All stakeholders interviewed were either AHJs themselves or had interacted with AHJs through their professional activities.

Research during all stages was structured to focus on:

- Building permit processes;
- Drawings and documentation;
- Inspections and approvals processes for on-site and in-factory work;
- How applicable building codes and standards impact the industry;
- Challenges that industry stakeholders face from a permitting and approvals perspective;
- Challenges specifically faced by AHJs when inspecting and approving modular construction;
- Opportunities for improvement/solutions to the challenges identified by the interviewee; and
- Guidance that could be implemented to assist those navigating the regulations applicable to the modular construction industry.

1.3 The Modular Construction Process

Modular construction should be considered a "process" and not a building type. The process involves the assembly of components at a factory to be transported to a secondary location where the building will be erected and fully finished.

Modular construction differs from traditional construction. In traditional construction, building materials arrive at the site where the building will be erected, and everything is assembled and built on-site. In modular construction, the modular parts of a building are constructed at a factory (off-site) and then transported to the build site by road, sea, or air. The factory-constructed components are then erected on-site and fully finished as part of the final building. Thus, traditional construction involves only one site, and modular construction involves two sites – one site is the factory (off-site), where components are assembled, and one site is the location where the building will be erected and stand (on-site).

Every part of a modular building or product must meet all applicable building code requirements, just the same as any traditional construction project. For example, modular construction must meet the same wind, snow, and seismic conditions as any traditionally constructed building.

2.0 AHJ Roles and Responsibilities

An authority having jurisdiction (AHJ) is the national, provincial, territorial, municipal, district, or on-reserve First Nations agency with authority over a specific aspect or aspects of a building's design, construction, and/or operation/use.

Different regions in Canada use different terminology for entities and individuals enacting similar roles and responsibilities. Depending on their duties as well as what region they are operating in, AHJs may be referred to as building inspectors, safety code inspectors or safety code officers, Architects of Record (AORs), Engineers of Record (EORs), building code officials, and so on.

AHJs' duties typically include but are not limited to:

- Reviewing application packages for prospective construction projects;
- Approving or denying building permits;
- Conducting inspections during the construction of buildings;
- Reviewing third-party inspection agency reports pertaining to the construction;
- Completing a final inspection and approval of buildings; and
- Issuing an occupancy permit.

Earlier research indicates that it is essential to clearly establish who the AHJs are for the entire duration of the modular construction process from the outset of the project [1]. Since there are, at minimum, two sites involved in modular construction, the process of inspection and approvals may include AHJs located in different regions, operating under different code requirements. One example of this is Case Study A, wherein both a municipal building department and a provincial level of government were involved. In such instances, close collaboration between the two agencies is necessary.

Case Study A: A Case for Collaboration

Abbotsford Temporary Modular Residence [3]

Location: Abbotsford, British Columbia
Completed: April 2019

Challenge: It was identified during this building's planning process that a high level of collaboration was required between jurisdictions [4]. The desired building design required meeting rigorous energy requirements and airtightness targets which were specific code requirements that had to meet Step 3 of the BC Energy Step Code. This required building design analysis and early engagement design collaboration between the design team and BC housing to help inform the design approach.

Solution: Early engagement by project overseers with the local jurisdictions and close collaboration with other jurisdictions facilitated this project. Modular construction practices allowed for fast on-site assembly, and the controlled factory environment helped meet the performance requirements set out by the BC Energy Step Code. Parties involved stated this experience as helpful for future projects [4].

3.0 Documentation during Modular Construction

Before any construction can begin on a project, a building permit application must be reviewed and approved by an AHJ. Most jurisdictions provide checklists to those seeking a building permit; a list of items, such as drawings and documentation about the building, must be provided by the constructor proposing the building. Once the applicant has submitted their building permit application, an AHJ reviews the application to ensure the proposed construction will meet all applicable building code requirements. The lists of required documents and drawings vary depending on the jurisdiction where the applicant is seeking a permit.

Clear and open communication between AHJs and constructors, starting at the beginning of the process and continuing throughout the modular project, has been identified as important [1]. Communication between jurisdictions and constructors has also been identified as important in Case Study A, as well as by all stakeholders interviewed for this report.

Since both off-site and on-site construction often occur simultaneously, complete and thorough documentation allows for ongoing checks and balances against the allotted schedule and helps to ensure the most efficient use of materials, labour, and the AHJ's time. This is especially true for larger, more complex projects involving a greater number of modules, projects such as Case Study B, a 25,139 sq ft (2,335.5 sq m) building composed of 52 modules, each with a private bathroom and kitchen.

Case Study B: Pre-Planning for Faster Permitting

Margaret Mitchell Place [5]

Location: Vancouver, British Columbia

Completed: September 2018

Challenge: A rapid response was needed to help provide housing for those experiencing homelessness or who were at high risk of homelessness. The Vancouver Affordable Housing Agency (VAHA) and the City of Vancouver sought safe, affordable transitional housing for homeless citizens to support them in transitioning to an independent lifestyle [5]. Traditional construction methods were considered suboptimal due to weather delays, change orders, and other factors [6].

Solution: The modular construction company developed and followed a standardized modular program that helped in fast-tracking the municipal permitting [6]. Part of the standardized modular program's function was to ensure that all the documentation AHJs needed was presented in a systematically organized fashion. This documentation processes' precision was instrumental in facilitating the project's rapid-build time, which was – from signing the contract to occupancy by residents – less than six months.

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4.0 Off-site/In-factory Inspections

Inspecting and approving modular components in factories is important. Once a module arrives on-site, it can be difficult or impossible for an AHJ to view components installed during construction in the factory; for example, mechanical, electrical, and plumbing (MEP) systems may be covered by walls, cabinetry, or otherwise obstructed from view.

In some jurisdictions, code requirements and/or provincial regulations require an off-site review by the AHJs of the jurisdiction where the product is to be installed (on-site). Additionally, for larger projects or more complex buildings, it may be a best practice to have AHJs responsible for the on-site approvals process come to the factory location for supplementary inspections even when local regulations do not require this. These supplementary inspections give AHJs the opportunity to become better informed about factory practices and procedures and be assured that factory-constructed components are being completed in a code-compliant manner. Furthermore, they allow AHJs to have a more comprehensive view of the building from an off-site perspective that helps facilitate the subsequent on-site inspections and approvals processes.

In addition to Canadian modular construction factories, there are also many international manufacturers [1]. The use of modules manufactured outside of the country on Canadian projects can result in the need for cross-jurisdictional communication on an international level. A great example of this approach is presented in Case Study C, in which a Netherlands-based hotel operator collaborated with inspectors from the City of Seattle to construct 228 modules for erection in the United States.

Regardless of whether the materials used in modular construction are sourced nationally or internationally, every component and material used during the off-site construction phase must meet applicable Canadian codes and standards; inspections need to be conducted at the factory to ensure all Canadian building codes and standards are met unless certified to CSA A277 [1]. International products can be certified to meet applicable Canadian standards requirements (see Section 5.1), and third-party agencies can assist in this process (see Section 6.0).

Case Study C: International Connections

citizenM Hotel [7]

Location: Seattle, Washington, USA
Completed: September 2020

Challenge: The factory constructing the modules was located in Poland, Europe, and the building was to be erected in the United States. Normal production and assembly processes in Europe differed from regulatory requirements in Seattle, Washington.

Solution: The constructors worked with officials from the jurisdiction where the building would be installed. Providers and officials modified their production and assembly processes to meet applicable US building codes and standards.

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Examples similar to Case Study C include buildings such as the Alt Hotel in Calgary, Alberta, where the modular portions of the 11-storey hotel were constructed in Poland and shipped to a seaport in Thunder Bay, Ontario, then transported to Calgary by truck [8].

5.0 Building Codes and Standards

Like traditional construction, modular construction must adhere to all applicable building code requirements, both in the factory and in the location where the building will be erected. Building codes set out technical provisions for the design and construction of new buildings. They also apply to alterations, change of use, and demolition of existing buildings.

Standards are more detailed and typically define technical specifications, methods, and sometimes procedures that are used during construction. The use of building codes and standards helps to implement more reliability and uniformity in construction practices.

In the following sections, building codes and standards that are relevant to modular construction are reviewed. Most municipalities in Canada adopt the national or their provincial code in their entirety. Municipalities also have the option to create bylaws that are applicable specifically in their region. Research conducted for this report focused on national and provincial Canadian building codes. Unless otherwise mentioned, municipal bylaws were not explored.

5.1 Standard on Certification of Prefabricated Buildings, Modules, and Panels

CAN/CSA A277-16 Procedure for Certification of Prefabricated Buildings, Modules, and Panels (CSA A277) is a standard used for certification of modular products [9]. Unless otherwise mentioned, this report references the most current version of CSA A277 published to date, issued in 2016.

CSA A277 specifies the procedure for the certification of prefabricated buildings and partially or fully enclosed modules and panels. The procedure can be applied to any type or size of building, from a single storey home to a 10-storey hospital.

CSA A277's requirements meet or exceed the requirements in all Canadian building codes (see Sections 5.3 and 5.4). Every modular product that meets the requirements of CSA A277 therefore meets or exceeds the requirements of all applicable Canadian building codes. This includes every component installed at the factory, such as plumbing, gas, and electrical systems; to meet CSA A277 requirements, each component and building system must be installed by a qualified professional.

CSA A277 stipulates that a quality program be implemented in the factory that includes a quality system with documented procedures and organizational structure established to help ensure compliance of a product or service with specified requirements, and to provide evidence of such compliance.

A quality program that is designed to meet CSA A277 requirements must include, but is not limited to:

1. Documentation of the qualified personnel involved in all processes of construction;
2. A detailed manual outlining design, development, and in-factory stages of construction;
3. Guidelines for the purchase of items;
4. Procedures for in-factory inspection that ensures that items, construction and installation comply with applicable technical requirements;
5. Quality program forms that accompany each product throughout all phases of construction;
6. Outlined Procedures for a record retention system; and
7. Methods for the disposition of non-compliant items.

If the requirements of CSA A277 have been satisfied, the certification body (CB) provides labels to be affixed to the modular product (see Section 6.0). Such markings provide visible assurance to AHJs that the product has met established parameters ensuring it is code-compliant.

CSA A277 stipulates that factories must provide instructions that accompany certain types of modular construction to their on-site location. These instructions can address transportation, lifting, placement, and installation procedures as well as, where applicable, the layout of the modules or prefabricated panels. Factory instructions must take into account the regulations and codes at various

points of delivery as well as the regulations and codes at the final location to help ensure that the product meets applicable requirements.

CSA A277 has different requirements for modular products to meet, depending on the type or size of building that the modular component is to be installed in. This is also true of different types of modules, such as bathroom or kitchen modules. Every modular component built to meet CSA A277 requirements must meet all the requirements for its intended use in the final structure.

5.2 Standard on Manufactured Homes

CAN/CSA Standard Z240 MH Series-16 *Manufactured Homes* (CSA Z240 MH) is a series of standards used for the certification of general, vehicular, and technical requirements of manufactured homes [10]. Unless mentioned, this report references the most current version of CSA Z240 MH published to date, issued in 2016.

CSA Z240 MH is a series of standards designed for one-storey buildings that provide specific performance requirements; however, not all of CSA Z240 MH's requirements have quantitative criteria to meet. Additionally, CSA Z240 MH references the National Building Code (NBC) (see Section 5.3) for some requirements and references CSA A277 for its quality program (see Section 5.1).

5.3 National Building Code

The National Building Code of Canada (NBC) is issued by the Canadian Commission on Building and Fire Codes and the National Research Council of Canada. This report references the most current version of the NBC published to date, issued in 2015.

The NBC is a model code, which means it is a code that has been developed to provide the minimum requirements that must be met in order to satisfy construction conditions. The NBC is developed independently of any one Canadian jurisdiction. A model code has no legal status unless adopted by a province, territory, or municipality. The NBC can be adopted by a jurisdiction in full or in part, and it can be amended and/or supplemented at the jurisdiction's discretion.

The following provinces and territories largely adopt the NBC [11]:

- All major municipalities in Prince Edward Island – adoption of the NBC without revision;
- New Brunswick, Newfoundland and Labrador, Nova Scotia, Manitoba, and Saskatchewan –adoption of the NBC with some modifications and additions; and
- Yukon, the Northwest Territories, and Nunavut – adoption of the NBC with some modifications and additions.

Modular construction must meet the same conditions as traditional construction by conforming to the NBC's requirements at the building's installation site. Additionally, under the Notes section in Part 9, "Housing and Small Buildings", the NBC specifically refers to CSA A277 as "a procedure whereby an independent certification agency can review the quality control procedures of a factory and make periodic unannounced inspections of its products". The NBC accepts certification to CSA A277 as providing "some assurance" to AHJs that the concealed components in a factory-constructed building do not require re-inspection on-site.

The fact that it can be impossible for an AHJ to inspect some of the in-factory built components in modular construction is mentioned in the NBC as being addressed by the procedure outlined in CSA A277. The NBC states that independent certification agencies (see Section 6.0) can review quality control procedures of factories to assure that factory products are certified to CSA A277 (see Section 5.1). However, since the NBC only refers to CSA A277 in the Notes section, the use of CSA A277 is not mandatory, but only a recommendation that may or may not be followed at the discretion of the local AHJ. Additionally, the note that refers to CSA A277 is under Part 9 of the NBC, "Housing and Small Buildings". Therefore, the recommendation only applies to buildings that are less than three storeys and have a building area not exceeding 600 sq m.

The NBC gives no mention to the acceptability by AHJs of buildings meeting CSA A277 requirements that fall outside of the conditions for Part 9.

The NBC does not reference CSA Z240 MH in its entirety and, therefore, buildings meeting the requirements of CSA Z240 MH are not recognized as having met local building code requirements. The NBC only references some of the clauses in the Z240 MH series, such as manufactured homes and foundation depths, the structural requirement of deformation resistance, and the anchorage of small buildings (i.e., more than 4.3 m wide and not more than one storey in height). The NBC also mentions that one of the CSA Z240 MH standards deals with the requirements of transporting manufactured homes over roads, which is noted in the NBC as an activity that is not currently addressed in Canadian codes.

The NBC has only two mentions related to the transportation of factory-built buildings. The first mention states that the thermal installation must be installed so that it will not dislodge during transportation. The second mention is regarding the energy performance of single-section factory-constructed buildings, in that the necessarily low-sloped roofs are recognized as an option to meet height restrictions during transportation.

5.4 Provincial Codes

There are four provinces that publish their own codes based on the NBC with significant additions or deletions: Alberta, British Columbia, Ontario, and Quebec (see Sections 5.4.1–5.4.4) [11].

5.4.1 Alberta

Alberta's building code is called the National Building Code – 2019 Alberta Edition, or NBC(AE). The NBC(AE) is published by the National Research Council of Canada in collaboration with Alberta Municipal Affairs. This report references the most current version published to date, issued in 2019.

The NBC(AE) adopts the NBC with some differences; those differences are generally written as additions or deletions to the NBC. However, a primary difference is that CSA A277 is more pervasively and concretely referenced in the NBC(AE) than in the NBC. The NBC(AE) dictates that all factory-built modular products must be certified in accordance with CSA A277 by an organization accredited for this purpose. Therefore, all modular components that have been certified to meet CSA A277 do not undergo inspections by AHJs in Alberta. This is applicable to all sizes and types of buildings.

Another notable requirement of the NBC(AE) is that specific schedules be signed-off by qualified professionals such as architects and engineers. These schedules indicate who the qualified professional on record is and what their capacity is on a project. They are used to help clearly define relationships between constructors and AHJs by indicating how the various qualified professionals will coordinate in the design and review of all aspects of the building.

Concerning transportation, the NBC(AE) gives the same considerations as the NBC regarding thermal installation and low-sloped roofs (see Section 5.3).

The NBC(AE) also references transportation in relation to relocatable buildings. Relocatable buildings are not intended to remain on-site for prolonged periods of time; they remain for a length of time that is established by the applicant and the municipality issuing the permit. The NBC(AE) states that the design criteria for these types of modules will account for forces endured during transportation and subsequent relocation.

CSA Z240 MH requirements are not recognized in the Province of Alberta; all modular products must comply with the NBC(AE).

5.4.2 British Columbia

The British Columbia Building Code (BCBC) is issued by Municipal Affairs and Housing, the Canadian Commission on Building and Fire Codes, and the National Research Council of Canada. The BCBC adopts substantial portions of the NBC with some variations that are primarily written as additions. The BCBC references an older version of CSA A277, namely the 2008 version (CSA A277-08).

The BCBC references CSA A277-08 in the Notes section, stating that if an in-factory constructed building bears the label of an accredited certification body (CB) indicating compliance with the NBC and

BCBC using the CSA A277 procedure, the AHJ will have some assurance that the concealed components do not require re-inspection on-site.

In 2015, the BC government's Building Safety Standards Branch issued an Information Bulletin that states that if a factory-built building is certified by an accredited certification agency as meeting CSA A277 requirements, then "it would be practical and reasonable for the accepting authority to rely on the certification label as means to verify that the construction done in the factory is code-compliant". Additionally, the bulletin states that the BCBC considers mobile homes certified to meet CSA Z240 requirements as acceptable housing. This acceptance of CSA A277 and CSA Z240 MH applies to housing and components produced off-site (in-factory); all on-site preparations, such as foundations and connections, are required to comply with the BCBC [12].

Concerning transportation of modules, the BCBC makes the same mentions as the NBC (see Section 5.3).

The Vancouver Building Bylaw was issued by Vancouver City Council in 2019. It provides the same conditions pertaining to modular construction as the BCBC; however, in the Vancouver Building Bylaw, CSA A277-08 is listed under Division B, "Acceptable Solutions". Modular construction practices that meet CSA A277 are therefore more likely to be accepted by AHJs without the need for re-inspection on-site. Overall, this results in a higher level of acceptance of modular construction practices, easier utilization of modular construction methods, and faster permitting and approvals throughout modular projects that require an alternative solution to a permitting process, which is explained in Section 5.5.

5.4.3 Ontario

The Ontario Building Code (OBC) is developed by Ontario's Ministry of Municipal Affairs and Housing. The OBC adopts fire and plumbing codes based on national model codes, but with significant variations in content and scope. The OBC also references the National Energy Code for Buildings. This report refers to the most current version of the OBC published to date, issued in 2012. The OBC references the 2008 version of CSA A277 (CSA A277-08).

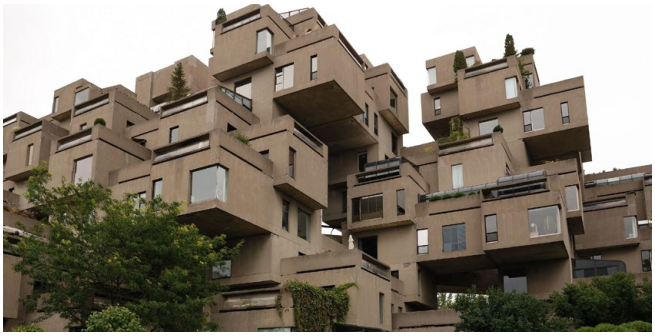
The OBC outlines that when a factory-built house has been certified to CSA A277-08, it does not need to be re-inspected by AHJs on-site. However, the OBC references CSA A277-08 in Part 9 of the Code, "Housing and Small Buildings", which means that the use of CSA A277-08 is only applicable to buildings that fall under that part of the code. If a factory-constructed product is intended for use in a building that falls outside of Part 9 of the Code, even if it is certified to CSA A277 requirements, the AHJ may request inspections off- and on-site, depending on their acceptance of the use of CSA A277.

A structure built to conform to CSA Z240 MH requirements is referenced in the OBC as being "constructed in sections not wider than 4.88 m". The OBC references some of the criteria in the CSA Z240 MH series, such as minimum depth of foundations requirements as they pertain to manufactured homes, foundations for deformation and resistant buildings requirements, and the anchorage of smaller buildings (not more than 4.3 m wide and not more than one storey).

Concerning transportation of factory-built buildings, the OBC only mentions that thermal installation must be installed so that it will not become dislodged during the building's transportation.

5.4.4 Quebec

Quebec has two codes: the Code de Construction (Quebec Construction Code), and the Code de Sécurité du Québec (Quebec Safety Code). The Quebec Construction Code provides specifications for planners, designers, and contractors. The Quebec Safety Code is for owners of buildings, facilities, and installation. Both documents are published by the National Research Council of Canada in collaboration with the Régie du bâtiment du Québec. These codes adopt building, plumbing, and energy codes that are substantially similar to national model codes, with some differences that are primarily written as additions. The 2010 Amendment to the 2015 version of the code references CSA A277.



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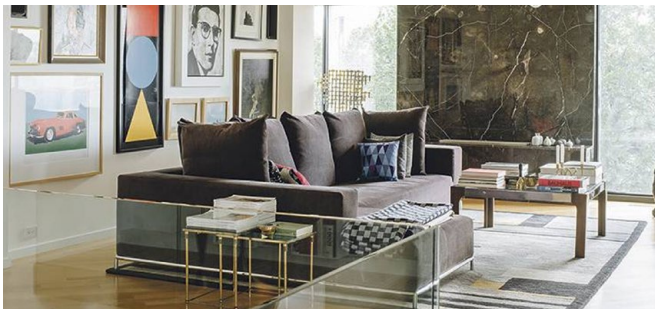


Photo description: Habitat 67 is a housing complex in Montreal, Quebec. Built for Expo 67, it is still used as a residential building today [13].

The Quebec Construction Code and the Quebec Safety Code state that any building whose sections or panels are manufactured must not be sold, rented, exchanged, or acquired unless certification to CSA A277 has been obtained. Every prefabricated building or component must be constructed by a company that has received certification. These certified products are not required to be re-inspected by AHJs on-site when installed in the province. These stipulations are applicable to products built with the intended use in all sizes and types of buildings.

The Quebec Construction Code and Quebec Safety Code reference some of the criteria from the Z240 MH series, such as the manufactured homes criteria for foundation depths, the structural requirement of deformation resistance, and the anchorage of smaller buildings (buildings not more than 4.3 m wide and not more than one storey in height).

No mention is given to the transportation of modular products in either the Quebec Construction Code or the Quebec Safety Code.

5.5 Alternative Solutions

Not all building methods and materials that can be used in a construction project are included in a building code. While most projects will use the acceptable solutions in the applicable code, sometimes a constructor wishes to use a material, component, or construction method that is different from those given as acceptable solutions. In this case, the constructor can apply for an alternative solution, which is a process that the building code allows to be pursued to provide flexibility for constructors, and to allow for the use of technology that has not been included in the code.

An alternative solution must be proven to achieve at least the minimum level of performance criteria provided in the applicable building code in a way that is not specifically set out by the building code.

Alternative solutions applications typically require a report detailing the alternative solution along with all supporting documentation proving that the performance criteria of the applicable codes are met.

What each jurisdiction considers to be an alternative solution varies. Only a qualified professional, such as an architect or engineer, can apply for an alternative solution.

In jurisdictions where CSA A277 is not directly referenced in their codes as an acceptable solution, constructors will need to apply for an alternative solution when including modular construction in their building process. Since the codes in Alberta and Quebec consider any modular construction product certified to CSA A277 as an acceptable solution, no alternative solution application is required for the use of products that have been certified to CSA A277. In Ontario, modular building types are covered as acceptable solutions under Part 9 of the OBC, "Housing and Small Buildings".

The process of obtaining an approved acceptable solution can take a long time and can be costly, particularly when the evaluation subject is especially innovative or complex [14]; completing the evaluation can take as long as five years. For example, the alternative solution in Case Study D required two years of research before it was accepted (see Section 8.2.1).

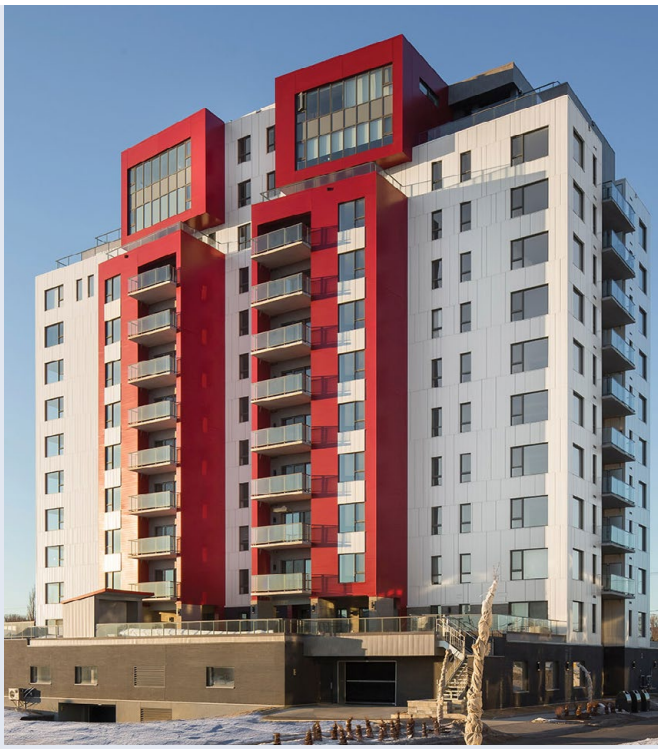
Case Study D: An Alternative Solution in Action

Quebec City's Origine [16]

Location: Quebec City, Quebec
Completed: October 2017

Challenge: Since the 13-storey building design used laminated timber rather than a material that would already be presented as acceptable by the building code, the constructors needed to demonstrate that their alternative design could meet all applicable build code requirements.

Solution: The project was extensively fire-tested at the National Research Council. Tests showed that Origine's building envelope could meet or even exceed existing fire safety standards [15]. Proving that this alternative solution would meet code requirements required two years of research [17].



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In Case Study D, the scale of the building combined with the fact that it was constructed predominantly of glue-laminated timber raised concerns about fire safety [15]. Since the code in place stipulated that buildings higher than four storeys cannot be built predominantly from wood, an alternative solution was sought.

Similar to Case Studies A, B, and C, collaboration between jurisdictions was important in Case Study D; reaching conclusions in the research processes of this building system required input from federal and provincial officials, as well as research institutes [16].

Each alternative solution is site-specific and is applicable to one project only; a new application must be made for every project, even if it is nearly identical to a previous project. For each application, the constructor must supply the AHJ with all of the technical information.

It is possible to use the services of a third-party agency to evaluate a proposed alternative solution and provide a report that demonstrates code compliance through testing and analysis. The third-party agency must develop a technical guide outlining all testing criteria a proposed alternative solution must meet, including specific performance requirements, testing protocols, and/or engineering analysis. AHJs use the report to assist them in the issuance of an approval or the denial of the constructor's proposed alternative solution.

Several organizations offer evaluation services. The Canadian Construction Materials Centre (CCMC) is an evaluation agency that is referenced in the NBC as providing code compliance assessments. The assessments provided by the CCMC are recognized by every Canadian province and territory [18].

5.6 Standard on the Process for Delivery of Volumetric Modular Buildings

CSA Standard Z250 *Process for Delivery of Volumetric Modular Buildings* (CSA Z250) describes the process for delivery of permanent volumetric modular buildings [19]. It covers procedures for pre-factory and post-factory delivery of modules. CSA Z250 is intended to complement CSA A277 and therefore references CSA A277 where applicable. For instance, CSA Z250 outlines a quality program for the overall process of modular construction projects, but refers to CSA A277 for the in-factory work.

CSA Z250 covers:

- Module design
- Quality control during manufacturing
- Approvals processes
- Logistics, transportation, and storage of modules
- Off-site and on-site construction
- Lifting, placement, and setting of modules
- Installation and finishing of modules
- Commissioning and handover

CSA Z250 also includes requirements to clarify the roles and responsibilities of stakeholders involved in the project. The standard emphasizes that clear communication and documentation between the project's owner, designers, general contractor, manufacturer, and the AHJ are imperative to a successful modular project.

6.0 Certification

Certification is a means to confirm compliance with applicable requirements. For a modular manufacturer, this helps to ensure that the factory meets the requirements of CSA A277 and therefore confirms that a quality program is in place for modular products. Certification is issued based on an assessment by the certification body (CB). In certain situations, a CB may choose to use a third-party inspection agency (TPIA) to conduct this assessment on its behalf.

A TPIA can either be an integral part of a CB, in which case the CB both inspects and certifies, or the TPIA can be independent, in which case it inspects factories and provides an assessment report to a CB that will issue certification. Most modular factories in Canada use TPIAs to audit and inspect in-factory procedures and practices to ensure their products are certified to CSA A277, even if the local building code does not require this.

A TPIA and CB must be accredited by the Standards Council of Canada to inspect and/or audit factory quality programs. In the case of CSA A277 certification programs, TPIAs are responsible for the factory's quality programs and systems. (See Section 5.1 for more information on the CSA A277 quality program and quality systems.)

TPIA roles and responsibilities include:

- Completing an evaluation of the factory's quality system and design documents;
- Inspecting and auditing the certification program;
- Ensuring in-factory work is being conducted by the appropriate qualified professionals;
- Ensuring the in-factory work is being completed to CSA A277 requirements, as applicable;
- Providing labels (provided to the TPIA by the CB) that will be affixed to products that have met all CSA A277 requirements;
- Performing, at minimum, one audit annually, and otherwise auditing at a frequency deemed appropriate by the TPIA based on prior inspections at a minimum rate of three per year, completing random in-factory inspections of products and completed records and forms to verify quality activities have been performed as required by the approved quality manual; and
- Ensuring that the quality program is using up-to-date codes and standards during the audits. All findings made by TPIAs during audits and inspections are put into reports that are made available for CB or AHJ review as applicable.

In jurisdictions such as Alberta and Quebec, off-site (in-factory) inspections by an AHJ are rarely required since products that have been certified to meet CSA A277 requirements are accepted as being code-compliant when they arrive on-site.

7.0 Post-Factory

Between the in-factory construction stage and the on-site installation stage, modules and modular products may be transported by land, air, sea, or a combination thereof. Following transportation, modules must be installed at the final building location.

This section covers the usual steps required after manufacturing, from transportation to installation.

Transportation

Every modular construction product certified in accordance with CSA A277 comes with instructions for transport procedures; however, the standard does not address the actual transportation of the buildings or modular products. Transportation regulations vary by jurisdiction. When transportation crosses through multiple jurisdictions, multiple transportation permits may be required from the applicable transportation authorities.

Arrival On-site

When a module arrives on-site, those responsible for their arrival should inspect the module and make detailed records of any damage that may have occurred during transport; AHJs must be notified of any post-factory damage and repairs. Constructors should have procedures in place for any repair work that must be done, and chain of custody records should be kept for the AHJ to review.

Installation Instructions

Every modular construction product certified in accordance with CSA A277 includes instructions necessary for lifting, placement, and installation, as well as instructions for the modular layout. These instructions are provided to the constructor from the manufacturer. Following the installation instructions that accompany the modules will help allow the building to perform as intended.

Manufactured homes constructed to CSA Z240 MH requirements come with instructions for set-up. The CSA Z240 MH series references CSA A277 for the instruction requirements; all instructions must be provided in the same manner as outlined in CSA A277.

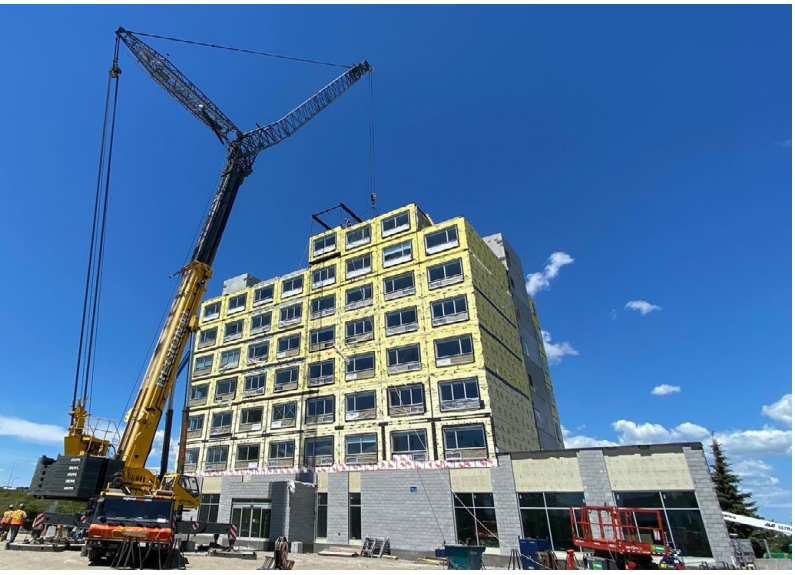
On-site Work

Throughout construction, matelines and connection points should be inspected for compliance to code and applicable drawings, including inspections of the air barrier system, vapour barrier, insulation, sheathing membrane, cladding, roofing, and flashing at joints, as applicable. All anchorage of the modules to the foundation and to the building's structural systems will be addressed in the installation instructions provided by the factory.

On-site surveys completed by qualified professionals verify fire detection equipment's positioning based on the design documents. Once all measurements and device types have been obtained, the necessary items are delivered and installed on-site. The continuity of all fire protections and alarms systems must be maintained between modules. Fire detection system cables must be installed and clipped to comply with industry standards. The installation of these systems is done on-site by qualified professionals.

All on-site work and modular connections, such as electrical, plumbing, mechanical, and utility connections, must be inspected and approved by a qualified professional throughout the process of construction. Systems will be demonstrated and confirmed on-site. Once the modular product has been fully installed, inspections for the building as a whole are carried out by the AHJ. All code requirements must be met for the modular construction as are met in a conventionally constructed building.

Prior to the handover to the client, an AHJ must complete a general review, a final inspection, and issue an occupancy permit.



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"The majority of the stakeholders interviewed noted that there is the need for a clear and uniform approach to be developed when cross-jurisdictional collaboration is required."

8.0 Modular Construction Processes Consultations

The following sections summarize the findings from interviews conducted with industry stakeholders. The information has been consolidated into the following categories: Collaboration, Permitting Process, Drawings and Outset Documentation, Certification, Building Codes and Standards, and Post-Factory.

8.1 Collaboration

A project that requires collaboration between AHJs in different jurisdictions, such as in Case Study A and Case Study C, is a common occurrence in modular construction; however, there is a lack of literature available on the subject. The majority of the stakeholders interviewed noted that there is the need for a clear and uniform approach to be developed when cross-jurisdictional collaboration is required. An increase in international and national cross-jurisdictional dealings was cited as attributing to an uptake in the use of modular construction; as a result, the need for more guidance for cross-jurisdictional dealings was identified as vital.

8.2 Permitting Process

Permits were identified as a major cause of time delay in the construction process. In part, time delays were attributable to incomplete submission packages. Since modular construction processes differ from traditional construction processes, a permitting process that is clear and separate from a traditional building permit application process could be developed to ensure the submission of complete building permit applications.

Another factor identified as contributing to permitting delays is the AHJs lack of familiarity with the modular construction process. Many of the AHJs interviewed, as well as other stakeholders, mentioned that having a more detailed understanding of modular construction would benefit the AHJs during the building permit review process. This would allow AHJs to complete faster and easier assessments of modular projects.

Having a separate permit process for modular construction projects to follow during the earliest stages of engagement with AHJs was made clear as being highly important and highlighted as being especially true for larger and more complex residential or commercial projects.

8.2.1 Alternative Solutions

A significant hurdle for modular construction projects is the need to apply for alternative solutions, except in Alberta and Quebec. The current case-by-case permitting and approvals process for alternative solutions relating to modular construction was reported to take up a significant amount of AHJs' time and to extend the building permit processing time by a considerable amount. This was exacerbated when the AHJ reviewing the application had limited exposure to modular construction methods. Additionally, interviewees identified that AHJs had varying openness

and acceptance of modular construction methods, which, at times, created barriers when attempting to pursue an alternative solution in a modular project.

8.2.2 Online Submissions

Online submissions for building permits were identified by AHJs as being easier and faster to review than those submitted non-electronically. AHJs stated that reviewing applications online was easier because the communication between AHJs and applicants was faster, so any changes the AHJ required of the applicant were much quicker and easier to implement.

8.2.3 Submission Packages for Permits

In the case where building permits were put forth for review and lacked certain details, the permitting process was notably delayed. Incomplete building permit applications were repeatedly raised by AHJs during interviews as an issue. In addition to stakeholders having more familiarity with modular construction practices, AHJs would benefit from early engagement by the constructor as well as from having more time to review permit applications. Developing checklists for building permit applications specific to modular construction was also raised as a possible solution to assist in the process for both applicants and permit reviewers.

Permitting delays were, at times, attributed to a lack of familiarity with certain aspects of modular construction. It was suggested that permitting delays could be mitigated if AHJs were more familiar with the roles and responsibilities of TPIAs as well as with compliance to CSA A277.

Lastly, interviewees identified that updating building codes nationally and provincially, where applicable, would eliminate the need for so many modular construction projects to apply for alternative solutions, which would reduce AHJs permit review workload.

8.3 Drawings and Outset Documentation

Drawings included in the permit application were of particular concern to AHJs, who indicated a need for a specific set of drawings that present information unique to a modular construction project. Interviewees suggested that more uniform elements should be included in drawings involving modular construction, such as specific symbols or drawing indicators for matelines and connection points.

It was indicated by AHJs that it would be highly beneficial if modular aspects of a building that comply with applicable building codes were identified as such on the drawings. This information, provided along with a list of materials used and other pertinent details such as the building's performance as a whole, would help expedite the building permit approvals process as well as approvals during the off- and on-site construction phases.

Stakeholders stated that permit application drawings should clearly establish which portions of the building will be constructed in a factory and which will be constructed on-site. Interviewees suggested including this on the building drawings by illustrating factory-constructed portions of the building differently than parts of the building that are to be constructed on-site. One architect suggested that this could be shown through the line-work on the drawing. For example, any factory-constructed portion of the building would be drawn using lighter, fainter lines, and anything that will be constructed on-site would have darker line-work.

Interviewees from Alberta indicated that drawings were less of an issue as applications usually included clear indications of where components of modular construction were being used as well as other details that were important in modular construction. This was attributed to the fact that Alberta has seen more modular construction than other Canadian jurisdictions and has a code that allows for a clearer path for modular construction (see Section 5.4.1). Nonetheless, interviewees from Alberta indicated the importance of permit application drawings showing all pertinent information, including the parts of the building that required off- and on-site inspecting. They also indicated the importance of employing a documentation system that delineates what is required to be inspected and approved, by whom, and at what stage inspections and approvals are required as the project progresses.

8.4 Certification

One interviewee likened the certification process to any product's certification, in that, because the product is certified, the product does not need to then be re-opened and examined by AHJs upon arrival to determine that the product is functional.

It was identified during the majority of interviews that there was a lack of confidence in inspections and approvals that had been done in factories. Some AHJs were uncomfortable accepting the in-factory approvals that had been issued for modular products arriving on-site. Some thought that the installation of the product caused any prior approvals that had been issued to be nullified. This led to re-inspections of products that had already been inspected and approved as meeting all building code requirements.

Interviews identified that there exists a limited understanding by stakeholders about factory and product certification programs and how CBs and TPIAs are involved in the modular construction approvals process. A better understanding of the roles and responsibilities of a CB and TPIA during the modular construction process and the way in which a CB or TPIA gains recognition was identified by several stakeholders as necessary to help ensure the industry's success.

8.5 Building Codes and Standards

A major barrier identified by stakeholders, primarily in jurisdictions outside of Alberta and Quebec, is a lack of knowledge that results in misconceptions about codes and standards as they apply to modular construction. Additionally, vague wording in some codes was cited as an issue, as was a lack of inclusion of references to modular construction processes in portions of the NBC and in some provincial codes.

This concern is expanded upon in the three sections that follow: CSA A277, National Building Code, and Provincial Building Codes.

8.5.1 CSA A277

In Alberta and Quebec, having all modular components certified to meet CSA A277 was reported to greatly assist in on-site approvals processes because it alleviated the need for AHJs to do inspections of certified products. In other jurisdictions, interviewees understood CSA A277 to be a trustworthy standard; however, there was a demonstrated lack of knowledge about the scope of this standard and its application to modular construction sites. For example, there exists a pervading notion that CSA A277 requirements are somehow different from national or provincial building code requirements.

Major manufacturer stakeholders expressed concerns about misconceptions surrounding CSA A277, stating that misunderstandings result in AHJs performing re-inspections of already-approved products both off- and on-site. Though the manufacturers welcomed the AHJs' inspections of their products, they felt these additional inspections by AHJs, in conjunction with the manufacturers' quality program and systems already in place, were somewhat unnecessary given that the quality program ensured the factory-built products met all applicable code requirements.

Interviewees stated that this misunderstanding could, at times, result in an extended delay in the permit's approval or, in some cases, denial of the permit. This sort of occurrence was particularly reported as occurring more frequently in Ontario; interviewees attributed this to the relatively recent rise of the use of modular construction methods in the province.

8.5.2 National Building Code (NBC)

The NBC states that modular products that have been certified using the procedure outlined in CSA A277 will provide AHJs "some assurance" that these certified components do not need further inspection (see Section 5.3). Both AHJs and other stakeholders found the wording "some assurance" to be too vague.

Stakeholders also identified issues with the limitations of the NBC in regards to modular construction processes. Manufacturers identified the need for modular construction processes to be included under more sections of the acceptable solutions portion of the code, stating that such inclusions would prevent delays during the permitting and approvals processes.

Interviewees stated that the fact that the NBC only refers to CSA A277 in the Notes (non-mandatory) section caused an unnecessary additional workload for AHJs (see Section 5.3).

8.5.3 Provincial Building Codes

In other jurisdictions, when interviewees were asked about barriers presented by current codes, the need to apply for an alternative solution was the prevailing issue, cited multiple times by stakeholders as a major barrier faced by the industry. Even stakeholders from Alberta and Quebec remarked on the barriers present in other jurisdictions due to the need to apply for an alternative solution.

Alberta

Alberta interviewees indicated that AHJs' better understanding of CSA A277 and acceptance of TPIAs has resulted in smoother approvals practices throughout all aspects of modular construction. On-site AHJs in Alberta felt assured that modular products certified to CSA A277 have met all applicable codes and therefore do not require re-inspection on-site.

Additionally, this provincial stakeholder group expressed a high level of confidence in the labelling system that identifies modular construction as being certified to meet CSA A277 requirements, saying that this compliance marking system highly facilitated on-site inspection and approvals processes.

British Columbia

The BCBC refers to CSA A277 in the non-mandatory Notes section; however, given BC's exposure to modular construction practices, these notes are considered to be generally acceptable solutions by AHJs. AHJs understood that CSA A277 was included in the building code, but they iterated that the implications of this inclusion could be clearer.

As part of the documentation practices in British Columbia, the Architect of Record (AOR) collects all of the information from all parties involved in a project, including all documentation provided by qualified professionals, as well as any documentation involved in the CSA A277 approval procedures. The AOR then reviews all of the information gathered, issues approvals, and signs the documentation over to the AHJ. This was reported to have had a streamlining effect during the process of approvals.

Ontario

Interviewees in Ontario reported that approvals processes can take a long time as AHJs often have to familiarize themselves with modular construction. This occurrence was identified as a frequent, major, and recurring issue by Ontario stakeholders. Manufacturers identified that this presented a barrier when attempting to apply for building permits in various jurisdictions, indicating that each jurisdiction required detailed information about basic modular construction practices. They reported spending a great deal more time than their conventional-construction counterparts informing AHJs about basic modular construction practices in use. Time spent on this endeavour resulted in prolonged permitting and approvals processes.

Interviewees in Ontario also stated that the reference to CSA A277 existing only in Part 9 of the OBC was an unnecessary barrier in the construction of larger buildings (see Section 5.4.3). They felt strongly that including modular construction building stipulations in the OBC would assist AHJs during the inspection and approvals processes. It was felt that this inclusion would eliminate the many instances of variances in rates of building permit approvals between different jurisdictions.

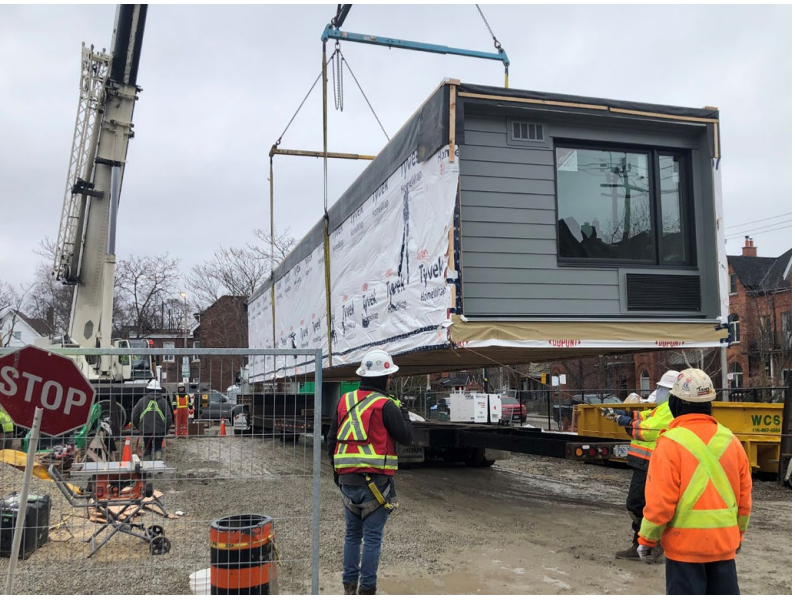
Quebec

Quebec practices were reported as running smoothly in this provincial stakeholder group. There was a good understanding of how CSA A277 is referenced in the building code. Overall, Quebec AHJs had a good understanding of the practices, and inspections and approvals were not reported as any more challenging than in traditional construction.

8.6 Post-Factory

Overall, the on-site process of inspections and approvals was identified by stakeholders as having the potential to be very confusing. AHJs expressed that the on-site approvals processes would be smoother if they had a more thorough understanding of how modular products are approved as meeting code requirements prior to their arrival on-site.

The on-site approvals processes would benefit from AHJs having more information about the project from the outset. For example, AHJs could be brought on board during the planning phases so that they may become familiar with the project early on. Additionally, clearly identifying the set of documents and drawings expected by AHJs, specifically for modular construction projects, would greatly facilitate on-site approvals.



"AHJs expressed that the on-site approvals processes would be smoother if they had a more thorough understanding of how modular products are approved as meeting code requirements prior to their arrival on-site."

Stakeholders suggested that this could be established by a checklist of the project's expected on-site documentation. The documentation should include a Scope of Work (SOW) document that clearly delineates who must approve what and which approvals have already been met.

The interviews conducted generated insights into each part of the post-factory process, and the information has been consolidated into four topics: On-site Documentation, Installation, High-Rise Construction, and Inspection and Approvals.

8.6.1 On-site Documentation

Interviewees identified documentation as paramount in modular construction processes; stakeholders stated that proper planning and documentation from early on would offer the best assurance that post-factory construction would proceed smoothly.

Stakeholders identified that it would be highly beneficial to on-site AHJs for all the modular aspects of a building that comply with applicable building codes to be identified as such on the drawings as reported in Section 8.3. Additionally, an on-site list of modules should be available to compare against the modules arriving from the factory, and clear and detailed on-site inspection procedures should be in place to receive those modules. Records of the inspection that takes place upon the modular product's arrival should be made through a combination of documentation and photography.

It was suggested that two sets of SOW documents be issued with each modular construction project – one for the work taking place in the factory and one specifically for the AHJs on-site. Having separate SOWs could help to alleviate some confusion, especially during on-site inspections. The SOW should list the designated party responsible for issuing the approval for each aspect. Additionally, quality control checklists could be utilized for each integral component, such as fire-safety-related assemblies; mechanical, electrical, and plumbing (MEP) systems; structural and architectural aspects.

AHJs interviewed suggested that on-site documentation should include a document that lists connection point locations and the time during the construction phase at which a connection point will be accessible for inspection by an AHJ. They additionally indicated that a checklist for positioning of all connections and utilities would assist in their duties.

8.6.2 Installation

One issue that AHJs identified as resulting in high levels of confusion was the point in time when CSA A277 certified products were installed on-site. Some AHJs stated that following factory-led instructions (for example, the connection of modules at matelines) invalidated any previously issued approvals and, that following the installation, they were required to inspect every component of the module both inside and out. Other AHJs expressed the belief that any in-factory issued approvals were wholly invalidated upon the moment of arrival on-site. This confusion existed even in some jurisdictions where modular construction was used with more frequency.

8.6.3 High-Rise Construction

Some interviewees raised concerns over whether a high-rise building constructed with modular methods would meet the necessary building code requirements. This included modular products certified to meet CSA A277 requirements. Size and complexity of the building were directly linked to acceptance levels by AHJs in that the larger or more complex the building, the higher the level of scrutiny by AHJs. Buildings under three or four storeys tall and with an overall footprint of less than 6500 sq ft (600 sq m) were reported to be more easily accepted as being compliant when certified to CSA A277; larger buildings were seen as potentially less structurally sound and requiring more scrutiny during the permit approval and on-site inspection processes, even when certified to CSA A277.

8.6.4 Inspection and Approvals

While discussing on-site approvals, some AHJs reported uncertainty surrounding which aspects of the modular portions of buildings required on-site inspection and approvals, including the methods involved in the in-factory approvals and how far an approval done in-factory extended on-site.

Table 1: Recommended Actions to Support the Modular Construction Industry Within the Existing Regulatory Framework of Canada

Consideration/Gap	Recommended Action
Facilitating Permitting, Inspections, and Approvals	
How the most common modular construction projects are designed and constructed. How processes, including permitting, inspections, and approvals off- and on-site, are conducted for each major jurisdiction, including information on projects that have required cross-jurisdictional collaboration.	▪ Create a guidance document for AHJs to reference when involved in typical modular construction projects. In addition to providing an overview of modular practices, the guidance should include a general walk-through of typical inspections, approvals procedures, permit review, and issuing approvals. Develop and promote more supportive educational opportunities that inform on this process, for instance, creating seminars, handbooks, workshops, conferences, online, or correspondence courses.
How the CSA A277 standard is involved in the context of a modular construction project and how CBs and TPIAs are involved in the process.	▪ Promote a better understanding of this information through seminars, training, and information sessions specific to the use of CSA A277, certification programs, CBs, and TPIAs. ▪ Guidance information in a stand-alone document and/or included in other guidance documents/informative opportunities (i.e., workshops, seminars).
Information on when and how to apply for an alternative solution in each major jurisdiction where this was found necessary for modular projects.	▪ Develop guidance on alternative solutions. ▪ Once developed, promote the use of these informative/educational materials in relevant jurisdictions, i.e., provide regionally relevant guides at the beginning of the construction/alternative solution application process, where applicable.
Improving and Promoting Modular Construction Practices	
Information about how modular construction is being conducted nationally and abroad.	▪ Create a comprehensive best practices construction guide that covers the process in a manner that will promote the best use of modular methods in Canada. ▪ Develop and promote more supportive educational opportunities about this process, such as seminars, handbooks, workshops, conferences, online or correspondence courses.
Information on constructing, transporting, storing, lifting, and installing modular products.	▪ Develop best practice guidelines in these areas.

Table 2: Recommended Actions to Support the Modular Construction Industry Administratively

Area	Recommended Action	Industry Impact
Permitting Process	▪ Develop a modular construction building permit application process that is separate from a traditional building permit application process and allow for online applications. ▪ Develop separate modular construction checklists and/or checklists to be used in conjunction with a conventional permit application list.	▪ Facilitates faster approvals. ▪ Creates a clearer pathway for constructors seeking to use modular methods. ▪ Facilitates communication between AHJs and constructors.
Drawings and Documents	▪ Develop a checklist of the modular-specific set of documentation and drawings required for a modular project. ▪ Develop a checklist of what should be indicated on modular construction drawings. ▪ Develop a uniform approach to illustrating modular construction aspects on drawings, such as indicating all off-site and on-site construction, mateline markings, connection points for utilities, etc.	▪ Facilitates use of best practices throughout the construction process. ▪ Assists in the collaboration between designers, constructors, manufacturers, and AHJs. ▪ Assists AHJs in that they can review more uniformly, prepared drawings and documents.
On-site Documentation	▪ Develop a checklist of documentation that must be made available on-site, including an on-site SOW and an appropriately detailed list of modules arriving from the factory to the on-site location. ▪ Develop a procedure for documentation and management of repairing any damage to modular products prior to their installation.	▪ Facilitates use of best practices throughout the construction process. ▪ Facilitates communication between stakeholders.

Furthermore, some expressed concerns about who was officially responsible for assuring that the modular portions of the building met all the code requirements. As a result, it was reported that many AHJs had re-inspected parts of buildings that had already been approved as meeting code requirements.

9.0 Analysis and Recommendations

With modular practices anticipated to rise in the near future, more education about the practices and approvals processes is highly necessary. This research has identified that the dissemination of information is the number one concern for many industry stakeholders. Specific areas that can be targeted and recommended actions that can be taken to assist in educating the industry are listed in Table 1. The recommended actions in these areas would facilitate AHJs as well as the industry as a whole by addressing the challenges identified throughout this report.

Table 2 provides recommendations to improve procedural administrative processes in modular construction. These recommendations were drawn from an analysis of the research in an effort to address the challenges present in the Canadian modular construction inspections and approvals landscape. In conclusion, use of these improved processes would support the industry for all involved stakeholders by facilitating best practices in all areas of modular construction.

Additional overarching long-term actions that exist outside of the scope of immediately actionable items were uncovered during the research; these items are listed in Section 9.1.

9.1 Other Considerations

Other considerations detailed below, while not immediately implementable or directly related to the current regulatory landscape of modular construction in Canada, were identified and found to be worthy of inclusion for future consideration in order to support industry growth.

CSA Z250 – Process for the Delivery of Volumetric Modular Buildings

- Create a comprehensive guide for all stakeholders that covers CSA Z250 with particularly detailed information on the certification procedures and the roles and responsibilities of CBs and TPIAs. This could be a standalone document or could be included with disseminated knowledge about the practices and procedures involved in CSA A277.
- Reference CSA Z250 (once published) in building codes.

Alternative Solutions

- Include more provisions for modular construction practices in all national and provincial Canadian codes to eliminate the need for the high-degree of alternative solution applications necessary in Canada's current regulatory landscape.

Building Codes and Standards

- Implement more precise wording in all Canadian codes where the phrasing "some assurance" is currently in use.
- Reference CSA A277 in all codes as a mandatory requirement to help facilitate permitting and approvals processes.
- Conduct research on the transportation of modular products to gather information and best practices to support specific inclusions addressing transportation of factory-built buildings in building codes.

Building Information Modeling (BIM)

BIM is a set of technologies and processes enabling multiple stakeholders to collaboratively design, construct, inspect, and operate a building in a 3D virtual space. ISO 19650 Part 1 refers to BIM as the "use of shared digital representation of a built asset to facilitate design, construction, and operation processes to form a reliable basis for decisions".

Current permit application processes are largely 2D and paper-based with a large number of plans and drawings that need to be organized and interpreted to determine if the proposed designs comply with regulations.

BIM could be used to have all pertinent information readily available for permit application submissions. Having a detailed, labelled, 3D rendering of the building project would assist AHJs in viewing materials, module matelines, intermodular connections, and systems connections such as mechanical, electrical, and plumbing (MEP), utility connections, fire and sound systems, and so on. Additionally, the use of BIM would facilitate AHJs during the building permitting processes by allowing for changes to be implemented more quickly when required by the AHJ of the applicant. BIM could potentially automate the permit review and increase the efficiency and accuracy of the approval process.

BIM could also be used for planning and ensuring all transportation requirements are met; for example, ensuring that the building size and load is designed to meet transportation requirements. The use of BIM would also carry over in application to the on-site inspection and approval process, allowing for planning surrounding connection point inspections, utility connection inspections, and so on.

10.0 Conclusion

Review of literature and case studies, analyses of codes and standards, and interviews with industry stakeholders provided an insightful look into the regulatory framework currently in place in the Canadian modular construction industry. These insights yielded several recommendations that can be enacted in both the short and long term in order to support this emerging industry.

Immediate actions that will best support the industry are summarized in the four points that follow:

1. Disseminate best practice educational material, such as seminars, handbooks, workshops, conferences, and courses with the aim to:
    a. Familiarize constructors, manufacturers, and AHJs with modular construction practices (including constructing, transporting, storing, lifting, and installing modular products) for buildings of any size and occupancy, with particular attention to aspects applicable to high-rise projects (buildings over three storeys).
    b. Familiarize constructors, manufacturers, and AHJs with building codes and standards applicable to modular construction and, in particular, in the use of CSA A277 and upon publication, the use of CSA Z250.
    c. Inform stakeholders in targeted jurisdictions about best practices and regulations in their area.
    d. Assist in the act of collaboration between stakeholders, including outset planning communication, site-to-site communication, and cross-jurisdictional communication, where applicable.
2. Develop guidelines for AHJs, designers, constructors, and manufacturers, with the aim to:
    a. Guide constructors and factories to efficiently apply for permits, effectively utilize certification programs, and schedule and pass inspections.
    b. Guide manufacturers through the process of obtaining certifications.
    c. Guide AHJs to expediently review permits and complete inspections and approvals for modular buildings of all sizes and occupancy.
    d. Inform plans developers in using a more uniform approach when drafting building plans, such as specific uniform methods used to indicate all off-site and on-site construction, mateline markings, and connection points for utilities.
3. Streamline the permit application process by:
    a. Developing a separate permit application process that includes a detailed documents and drawings checklist and guidelines for the application that take into consideration and inform on regional requirements at the site of erection.
    b. Transitioning the permitting application processes to be largely online.
4. Standardize the industry by:
    a. Mandating the use of CSA A277 throughout Canada to help make the approvals and permitting process for modular construction more uniform.
    b. Mandating the use of CSA Z250 to help standardize practices outside the factory more broadly throughout the process of construction.

The information presented in this report indicates that modular construction inspections and approvals, requirements of codes and how those codes reference standards vary across Canada; overall, the industry would highly benefit from uniform adoption of best practices industry-wide. The areas of opportunity outlined above not only hold the potential to benefit the industry's stakeholders but also hold the potential to benefit Canadian citizens nationwide.

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