CSA PUBLIC POLICY CENTRE

Seizing the Modular Construction Opportunity

January 2024

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CSA Public Policy Centre

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Acknowledgments

The authors wish to thank Reza Hessabi and Laurie Robert for their expert insights, as well as CSA Group's Sarah Chung, Lauro Pilla, Dwayne Torrey and Ben Howe for their valuable contributions and feedback on earlier drafts.

Disclaimer

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Introduction

As Canadians confront a growing housing supply and affordability gap, as well as the need to build more facilities like hospitals and long-term care homes, policymakers are starting to look to the potential of modular construction to help accelerate the pace of building.

Modular construction is an innovative method that can be used in the production of various building forms, from single unit housing to complex high-rises. At a time when Canada's construction needs are rising and the industry grapples with numerous challenges, modular construction can provide an efficient and cost-effective alternative to the development of high-quality, attractive buildings that are affordable, durable, energy-efficient, and even recyclable.

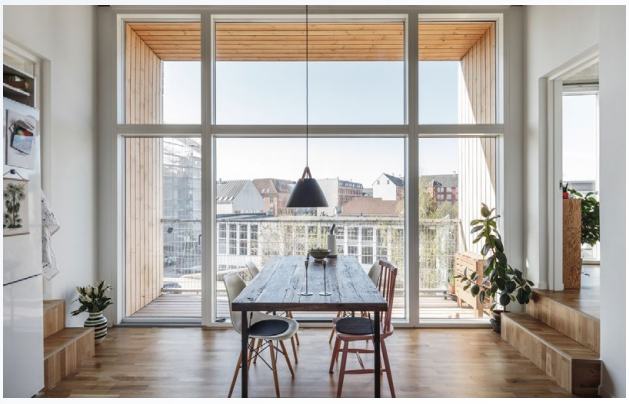
Modular Affordable Housing Examples

Dortheavej Residence,
Copenhagen, Denmark

Dortheavej Residence is a 66-unit, 6,800-square-meter building for low-income residents. The modules feature high ceilings (3.5-metres), balconies, and full-height window glazing to let in natural light. It was completed on a tight $9.8 million budget in 2018.[1]

Trethewey Supportive Housing,
Chilliwack, BC

Trethewey Supportive Housing is part of the provincial government's $291 million commitment to deliver 2,000 modular supportive housing units for people who are homeless or at risk of homelessness. Completed in 2019, the three-story complex contains 46 housing units, five of which are fully accessible. The main floor features office space, a common dining room, and tenant support rooms where residents can receive services. Cost savings were achieved through reduced on-site construction time and an overall shortened construction schedule—299 days in total.[2] The building follows BC's Energy Step Code, helping to achieve the province's energy saving targets.



***Source:** Photography by Rasmus Hjortshoj*

Dortheavej Residence, Copenhagen, Denmark

1. Pressures on Canada's Construction Industry

Canada's construction industry is facing significant pressures and limitations and is struggling to keep pace with rising demand for various building types both efficiently and sustainably.

Industry Challenges

Growing labour shortage

700,000 skilled-trades workers are expected to retire between 2019–2028.[3] In July 2023, there were a record **80,000 vacancies** in the industry.[4]

Stagnant productivity

Labour productivity in Canada's construction industry has remained stagnant for years and experienced a negative growth rate of -1.2% during the first quarter of 2023.[5]

Rising costs of construction

Costs are up 51% since the start of the pandemic, driven by soaring prices for key building materials.[6]

Demographic Changes Reshaping Demand

Record population growth

Driven largely by immigration, **Canada's annual population growth rate, 2.7%, is the highest since 1957** following the post-war baby boom.[9]

Aging population

Between 1971 and 2021, **the median age in Canada increased by 14.9 years**—from 26.2 to 41, putting more pressure on healthcare facilities.

Urbanization

Large urban centres (100,000 or more people) accounted for most of Canada's population growth between 2016 and 2021, driving the need for more residential construction in cities.[10]

Sustainability Concerns

High waste production

The construction sector generates one-third of total solid waste in Canada, the equivalent of more than **4 million tonnes of waste annually.**[7]

Low level of diversion

The vast majority of construction and demolition waste is disposed of in landfills—just 16% is recycled.[8]

Dragging Supply

Building starts down

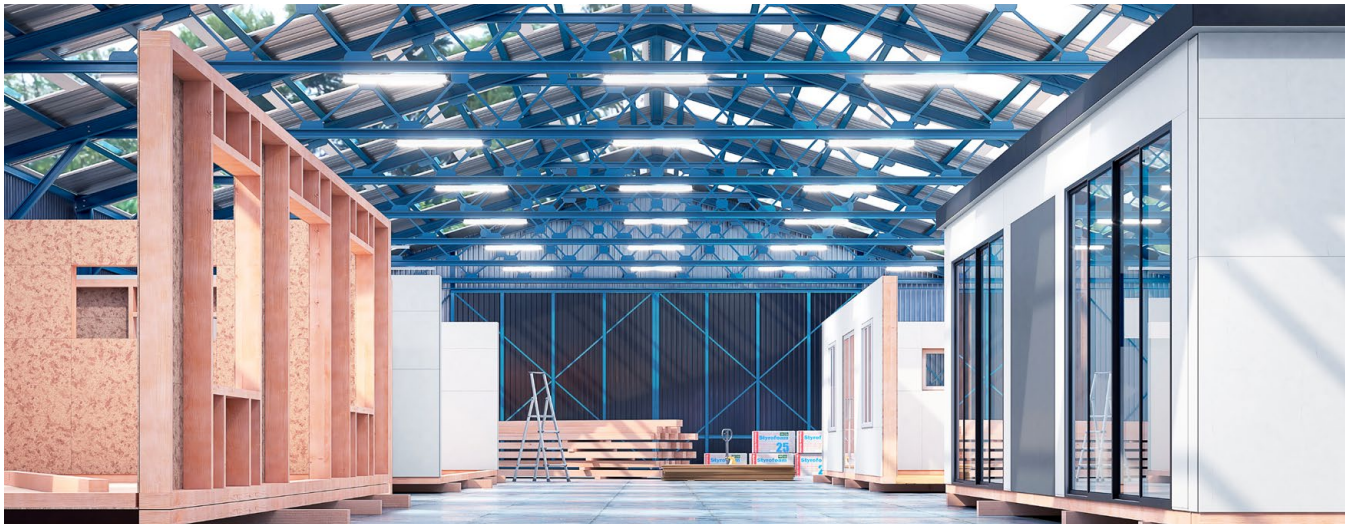
Investment in residential building construction has fallen to the lowest levels since June 2020.[11] **New multi-family starts hit 144,332 units in January 2022**, down 9% from the previous year.[12]

Housing supply gap

Canada has a deficit of 4.3 million homes that are affordable to those with very low incomes, students, individuals who are unsheltered, and those living in congregate settings (e.g., supportive housing for people with disabilities).[13] This is on top of the additional 3.5 million homes the Canadian Mortgage and Housing Corporation estimates are needed by 2030 to meet rising demand.

More long-term care (LTC) spaces needed

By 2035, 199,000 new LTC beds will be needed to accommodate increasing need from an aging population.[14]



2. The Modular Construction Opportunity

Modular construction represents a significant opportunity to give the construction sector more options to meet demand through the practice of fabricating building components, or "modules," in an off-site, controlled environment.[15] These modules, which can range from individual rooms to entire sections of a building, are then transported to a construction site and assembled.

While processes and execution differ in modular methods, some steps mirror those typical of conventional on-site (e.g. *stick-built*) construction. For example, the materials utilized in modular projects can be the same, including steel, concrete, wood, and glass.[16] Additionally, like traditional construction, modular projects are not limited to a specific building type or structure; projects can range from detached dwellings to mixed-use high-rise skyscrapers. (Figure 1)

Figure 1: Ways of Building with Modular

Unit Module

Modules—such as a bathroom or kitchen—are manufactured in a factory setting, then shipped to a site to be assembled to be installed into a building on-site.

Volumetric Modular Construction

Six-sided (four walls, floor, ceiling) enclosed spaces such as for an apartment, office, hospital room, or classroom—are manufactured in a module. The modules are shipped to a site and assembled into a larger building, including tall buildings.

Hybrid Construction

Conventional and modular methods are combined, allowing for greater flexibility and customization while benefiting from speed and quality control of prefabrication.

Misconception #1: Modular construction is an "all or nothing" approach.

While an entire building can be factory-built using modular methods, it is equally possible to use modular construction as an extension to new or existing stick-built buildings, for example by adding modular wings to a hospital or a school. Modular construction can also be leveraged in more limited ways, such as using prefabricated HVAC systems or bathroom pods. Ultimately, the balance of modular and traditional construction is a strategic choice, to be determined as part of the project planning process.[17]

Key Benefits of Modular Construction

Speed: Modular construction can offer substantial time savings, achieving construction schedule completion rates 25% to 50% faster than conventional approaches.[18] Modular methods permit concurrent execution of multiple tasks—as opposed to the mostly sequential nature of traditional construction—that can effectively streamline the construction process. With approximately 80% of the construction occurring in a controlled off-site environment, external hindrances such as weather delays are also mitigated.

Cost-effectiveness: Under the right circumstances, and as the industry matures, analysis shows that modular methods could help achieve up to 20% in cost savings.[19] Another recent survey of North American general contractors who used modular components, also showed that nearly half reported savings of at least 10%.[20] Efficient assembly line methods, reduced on-site work, and faster project schedules yield reduced costs. Further schedule savings can be achieved by a process that requires front-load design, helping to avoid costly changes and delays down the road.

Sustainability: By standardizing components used in the manufacturing process, modular construction allows for greater reuse and recycling of its components, thus reducing demand for raw materials and new production.[21] From global examples, modular projects have the potential to significantly reduce waste by as much as 46%.[22] Due to the controlled production environment, emissions can be reduced by up to 22%, while accelerated schedules of modular projects also result in less energy use overall.[23]

Adaptability: Modular construction allows for repurposing in various contexts. 1.3 million tonnes of embodied carbon could be avoided on a per annum basis if buildings were repurposed.[24] Through utilizing modules in the construction process, structures can be reconfigured and relocated to accommodate varying uses with less demolition or reconstruction required, thus optimizing resource efficiency.

Safety: Construction sites are some of the most hazardous workplaces in Canada with heightened exposure to poor air quality, loud noise, extreme weather, and potential for serious and even fatal injuries from falls.[25] With modular construction, about 80% of the work can be completed indoors, at ground level, in a safe, controlled factory environment.[26]

Misconception #2: Labour shortages do not affect modular construction projects.

Because modular construction relies on skilled labour, modular projects are affected by the same labour shortages that hamper the wider construction industry. However, modular construction projects may be more adaptable to a shrinking labour pool. For example, because much of the work is done in a plant setting, tasks that do not require skilled labour can be automated. Modular construction's shorter schedules may also provide greater flexibility in a tighter labour market. Overall, however, there is insufficient data on the specific labour needs or gaps in the modular construction sector.

Examples of Key Benefits

SPEED

Mini Sky City in Changsha, China. Mini Sky City is a 57-storey mixed-use tower that has 19 atriums, 800 apartments, and enough office space for 4,000 people. It took 4.5 months to fabricate the 2,736 modules that were required to complete the project, which was assembled in just 19 days at a rate of three stories per day.[27]

COST- EFFECTIVENESS

Affordability of Modernizing Schools in California, USA. By implementing hybrid modular designs, school projects across California reduced total project costs by 25% to 35%, with savings in both material and labour costs.[28] In one case, the need to design and build a new school in Stockton, CA within two years led to a hybrid solution that combined modular classrooms with a stick-built administrative and library building.[29] It is estimated that this approach saved nearly US$10 million in costs and accelerated delivery by one year.[30]

SUSTAINABILITY

Aboriginal Health Clinic in Western Australian Desert. Kaunitz Yeung Architecture designed Punmu and Parnngurr Aboriginal Health Clinics for four Indigenous communities in the western Australian desert. Modular construction was ideal for this remote location, which was nearly 2,000 kilometres away from the resources and equipment necessary to construct these structures. Sustainability was of paramount importance due to extreme temperatures; the roofs host 60 solar panels, providing 30% of total power.[31] Shaded awnings and an integrated solar hot water unit were also made possible through modular methods.

ADAPTABILITY

Vancouver's Olympic Village. The Olympic Village, a mixed-use complex built for nearly $1 billion, included 1,100 living units, almost a third of which were relocated and repurposed as affordable housing after the Games. Through a collaboration between the provincial government and the organizing committee, 320 modular units from the village found new life as permanent, affordable apartments in various communities across British Columbia.[32]

Limitations of Modular Construction

Though modular construction can offer a number of clear benefits, there are a few limitations that should be noted:

Repeatability: Modular construction benefits from "repeatability"—the ability to reproduce and mass produce standardized modules—which helps realize economies of scale and drive down costs. This process may limit its suitability for all building types. From a cost and efficiency perspective, the modular approach could be better suited to building forms that have repeatable floor layouts, systems, and finishes.

Transportation costs and risks: While modular units are designed for efficient transportation to the construction site, factors such as module size, weight, and distance from the destination site can result in elevated costs. Long-distance transportation for delivery to remote locations may incur substantial expenses, impacting the overall project budget. Additionally, logistical challenges and the potential for damage during transit can introduce uncertainties that could lead to delays and increased risk. Moisture damage, especially during transportation and storage, is a critical issue that could require costly remediation.[33]

Front-loaded costs: While beneficial from a cost-certainty and predictability perspective, the front-loaded investment demands of modular projects can become a liability under certain circumstances. For example, factory-built units can get stuck in limbo and accumulate significant storage costs if the project is delayed, as a recent affordable housing project in Toronto demonstrated.[34] While similar challenges also affect traditional construction, the financial stakes can be higher for modular construction because most of the investment is required and spent upfront. In general, much of the operating environment for construction—including financing, procurement, insurance, and regulatory requirements—is not geared to the front-loaded nature of modular.

Misconception #3: Modular construction is always cheaper and faster.

A positive misconception is that modular construction projects automatically deliver cost savings and speed. While evidence demonstrates that achieving both is possible, those outcomes are not guaranteed. The choice of materials, level of project complexity and customizations, and regulatory barriers can increase costs and significantly slow on-site assembly.

3. Barriers to Modular Construction

Though modular construction has seen strong growth in recent years—increasing from 2.14% of all construction starts in North America in 2018 to 6.0% in 2022[35]—several key barriers hinder greater uptake:

Lack of building industry knowledge: The most fundamental barrier to modular construction is that it is poorly understood. From developers to tradespeople and among key professionals like architects, engineers, and financiers, there is a general lack of awareness and technical know-how when it comes to designing, financing, and building modular projects.

Limited awareness among industry regulators: Authorities Having Jurisdiction (AHJs) are the bodies responsible for overseeing product safety, issuing construction permits, undertaking inspections, and approving changes to applicable building codes. For example, municipalities are AHJs for issuing permits and performing inspections, while provinces can approve code changes. Many AHJs have limited experience with modular projects, which results in longer review and approval times.[36] Further, though modules are technically products—like appliances or industrial equipment—that are eligible for certification under CSA A277, they are also building parts that are subject to applicable building codes and various

regulatory approvals. This chain of inspections and approvals requires a high degree of orchestration among various parties, which can be difficult to achieve given current lack of process clarity and limited regulatory experience with modular construction.

Building code gaps and inconsistencies: Permanent modular buildings and those constructed through conventional methods must both adhere to building codes and standards in their regions. However, with prefabrication, it may not be possible to perform a full inspection of the modules that arrive on-site. CSA A277 (see below) can be used to certify a manufacturer's products in the factory, *before* modules are delivered to their destination for assembly. Not all provinces and territories require CSA A277 certification under their building codes, however. While some jurisdictions require the certification (i.e., make compliance mandatory), others only recognize it (i.e., make compliance optional). Further, building codes do not address some unique aspects of factory-built modular construction that are also outside the scope of CSA A277, such as transport and lifting and placement of modules on-site.[37]

CSA A277 *is a standard that specifies the procedure for certification of prefabricated buildings and partially or fully enclosed modules and panels (including those installed in high rises). The purpose of CSA A277 is to help ensure that factory-built modules and buildings are constructed to meet the requirements of applicable building codes and to deliver a consistent level of manufacturing quality, safety, and durability. The standard was added as a reference to the Division A Notes of Part 1 of the National Building Code—the model code for Canada — in 2008.*

Misconception #4: Zoning by-laws prohibit modular buildings

A permanent, factory-built modular building is generally acceptable under zoning by-laws – the method of construction for a building that is code-compliant should be largely irrelevant. Still, because local zoning and site assessments are designed around a conventional construction process (versus a front-loaded modular process) the time it can take to demonstrate a modular building is meeting applicable by-laws can significantly delay projects. This can negate the potential speed benefits associated with modular projects.

Incompatible procurement approaches: Some of the most-used public procurement approaches for construction projects, such as "design–bid–build," are inherently at odds with modular construction methods. Requests for Proposals for projects like hospitals or schools often come with a highly prescribed set of architectural and engineering specifications that are more readily met by proponents offering traditional construction services. This is because modular manufacturers have factory systems in place that limit dimensions and finishes that can be produced. While customization is possible to fit prescribed criteria, doing so negates the cost and speed benefits that could otherwise be achieved.

Financing issues: Typically, construction projects receive progress payments based on a schedule that aligns with meeting specific on-site deliverables. However, because as much as 80% of a modular project is completed in a factory, manufacturers require a much larger payment upfront to obtain needed materials and build modules concurrently. Current practices among both private and public lenders rarely align with this process, severely limiting the availability of financing options for modular projects.

4. Recommendations

Greater use of modular construction methods could help Canadian communities meet the growing construction demands more quickly and cost-effectively, especially in the housing sector. Importantly, given modular construction's sustainable building process, modular construction also has the benefit of supporting Canada's lower emission targets. As mentioned however, the potential cost and time savings of modular construction are not guaranteed, and, in large part, depend on early design decisions and efficient approvals if they are to be realized.

Federal, provincial/territorial, and municipal governments all have important roles to play in facilitating an environment where modular construction's potential can be seized:

1 Develop Guidance Materials and Training for Industry and AHJs

There is too much uncertainty when it comes to certifying and approving modular components and buildings. From an industry perspective, there is little information on how standards like CSA A277 are enforced and expected outcomes from the certification process.[38] From the AHJ's perspective, there is a lack of clarity on roles and responsibilities for on-site vs. off-site (factory) inspections, as well as general unfamiliarity with modular methods and processes, which results in slower approval times.

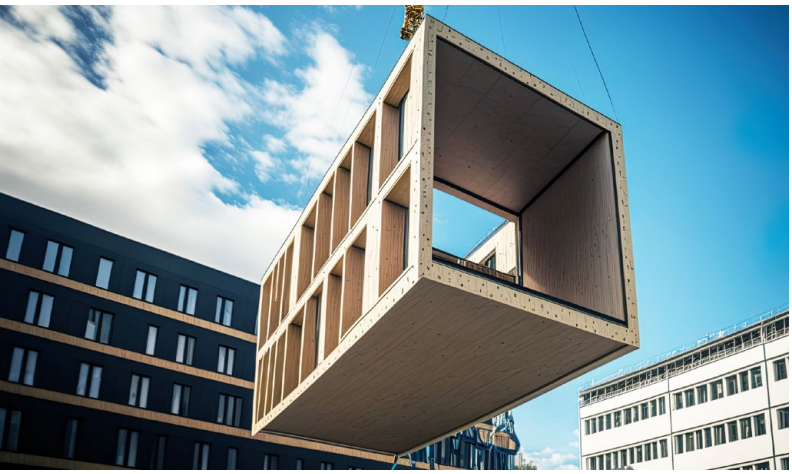
Provinces/territories can issue guidance materials and training to both educate AHJs, particularly municipalities, on modular construction and help clarify processes and responsibilities around certification, inspections, and approvals, allowing projects to move forward quickly and safely. Encouragingly, Ontario and British Columbia have already developed such materials. Municipalities in turn should also ensure that site reviewers, inspectors, and other functions in the permitting and approvals process receive appropriate guidance and training.

CSA Group is developing an online training course *to close the knowledge gap on modular construction. The course will include information on key differences between conventional and factory-built construction approvals processes as well as a general step-by-step overview of modular construction phases. This training can be useful to professions and trades that need to keep pace with evolving trends in the construction industry. The course is based on CSA Z252, a guidance document that provides best practices in obtaining permits, facilitating inspections, and issuing approvals.*

2 Address Building Code Gaps and Inconsistencies

To ensure smoother inspections and approvals, and ultimately leverage modular construction's shorter completion schedules, greater regulatory clarity and consistency is needed.

As mentioned, CSA A277 offers a procedure for certifying modules constructed off-site. It holds varying degrees of enforceability across different provinces in Canada. While it is recognized in the National Building Code, CSA A277 is classified as an administrative document within the code, preventing it from being officially designated as an "approved methodology."[39] This situation leads to uncertainty at the municipal level, where local inspectors may not be aware of the application of CSA A277. Furthermore, as modules are frequently manufactured in one province and transported to another for assembly, the lack of regulatory harmonization introduces additional complications and delays.



While the most comprehensive solution would be consistent and harmonized recognition of CSA A277, an initial step should involve raising awareness and enhancing education about CSA A277 at the municipal level. This step can expedite the safe inspection and approval of modules.

Another priority should be the recognition of CSA Z250 in the National Building Code as well as adoptions at the provincial/territorial level. CSA Z250 was recently developed to address unique aspects of factory-built construction modules that are not currently covered by building codes—mainly the transport, lifting, and placement of modules. These changes to the National Building Code would support needed innovation in the homebuilding sector and bring urgently needed housing to Canadians.

CSA Z250 *is a standard that describes the processes for the delivery of permanent volumetric modular buildings that have been constructed in a factory. It specifies a number of key processes, including those for design; logistics, transportation, and storage; non-modular and modular sitework; lifting, placement, and setting; installation and finishing; and commissioning and handover.*

3 Make it Easier to Procure Modular Units

When governments issue highly prescriptive designs for institutional facilities like LTC homes or elementary schools, they narrow the pool of potential proponents as many modular firms will not be able to configure their factory systems to match stated requirements. Alternatively, though some manufacturers may be able to build to required specifications, the level of customization will erode potential savings that could otherwise be generated.

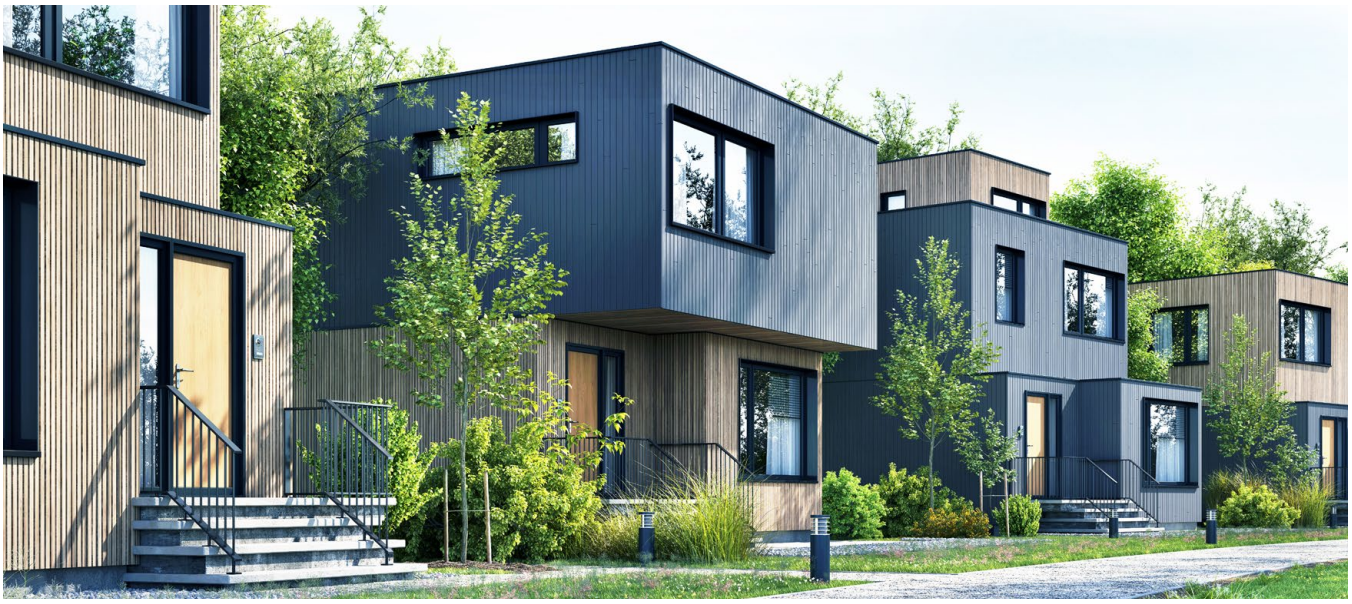
An alternative approach is to engage in more collaborative procurement methods. For example, an integrated procurement approach would engage manufacturers in design and planning earlier in the process, helping to secure more cost-certainty and quality of construction, without compromising on the essential requirements of a given project.

Additionally, when modular builders have successfully demonstrated their value and quality, they could be added to preferred vendor lists to further encourage consideration of modular proponents for future capital projects.

4 Improve Access to Financing

An important action that federal and provincial/territorial governments can take is to encourage modular builders to apply for low-cost government loans for housing developments by revising financing criteria that currently deter applications from modular construction firms. The federal government has set aside billions of dollars for affordable housing development through the National Housing Strategy that could be made accessible to modular builders who have unique advantages in producing buildings with repeatable floor plans at speed, thus helping to achieve national housing targets to build more affordable homes, including much needed rental units.

Further, the federal government could also provide and publicize guidance for private lending institutions to create more financing options for modular construction projects in the open market. Similar guidance has been developed by the US Federal National Mortgage Association for prefabricated homes, with forthcoming guidance also in development for modular buildings.[40]



5 Build a Canadian Evidence Base

If modular construction is to become part of Canada's housing supply solution or help meet the country's growing need for healthcare spaces, more evidence is needed to inform policymakers, regulators, and private developers of modulars' functions, merits, and limitations.

Though evidence from other countries is demonstrating the cost effectiveness, speed, safety, and sustainability advantages of modular construction, decision-makers in the public and private realm are more likely to be persuaded by Canadian data that considers Canada's unique context. Academic–industry partnerships can help produce more evidence on the current Canadian modular construction landscape, including best practices, labour trends, lessons from completed projects, as well as measures of waste diversion, energy and cost savings, and length of projects.

Conclusion

Under the right circumstances, modular construction can speed up project timelines, achieve cost-efficiencies, and reduce construction waste. However, these benefits can only be realized with broader awareness and understanding of modular construction methods, greater regulatory consistency and guidance, and more compatible procurement and financing practices. All levels of government have important roles to play in facilitating an environment where the potential of modular construction can be seized.

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