# 2024 PERMANENT MODULAR CONSTRUCTION REPORT

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THE MODULAR BUILDING INSTITUTE'S

Key Findings and Best Practices for Successful Modular Projects

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# CONTENTS


4 **About the Modular Building Institute**
- Mission
- Modular Advocacy Program (MAP)

6 **About Modular Construction**

8 **About Permanent Modular Construction**

10 **Markets Served**

12 **Key Advantages**
- Cost Savings and Certainty
- Schedule Savings and Certainty
- Quality Control and Assurance
- Environmental Impact
- Worker Safety, Productivity, and Diversity

22 **Best Practices for Implementing Modular Construction**

24 **Design for Modular Manufacturing**
- The Architect's Role

26 **North American Project and Production Data**

28 **North American Financial Data**
- Revenue and Market Share
- PMC Market Shares

31 **Canadian Market**

32 **Definitions**


# 2024 PERMANENT MODULAR CONSTRUCTION REPORT

*Cover Image:* **College Road, Croydon.** Designed by MJH Structural Engineers and built by Vision Modular Systems UK Limited. First Place, Permanent Modular Multifamily. Best of Show, Green Building.

The images in this report represent some of the winners of the Modular Building Institute's 2024 Awards of Distinction. To see the complete list of winners and learn more about each project, visit modular.org/awards.

## ABOUT THE MODULAR BUILDING INSTITUTE

Founded in 1983, the Modular Building Institute (MBI) is the only international nonprofit trade association serving the commercial modular construction industry. For more than 40 years, MBI has promoted the advantages of modular construction while advocating for the removal of barriers that limit growth opportunities. MBI represents nearly 600 member companies in 20 countries, serving as an information clearinghouse for end-users and as an advocate for the industry on public policy matters.

## MISSION

As the Voice of Commercial Modular Construction™, MBI works to fulfill its mission to expand the use of offsite and modular construction through innovative construction practices, outreach and education to the construction community and its customers, and recognition of high-quality modular designs and facilities.

## MODULAR ADVOCACY PROGRAM

In September 2023, the MBI Board of Directors voted to embark on a multiyear, multimillion-dollar advocacy effort known as the Modular Advocacy Program (MAP). For far too long, the modular industry has been fragmented and seemingly content competing for less than 10 percent of the overall market share. This collaborative, united effort will not only target barriers to be removed, but also create new opportunities for modular construction. A key component of this initiative will be a focus on workforce development and creating paths for those interested in pursuing careers in modular construction.

MAP

MODULAR ADVOCACY PROGRAM

**The Modular Advocacy Program ("MAP") is MBI's multiyear, multi-million dollar campaign to spur investment in, and promote the greater adoption of, the commercial modular construction industry.**

In order to meet the growing needs of its members and the greater modular construction industry, MBI's MAP program will drive industry growth in the following areas:

1. Influencing government legislation, regulations, procurement, programs, and codes.
2. Creating new business opportunities for the industry.
3. Expanding outreach efforts to developers, architects, and code officials.
4. Attracting new employees to the industry, including nontraditional workers.

MBI, leveraging its growing international membership, plans to fund this program through a variety of initiatives.

# Funding the Modular Industry's Most Important Initiative

**Your company can support MBI's Modular Advocacy Program in three ways:**

## MBI Seals

MBI Seals are 4-inch square stickers that are meant to be affixed inside each module that MBI member manufacturers produce. Each MBI Seal costs $20. These costs are intended to passed along to your customers, which means a net-zero cost to you.

**Manufacturers** — Order and affix an MBI Seal inside each module you manufacture.

**Architects, Contractors, & Developers** — Spec the MBI Seal on your future projects.

**Fleet Owners** — Ensure all new and existing units have the MBI Seal.

## Sponsoring the MAP

Annual sponsorships for the MAP program are available for $1,000. If you're not buying Seals, this is an ideal way to show your support of MBI and contribute to MAP funding.

With your annual sponsorship, your company will receive:

- sponsor recognition and logo inclusion in every MBI printed piece (magazines, annual reports, event brochures),
- a dedicated eblast thanking each sponsor, AND
- a special thanks at the next World of Modular annual conference, including logo inclusion in the opening presentation.

## Voluntary Donations

- If Seals and MAP sponsorship don't match your company's current objectives, support the MAP by making a voluntary donation in any amount.
- In combination with the revenues from Seals and sponsorships, these donations will be used to grow and protect the commercial modular construction industry through government affairs advocacy, business development, expanding MBI's membership, and industry workforce development.

## MBI Needs You to Support the MAP

**Full member support of the Modular Advocacy Program will be critical to MBI's goals in 2024 and beyond. And if your company has not yet joined MBI, now is the perfect time. With more resources than ever, the Modular Building Institute is helping to build the future of modular construction. Join us!**

# ABOUT MODULAR CONSTRUCTION

Modular construction can be considered a hybrid between the construction and manufacturing industries. This method involves constructing buildings offsite in a factory-controlled environment, then transporting them to the final site for assembly, incorporating elements of both industries:

**Construction:** Modular construction involves traditional construction practices such as designing the building, planning the site, and assembling the modules into the final structure. Site preparation, foundation work, and utility connections are also part of the construction process.

**Manufacturing:** The fabrication of building components, such as walls, floors, and roofs, occurs in a factory setting using assembly-line production methods. This approach allows for standardized processes, quality control, and efficient use of materials and labor.

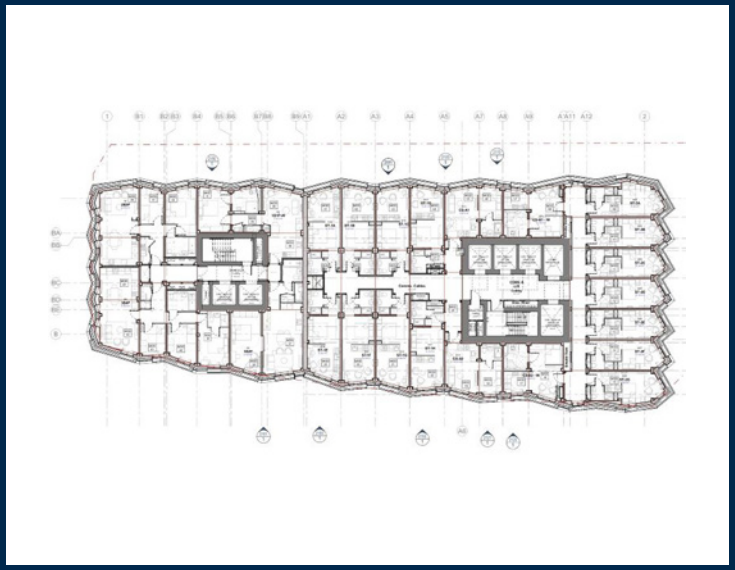
In essence, modular construction bridges the gap between traditional construction and manufacturing by leveraging the benefits of both industries to streamline the building process.

**College Road, Croydon.** Designed by MJH Structural Engineers and built by Vision Modular Systems UK Limited. First Place, Permanent Modular Multifamily.

**Location:** Croydon, UK

**Gross Size of Project:** Tower A — 376,234 Square Feet, Tower B — 125,164 Square Feet

**Days to Complete:** 655



For the purposes of this report, the term “modular” refers to volumetric, three-dimensional boxes (or modules) fabricated at an offsite location. The modular construction industry is regulated at the state and local levels by building code administrators and authorities having jurisdiction.

Unlike federal manufactured housing products, which are built in accordance with U.S. Department of Housing and Urban Development standards, there is no unique “modular building code.” As such, modular projects must meet the local codes in force where the building will be placed, similar to site-built projects. In the United States, this is most often the International Building Code or International Residential Code. In Canada, the National Building Code sets out technical requirements for the design and construction of new buildings.

Modular construction can be used for a variety of purposes, including single-family residential, multifamily, commercial, or industrial applications. MBI members commonly build for multifamily and commercial markets.

# ABOUT PERMANENT MODULAR CONSTRUCTION

Many industries, including schools, banks, restaurants, hospitals, hotels, medical clinics, and housing developers, regularly use permanent modular construction (PMC). As measured by the North American Industry Classification System, the most common PMC categories include:

**236116: New Multifamily Housing Construction**

**236220: Commercial and Institutional Building Construction**

MBI obtained industry information for this report from multiple sources, including:

**MBI member surveys:** Each year, MBI asks all members for data regarding their annual revenues, sources of revenue, markets served, production, capacity, and total number of employees.

**MBI's project database:** Through the annual Awards of Distinction contest, MBI gathers specific project data to calculate average square footage of buildings by market type, average days to complete by market type, modular project costs, and total project costs.

**ConstructConnect Insight:** MBI uses this database to determine the baseline for new construction starts in key markets and to measure overall industry market share.

**Publicly available data** such as news stories, public filings (U.S. and Canada), and corporate websites.

**Artificial intelligence (AI):** New this year, MBI utilized AI (specifically ChatGPT) to assist in rewriting some basic industry information.

Every effort has been made to ensure the accuracy and reliability of this data. In some cases, MBI's best estimates are used, based on the best data available. MBI is confident that this report represents the most comprehensive and accurate information available on the commercial modular construction industry in North America.

**Q'anapsu Dispensary.**
Built by ROXBOX Containers. First Place, Permanent Modular Retail.

**Location:** Ridgefield, WA, US

**Gross Size of Project:** 5,120 Square Feet

**Days to Complete:** 139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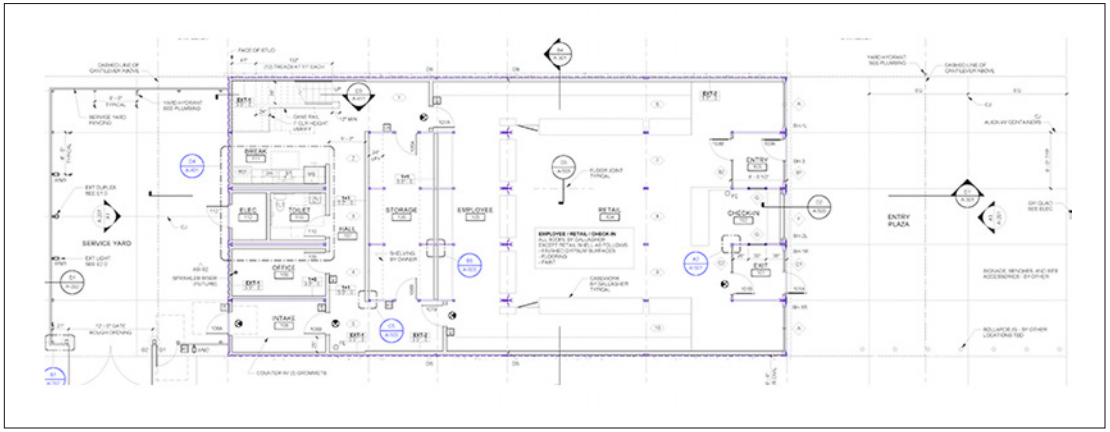

SERVICE YARD
ENTRY PLAZA

# MARKETS SERVED

The best market for a modular construction company in North America can vary depending on several factors, including the company's specialization, target market, and competitive landscape. However, some regions and sectors, including the following, have shown greater demand and potential for modular construction.

**Urban Areas with High Housing Demand:** Cities experiencing rapid population growth, such as New York City, Los Angeles, Toronto, and Dallas, often have high demand for affordable housing solutions. Modular construction can offer a faster and more cost-effective way to build housing in these areas.

**Affordable Housing Initiatives:** Many states, provinces, and municipalities have initiatives to address affordable housing shortages. Modular construction can be a preferred method due to its efficiency and cost-effectiveness, making it a good fit for markets with affordable housing needs.

**Disaster Recovery and Resilience Projects:** Regions prone to natural disasters like hurricanes, floods, and wildfires often require rapid rebuilding efforts. Modular construction can facilitate quick and efficient reconstruction, making it a viable solution for disaster recovery projects.

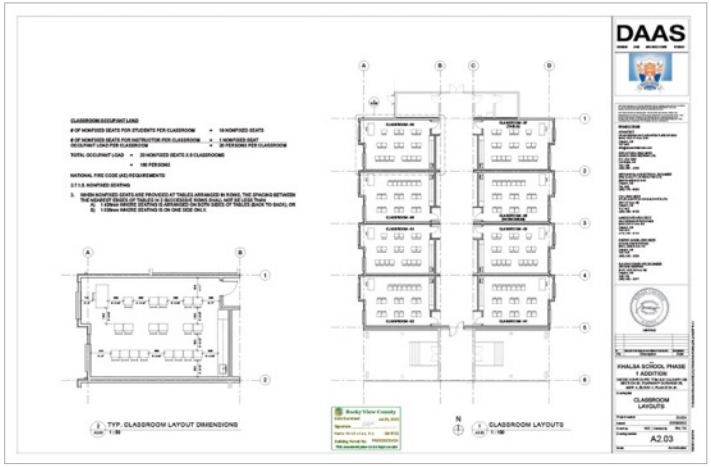
**Commercial and Institutional Construction:** Beyond residential construction, a growing demand for modular buildings exists in commercial and institutional sectors, including schools, healthcare facilities, offices, and hotels. Markets in which these industries have a strong presence can offer opportunities for modular construction companies.

**Infrastructure Projects:** Infrastructure development, such as transportation hubs, educational facilities, and government buildings, can benefit from modular construction's speed and efficiency. Regions with substantial infrastructure investments may present opportunities for modular construction firms.

**Sustainability-Focused Markets:** Modular construction's potential for reduced waste and energy efficiency aligns well with markets prioritizing sustainability. Regions with stringent environmental regulations or strong green building initiatives may favor modular construction methods.

**Emerging Markets:** Some regions within North America may be relatively untapped or underserved by traditional construction methods, presenting opportunities for modular construction companies to establish a foothold.

Ultimately, the best market for a modular construction company depends on factors such as market demand, regulatory environment, competition, and the company's unique capabilities and offerings. Conducting thorough market research and identifying specific market niches or opportunities can help a modular construction company determine the most suitable markets to target.




**Thompson Rivers University Student Housing.** Built by NRB Modular Solutions. First Place, Permanent Modular Dormitory.

**Location:** Kamloops, BC, Canada

**Gross Size of Project:** 43,184 Square Feet

**Days to Complete:** 158

# KEY ADVANTAGES

## Cost Savings and Certainty

Is modular construction less costly than traditional construction methods?

Generally speaking, yes. Modular projects, much like conventional construction projects, come with a lot of variables. Availability and cost of onsite labor are key factors. In larger urban areas where labor is scarce and/or more expensive, shifting construction to an offsite (often rural) location can yield significant cost savings.

The overall efficiency of the modular process also can lead to cost savings. With modular, fewer labor hours are needed to complete a comparable project, and waste is significantly reduced. The shortened modular construction schedule can reduce the time needed for a construction loan and dramatically advance the occupancy date—critical considerations for revenue-generating businesses such as hotels and fast-food restaurants.

According to the SmartMarket report "Prefabrication and Modularization: Increasing Productivity in the Construction Industry," published by McGraw-Hill in 2020, 91 percent of all general contractors reported a favorable impact from modular construction on project budget performance, with 48 percent indicating that costs


**SERV.** Built by Falcon Structures. Honorable Mention, Permanent Modular Retail.
**Location:** Overland Park, KS, USA
**Gross Size of Project:** 4,872 Square Feet
**Days to Complete:** 280

decreased by more than 10 percent. More than two-thirds of respondents (68 percent) cited a positive budget impact of greater than 5 percent.

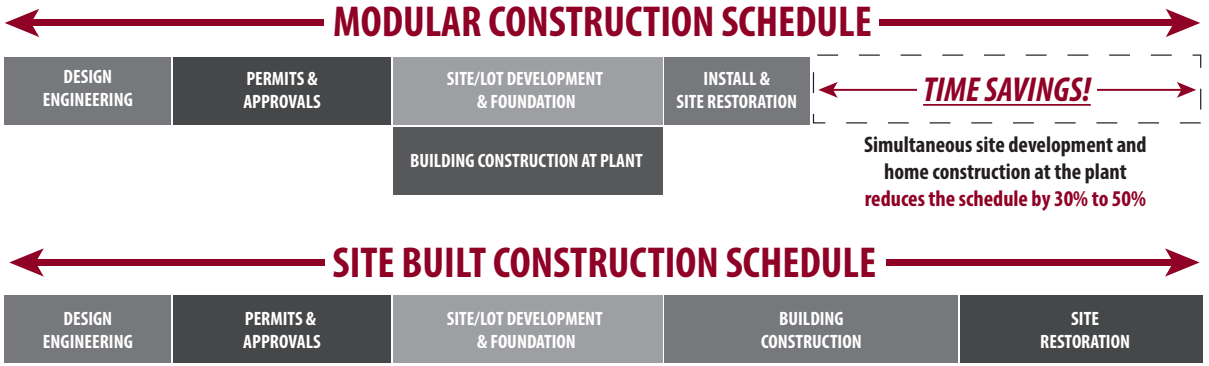
Additionally, on government-funded projects where Davis-Bacon and state prevailing wages typically apply, offsite fabrication is generally exempt from these inflationary rates. By definition, work done in a modular factory is "offsite."

In the recent 2023 study "Modular Multi-family Construction: A Field Study of Energy Code Compliance and Performance through Offsite Prefabrication" from the University of Nebraska's Durham School of Architectural Engineering and Construction, Professor Kevin Groskopf found construction costs for site-built projects in his study averaged $251 per square foot. The cost for modular projects averaged $243 per square foot, approximately 4 percent less than site-built construction.

Site-built construction contracts, including firm, fixed-price contracts, usually have change orders and a contingency for unforeseen conditions. By comparison, modular contracts, which typically make up 40 percent or more of a project, are "locked in" prior to construction, with greatly reduced (or eliminated) change orders and contingency. The modular manufacturer can also consolidate the markups and contingencies of several subcontractors.

## Schedule Savings and Certainty

According to the 2019 McKinsey & Company report "Modular construction: From projects to products," overruns of 25-50 percent of projected construction duration are common with traditional methods. However, recent modular projects have actually established a solid track record of *accelerating* project timelines by 20-50 percent. Since construction of modular building components occurs simultaneously with site work, projects can be completed in less time than with traditional construction. Additionally, 60-90 percent of modular construction is completed inside a factory, which mitigates the risk of weather delays. As a result, buildings are occupied sooner, creating a faster return on investment.



## Quality Control and Assurance

It is helpful to think of the term "modular" as a construction process rather than a building type. A modularly constructed building simply means that the materials were delivered to an offsite location (the modular manufacturing facility), assembled into components or three-dimensional building modules, and then transported to the final site for assembly. As such, a building constructed in this manner must still meet all the same building codes and requirements as if it were built onsite. Such codes are most commonly a version of the International Building Code (IBC) in the United States or the National Building Code (NBC) in Canada.

There is no specific or unique modular building code, however. The industry is regulated primarily at the state/provincial level through administrative agencies that implement and enforce the rules for building in that jurisdiction. The administrative rules of each agency provide for quality control, quality assurance, safety standards, and inspection procedures for industrialized building construction, design, and manufacture. The purpose of these rules is to provide minimum requirements to safeguard public health, safety, and general welfare, and to address societal and industry challenges for the inspection and regulatory compliance of offsite construction. Once a factory has been approved to build in a jurisdiction, a modular building project consists of four stages:

1. Design approval by the end-user and regulating authorities.
2. Fabrication of module components in a controlled factory environment.
3. Transportation of modules to the final building destination.
4. Assembly of modular units to form a finished building, and approval by local authorities.

Buildings constructed using the modular process must comply with all applicable building code requirements, including wind, snow, and seismic conditions, where the building will ultimately be located—not at the fabrication location.

Since most elements of the building, including electrical and plumbing, are completed and considered closed construction (i.e., concealed behind the drywall when leaving the factory), inspection protocols must be clear, concise, and coordinated between state and local authorities.

A design package consisting of the aggregate of all plans, designs, specifications, and documentation, including the compliance control manual and the onsite construction documentation, is submitted by the manufacturer to the design review agency for compliance review. Where required by the authority having jurisdiction, construction documents and other documentation will bear the signature and seal of the registered design professional.

Once the plans are approved, the building components can be fabricated. One of the key advantages of modular construction is that the building modules can be inspected by the staff quality control/quality assurance manager at each station (e.g., framing, electrical, plumbing, drywall), so any mistakes can be corrected before the modules arrive on site.

In-plant inspections are conducted by a third-party inspection agency on behalf of a state agency to verify that construction is in compliance with the approved construction documents. The inspection agency inspects each modular or panelized unit in a phase of construction for compliance. A data plate containing identifying information is attached to the modular component, providing the local code official with all pertinent information in an easily accessible location.

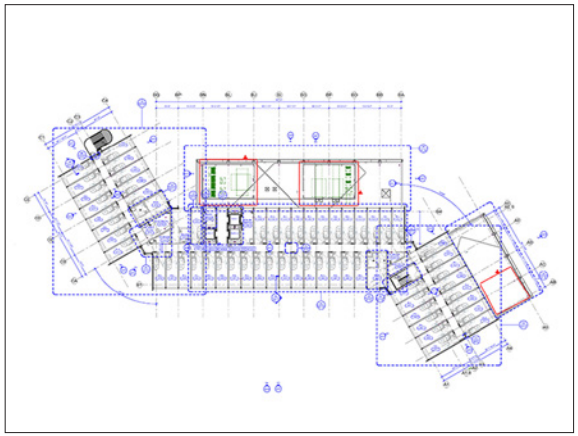
An agency decal (insignia, label) issued by the authority having jurisdiction is also permanently attached to the modular component, indicating that it has been constructed to meet or exceed the applicable building code requirements.

These steps are necessary to assure the local code official that the building has been inspected and will meet all local requirements, thus avoiding destructive inspections of the component on site.

Once the modules are delivered to the final site (often by third-party transportation companies), other site-related requirements are subject to approval at the local level. These requirements may include land use and zoning, local fire zones, site development, building setback, and side and rear yard requirements. Other requirements could include property line requirements, subdivision regulations, subdivision control, review and regulation of architectural and aesthetic requirements, foundation design, utility hookups, and module connections.

Onsite inspections of components verify that installation is compliant with approved manufacturer's installation instructions, and that connections performed on site are compliant with approved construction documents.

**citizenM Hotel Menlo Park.** Built by CIMC MBS Hong Kong Limited. First Place, Permanent Modular Hotel.
**Location:** Menlo Park, CA, USA
**Gross Size of Project:** 89,000 Square Feet
**Days to Complete:** 560



## Environmental Impact

The U.S. Environmental Protection Agency (EPA) considers construction waste and debris to be one of the largest contributors to landfills. Construction demolition of existing structures represents about 90 percent of such landfill waste, and new construction activity accounts for approximately 57 million tons of landfill waste.

But it does not have to be this way.

According to a March 2022 article by McKinsey & Company, the world will see a once-in-a-lifetime wave of capital spending on physical assets between now and 2027. This surge of investment—amounting to roughly $130 trillion—will flood into projects to decarbonize and renew critical infrastructure. Ninety-three percent of CEOs say that sustainability issues are important for the future success of their businesses, and 54 percent expect sustainability to be embedded within the core business strategies of most companies in the next decade.

From a sustainable and strategic perspective, modular construction has the potential to dramatically change how we build in four key areas:

- Significant waste reduction
- Lower carbon footprint
- Increased ability to relocate, renovate, and repurpose modules
- Greater energy efficiency/tighter building envelope

Several studies and reports have been conducted globally on the impact that modular and prefabrication have on overall waste reduction. According to the groundbreaking "Prefabrication and Modular Construction 2020" report by Dodge Data & Analytics, 86 percent of architect, contractor, and developer respondents said that utilizing modular construction had a medium, high, or very high impact on reducing waste generated by construction activities.

Other research findings:

***Comparative Study of Waste Reduction Practices in Multi-Family Construction: Modular Construction as a Circular Economic Solution—J. Killingsworth, J. Elliott, K. Bond***

This study compared two multifamily housing projects, both wood-framed and both located in U.S. Mountain West states. The fundamental conclusion of this study is that offsite framing practices achieve the following notable results:

1. Reduces wood waste by at least 23 percent (compared by framed square footage)
2. Nearly eliminates ALL methane-producing landfill waste by practice
3. More effectively reuses wood cutoff waste by practice, and
4. Achieves higher "circularity" for wood cutoff waste.

In every comparison made, offsite framing produced less waste. Applying the highest density factors of wood-filled dumpsters from the EPA (4.94 tons per 30-yard dumpster), the offsite framed multifamily residence produced 22.4 percent less waste than equivalent site-built projects. Taking into account that all dumpsters may not be "densely packed," the average density of the modular roll-off waste was also calculated based on the site-built project's average of 3.67 tons per 30-yard dumpster. At 3.67 tons per 30-yard dumpster, the results demonstrate that volumetric modular projects generate 42.4 percent less waste than site-built projects.

***Quantifying Advantages of Modular Construction: Waste Generation—Loizos Loizou; Khalegh Barati; Xuesong Shen, ORCID; and Binghao Li, School of Civil and Environmental Engineering, University of New South Wales, Sydney, NSW 2052, Australia, November 2021***

This paper focuses on modular construction as an offsite production system, proposing a framework to compare waste generation of modular and conventional, in-situ construction methods and aiming to quantify those differences. The framework relies on a comprehensive literature review to estimate the waste rates of building materials, which are then applied to realistic case studies to determine the differences in waste generation. Overall, modular construction reduces the overall weight of waste by up to 83.2 percent for the cases considered. *This corresponds to a 47.9 percent decrease in the cost of waste for large structures.*

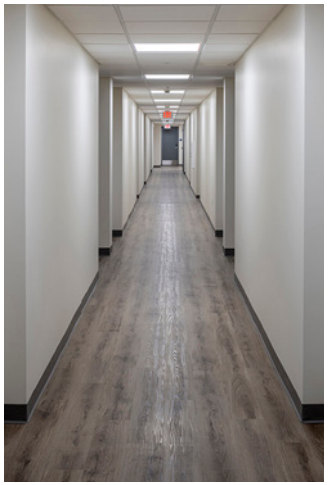
Qualitative comparisons asserting that prefabrication reduces waste have also been verified. For quantitative comparisons, the results show greater waste reductions than shown by most previous studies. *Quale et al.; Jaillon et al.; Kim, Jaillon and Poon; and Hosseini et al. showed waste reductions of 20.1 percent, 52 percent, 60 percent, 65 percent, and 92 percent, respectively.*

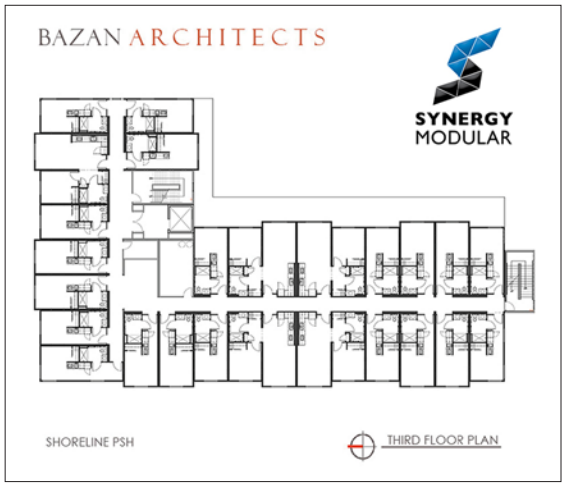
**St. Margaret's Place.** Built by Synergy Modular with NRB Modular Solutions, Prefab Logic, Axiom PLLC & Acc U Set Construction. First Place, Green Building.

**Location:** Shoreline, WA, USA

**Gross Size of Project:** 71,681 Square Feet

**Days to Complete:** 477





***Onsite Versus Offsite: Comparing environmental impacts—Quale et al.***

The University of Virginia conducted a study (Quale et al.) using life-cycle assessment to quantify the environmental impacts of constructing a typical residential home using two methods, based on data from several modular construction companies and conventional homebuilders. The study, peer-reviewed and published in the *Journal of Industrial Ecology,* included impacts from material production and transport, offsite and onsite energy use, worker transport, and waste management.

In terms of materials usage and waste, homes constructed using a modular process were found to use about 20 percent less material overall. This included greater material use for modular mate lines and transportation, but significantly less material waste for modular. *In fact, the modular homes sent about 75 percent less wood and drywall waste to the landfill per project (1,380 pounds for modular versus 5,500 pounds for conventional).* Worker transport to the job site daily had a negative impact for conventional construction, while energy use in the factory reduced the environmental impact of modular construction projects.

***Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong—L. Jaillon, C.S. Poon, and Y.H. Chiang***

As Hong Kong is a compact city with limited available land and high land prices, the construction of high-rise buildings is prevalent. In 2005, about 21.5 million tonnes of construction waste were generated, of which 11 percent was disposed of in landfills and 89 percent in public filling areas. At the present rate, Hong Kong will run out of both public filling areas and landfill space within the next decade. The government is taking action to tackle the problem, such as by introducing a construction waste landfill charge and promoting prefabrication to reduce onsite waste generation. This paper reports an ongoing study on the use of prefabrication in buildings and its impact on waste reduction in Hong Kong. A questionnaire survey was administered to experienced professionals, and case studies of recently completed building projects were conducted. The results revealed that construction waste reduction is one of the major benefits of using prefabrication instead of conventional construction. The average waste reduction level was about 52 percent, implying that wider use of prefabrication could considerably reduce construction waste generation in Hong Kong and alleviate the burdens associated with its management.

A study conducted by the University of Alberta (North Ridge CO2 Analysis Report—Al-Hussein et al.) comparing modular and onsite construction noted even greater advantages for modular construction. The research found that by using modular construction, the overall schedule was shortened by four months on an 11-month project, and CO2 emissions were reduced by 43 percent.

From the Quale et al. research, the analysis revealed that environmental impacts from modular construction are, on average, lower than those from onsite construction, with total greenhouse gas emissions about 30 percent less with modular construction.

According to the National Renewable Energy Lab, "Industrialized construction has immense potential to address the growing need globally to build and upgrade the building stock to be affordable, energy-efficient, and resilient. It can also help achieve the United States' goal of a 50 percent reduction in U.S. greenhouse gas emissions by 2030. The industrialized construction of Net Zero Energy, low-carbon modular buildings is an essential step for developing a transformational pathway for our clean energy future."

***Modular Construction: Energy-Efficiency Field Study in Commercial and Multifamily Buildings—University of Nebraska-Lincoln, Colorado State University, and New Buildings Institute, July 9, 2020***

A multiyear field study that targeted four climate zones in three states (California, Pennsylvania, and Washington) and documented energy performance of 45 modular projects, with a focus on multifamily buildings. According to the study's findings, prefabrication in a controlled factory setting has the potential to improve energy efficiency and performance, while streamlining related code-compliance processes and better enabling the integration of advanced technologies. When integrated, this approach may reduce total energy use by 50 percent when compared to comparable site-built construction.

**Helena Montana Temple.** Built by Haskell with Blox, LLC. First Place, Permanent Modular Assembly.

**Location:** Helena, MT, USA

**Gross Size of Project:** 9,950 Square Feet

**Days to Complete:** 641

## Worker Safety, Productivity, and Diversity

The construction industry has about three times the number of workplace fatalities as the manufacturing industry (1,008 versus 340 deaths annually). *(Unless otherwise noted, all data in this section was obtained at the U.S. Bureau of Labor Statistics (BLS) website at bls.gov.)*

In 2020, the latest year for which construction safety data is available, the construction industry accounted for about one in five of all workplace deaths. This is the highest number of fatalities of any industry reported, and nearly three times the rate of the manufacturing sector.
Modular construction has demonstrated the ability to provide a safer environment for the construction workforce. Simply by shifting large portions of the building construction to an offsite manufacturing setting, the BLS data suggests that the number of fatalities would drop significantly.

Of those 1,000-plus construction industry deaths, more than one-third are attributable to fall hazards. The ability of workers to construct multistory buildings in modules while remaining on the ground floor of a factory virtually eliminates hazards associated with falls, potentially saving hundreds of lives annually.

In addition, the 2023 Groskopf study found that fewer workers and shortened construction schedules result in less noise and traffic and fewer other disruptions to the surrounding community. In contrast to a transient workforce under the control of multiple trade contractors, offsite construction relies on a stable, permanent workforce under a central point of control. The repetitive, less specialized nature of prefabrication in a controlled factory setting also allows fabricators to better utilize a diverse workforce.

Modular manufacturing may also provide opportunities for older workers and those with disabilities to extend their careers, given a more comfortable work environment and fewer physical demands. The average age of workers among modular manufacturers surveyed was 35, although several workers were over 60. Women comprised 15-20 percent of the offsite workforce. Compared to site-built construction, the higher proportion of women and older workers may be attributed to a less physically challenging work environment. Workers' compensation Experience Modification Ratings (EMR) were found to be better for offsite worker safety (0.91) than for onsite worker safety (1.00) (a lower EMR generally results in lower premiums for workers' compensation coverage).

The Dodge SmartMarket report "Prefabrication and Modular Construction 2020" addressed the issue of workplace safety. Of the 203 responses received regarding safety, 89 percent of architects, engineers, and contractors indicated that the use of modular construction demonstrated safety benefits. The results were even more dramatic among large contractors with revenues over $100 million annually. Among the 18 contractors in that subset, half said that modular construction had a very high impact on safety. A full 100 percent of those respondents said that modular construction had a medium (11 percent), high (39 percent), or very high (50 percent) impact on worker safety.

Simply put, this means that the modular construction industry has greater access to a larger number of potential workers—including those who might not be able to meet the physical demands on a job site over a long period of time. It means fewer bad backs and knees. It means less exposure to inclement weather, less exposure to heights, and less heavy lifting. It means workers can go home at night, not be physically exhausted, and have a better quality of life. It means a safer workplace environment that leads to greater employee retention and higher productivity.

Here are some other factors to consider regarding safety:

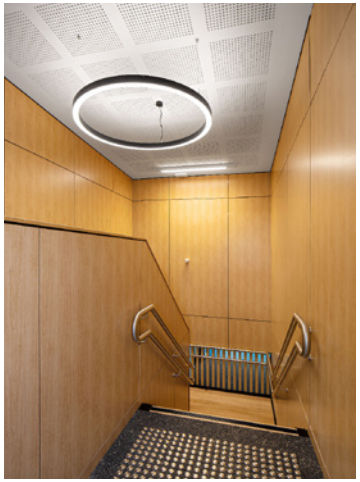
**Controlled environment:** Modular construction often takes place indoors, which can reduce risks associated with outdoor construction, such as adverse weather conditions.

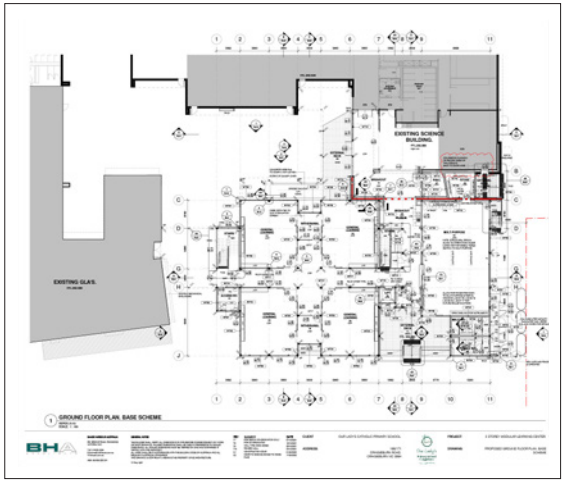
**Quality control:** Factory-controlled construction allows for greater oversight and consistency in materials and construction processes, potentially reducing errors and safety risks associated with onsite construction.

**Reduced onsite labor:** With modular construction, a significant portion of the construction work is completed offsite. This can potentially reduce the number of workers needed onsite, minimizing the risk of accidents and injuries.

**Efficiency:** The assembly process for modular construction tends to be faster than traditional construction methods, which can reduce the overall duration of onsite construction activities, thereby potentially reducing the exposure to safety hazards.

**Our Lady's Primary School.** Built by Fleetwood Australia. First Place, Permanent Modular Education.
**Location:** Surrey Hills VIC Australia
**Gross Size of Project:** 13,670 Square Feet
**Days to Complete:** 419





# BEST PRACTICES FOR IMPLEMENTING MODULAR CONSTRUCTION

When considering utilizing modular construction for a project, the best advice is to visit several factories, as the process is much easier to grasp visually. Factory capabilities, timing, workload, size, and specialty are all variables that need to match your project. MBI can assist in facilitating factory tours.

Deciding to consider modular construction for your next project is just the first step. Given that every aspect of construction was written for a site-built world, there are many differences and nuances to consider to help ensure that your first modular project is successful.

Here are some best practices:

**Ask yourself these questions first:** Are there any elements of this project that could be built offsite more efficiently? Are there repeating design elements or standard configurations? Is this project a "one-off," or will more projects similar to this one be considered? Answering these questions first reframes the entire discussion about the project. Some elements of your project, such as guest rooms or offices, may be ideal for a factory setting, while other parts, such as large, open spaces; lobbies; and dining areas, may need to be site-built.

**What do you hope to gain by using modular construction?** More often than not, schedule considerations help drive the decision to use modular construction, given its significant positive impact on the overall schedule. Others choose modular for better quality control and a safer work environment. If you are choosing modular only to save money, though, set realistic expectations. In general, cost savings of 5-10 percent are not uncommon. However, savings depend on several variables, including labor costs at the project site versus at the factory, the repeatability of the design elements, and the experience of the team in using modular construction. It is also not uncommon for a project utilizing modular construction to have a slightly higher upfront cost—particularly if it is your team's first modular project. It is best initially to assume cost neutrality.

**Site considerations:** Is your project site irregular or located in a congested area? Are there barriers that would prevent or limit the ability of a company to deliver a module that is approximately 14-16 feet wide and 14 feet high? Modular projects often reduce the amount of space required for "laydown" or onsite operations, but they do require trucks and cranes to be set up to stack the building. Is there a nearby area that can be used as a staging area as the modules are delivered? What size crane will be necessary for the installation? All of these factors can be mitigated, but it is far better to know about them in advance.

**Design phase:** If modular construction is even a remote possibility, find an architect in your area who understands the process. MBI has more than 60 architect firms in its membership, all well versed in modular construction. Also, the modular factory would likely recommend an architect they have worked with successfully in the past who understands modular and can help you avoid some pitfalls along the way.

MBI worked with the American Institute of Architects and the National Institute of Building Sciences on a Modular Design Guide for Architects (see the next section, "Design for Modular Manufacturing"). An architect who understands typical

modular sizes and configurations can add significant value to your project.

**Procurement—issuing the request for proposal/request for quotation (RFP/RFQ):** The sooner you can involve the modular manufacturer in the project discussion, the greater overall success you are likely to achieve. As such, procurement methods such as design-bid-build are generally not as favorable to the industry, as the modular provider is late to the conversation. Design-build and integrated project delivery are more industry-friendly processes for public projects.

However, a modular project is more often a negotiated, collaborative process with a factory that fits the project, rather than the lowest bidder on the list. It's extremely valuable to have a factory join the stakeholder meetings during the conceptual phase of a project to provide valuable input to the design.

How many experienced and interested parties responded to your RFP/RFQ? Are they approved to do business in the state where the project will take place? How far away is the factory from the site? Is transportation of the modules included in the quoted price?

**Roles and scopes of services:** Communication, communication, communication! Most general contractors are not familiar with the modular construction process. As a result, it can be common for gaps or overlaps in scopes of service—neither of which contributes to a successful project. Occasionally, the modular manufacturer will also serve as the general contractor on a project. These "direct" or "integrated" manufacturers provide turnkey construction services. More commonly, however, the modular manufacturer will serve as a subcontractor to the general contractor. MBI worked with representatives from the Associated General Contractors of America and ConsensusDocs to create two new contract templates for "prefabrication" that force all parties to address areas that may have fallen between the gaps. These two documents are:

> Consensus Doc 753: Standard Prefabricated Construction Agreement Between Constructor and Prefabricator
>
> Consensus Doc 253: Standard Agreement and General Conditions Between Owner and Prefabricator

These contracts help address key issues, such as the liability of the modular units at various stages of the project. Typically, the manufacturer arranges for the modules to be transported to the site, often contracting with a transport company. Regardless, it is imperative that the transport company thoroughly understands the permit process of each jurisdiction and any potential barriers that could delay delivery.

**Financing a modular project:** One of the key advantages of a modular project is a shorter overall construction schedule, which allows for quicker building occupancy and quicker return on investment. In some cases, when a site-built project won't "pencil out" given a long construction schedule, shifting to a modular project and advancing revenue streams ahead several months can allow the project to proceed.

One trade-off to quicker occupancy, however, is the need for more funding on the front end of a modular project. Typically, a modular manufacturer will require a larger initial draw to begin a project. Initial draws of 30-40 percent of the modular portion of the project are not uncommon, since the manufacturer will need to procure ALL the materials needed for the project up front. However, early, bulk procurement of materials provides both economies of scale and surety against material shortages during the process.

**Design freeze:** Once a project's design has been agreed upon, it is important for all parties to agree to a "design freeze" date. Since the modular manufacturer acquires all the materials for the project in advance, it is much more costly to make changes to the layout once production starts in the factory.

**Quality control, inspections, and progress updates:** Once factory production begins, it is prudent to schedule times for regular factory visits to check on the progress of your building. Draws can be scheduled in part based on progress made in the factory. If traveling to the factory is not possible, ask the factory rep to conduct a virtual tour/inspection with you. Often an owner will hire a third-party inspection company to represent them for quality and payment inspections. It's important to inspect the units for quality prior to leaving the factory. Additionally, once the modules arrive on site, inspect them for possible damage that may have occurred either in the factory or during transport.

Work with the modular manufacturer to coordinate and understand site install requirements, including foundations, utility hookups, mechanical, low voltage, and other site conditions.

Lastly, communicate, communicate, communicate!

# DESIGN FOR MODULAR MANUFACTURING

In 2019, MBI worked with the American Institute of Architects to help develop "Design for Modular Construction: An Introduction for Architects," which serves as a primer on the modular approach for architects. The document can be downloaded from the MBI Resources page at www.modular.org/research-whitepapers-studies/.

## The Architect's Role

In general, the architect's role in a construction project is critical to its overall success. The decision to utilize modular construction should be made prior to design and should factor in the following considerations:

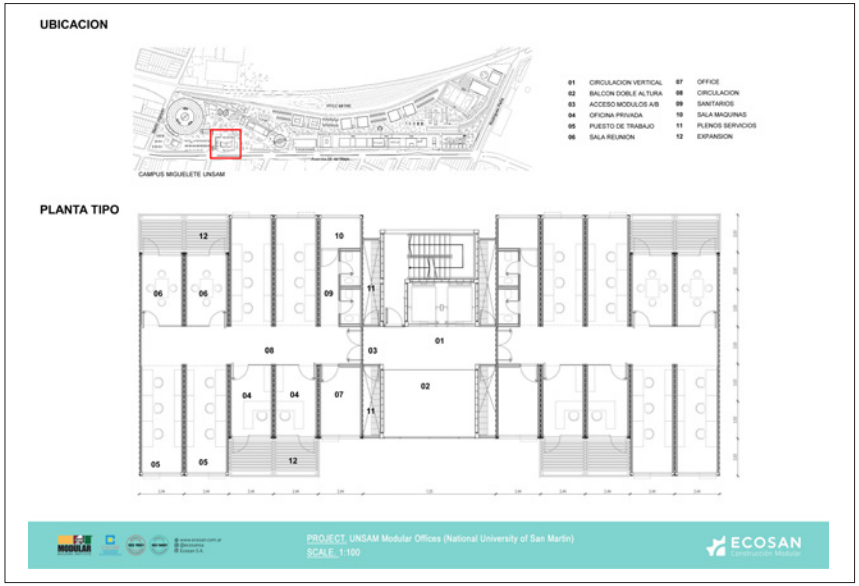
- Three-dimensional modules have widths that are typically nominal 8, 10, 12, 14, and 16 feet, with 12 and 14 feet being the most common. Framing dimensions are typically 2 inches less than nominal size.
- Module lengths are up to 70 feet, usually in 2-foot increments.
- Module heights vary from approximately 11 feet, 6 inches to 13 feet, not including the height of the unit's transport trailer or frame.
- Wood-frame construction is the most common type of construction; however, manufacturers also build with steel and concrete and can meet the requirements for Type I, II, and III construction.
- Multistory modular buildings can be built up to the maximum stories allowed by code. While most modular buildings contain one to four stories, increasing numbers of projects have exceeded 10 stories in recent years, including a 32-story project in New York.
- Restroom areas should be designed so that a module "marriage line" does not split the space.
- Multiple roof-framing styles are available. Some can be completed in the factory, while others may require the installation of trusses onsite.
- Modular buildings can be configured using modules of various lengths and widths.
- Design elements (e.g., paint color) need to be decided earlier in the process, since the offsite construction process begins earlier and is completed more quickly.

**UNSAM Modular Offices (National University of San Martin).** Built by Ecosan S.A. Winner, Permanent Modular Office.

**Location:** San Martín, Buenos Aires Province, Argentina

**Gross Size of Project:** 31,656 Square Feet

**Days to Complete:** 212


UBICACION
CAMPUS MIGUELETE UNSAM
01 CIRCULACION VERTICAL
02 BALCON DOBLE ALTURA
03 ACCESO MODULOS A/B
04 OFICINA PRIVADA
05 PUESTO DE TRABAJO
06 SALA REUNION
07 OFFICE
08 CIRCULACION
09 SANITARIOS
10 SALA MAQUINAS
11 PLENOS SERVICIOS
12 EXPANSION
PLANTA TIPO
PROJECT: UNSAM Modular Offices (National University of San Martín)
SCALE: 1:100
ECOSAN

# NORTH AMERICAN PROJECT AND PRODUCTION DATA

MBI analyzed 75 total projects completed in 2023, including 62 in the United States and 13 in Canada. Within the U.S., 19 of the projects were located in California. Data from these projects is not necessarily indicative of overall industry averages, but is rather anecdotal and supportive of other data collected.

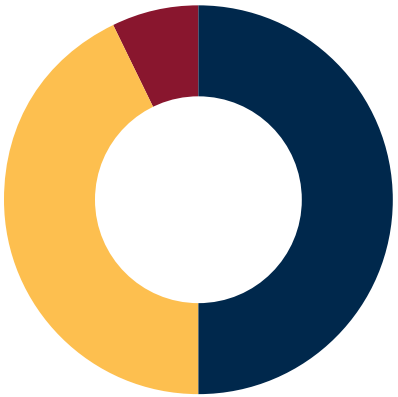
On average, the projects analyzed covered 26,771 square feet and consisted of 37 modules. The total average cost of the projects was $7,851,400, with the modular portion of the cost equal to 43 percent of the total.

MBI obtained cost data on 30 total projects, including five from California. The average cost per square foot across all geographies and markets was $403.33, ranging from a low of $95.98 to a high of $937.50.

The projects analyzed were from the following markets:

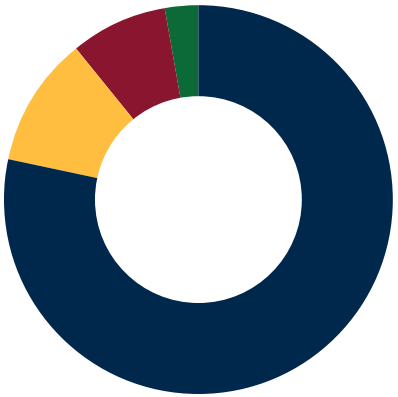
- Multifamily: 20%
- Office (incl. government): 18%
- Educational: 15%
- Retail: 11%
- Workforce housing: 8%
- Healthcare: 6%
- Correctional: 2%
- Bathrooms/Pods: 2%
- Other (includes data centers, testing labs, kiosks, ticket booths): 18%

Fifty percent of the projects were wood-framed, 43 percent steel, and 7 percent concrete. Average time to complete a project in our sample was 324 days, which included some projects that were started pre-COVID and delayed.



- Wood frame: 50%
- Steel frame: 42.9%
- Concrete: 7.1%

A vast majority (80 percent) of these projects were contracted under the design-bid-build process. Other contractual arrangements include design-build (10 percent), public-private partnerships (7 percent), and integrated project delivery (3 percent).



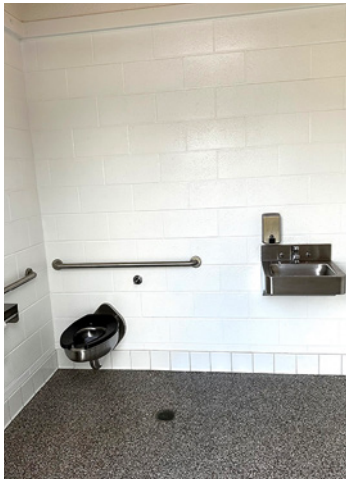
- Design-bid-build: 78.4%
- Design-build: 10.8%
- Public-private partnerships: 8.1%
- Integrated project delivery: 2.7%

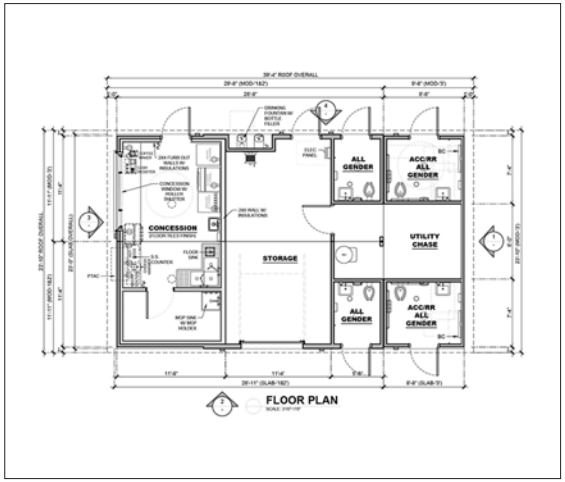

**Willow Grove Park Restroom & Concession.** Built by Public Restroom Company. First Place, Permanent Modular Special Application.

**Location:** Fallbrook, CA, USA

**Gross Size of Project:**
859 Square Feet

**Days to Complete:** 118





# NORTH AMERICAN FINANCIAL DATA

## Revenue and Market Share

MBI estimates that there are 255 modular manufacturing companies in North America generating a portion of revenues from the commercial modular industry. This figure does not include modular factories that generate no revenue from the commercial sector (i.e., all revenue comes exclusively from the single-family modular homes or manufactured housing sectors). About half (122) of these companies are MBI members.

This estimate takes into account a number of recent mergers, acquisitions, and closures, as well as a number of new factories coming online over the past five years, and is based on the total number of modular manufacturers in MBI's database (members and prospects), in addition to an exhaustive online search of other online directories, membership rosters, and news articles.

In estimating the overall North American market share for commercial modular construction, it is necessary to make some calculations and adjustments to compare to a baseline figure more accurately.

MBI uses a three-year average construction start value from ConstructConnect Insight as its baseline measurement for new construction starts in the key markets previously mentioned.

MBI obtains revenue and production data from its manufacturer base to determine the average (mean) revenue per manufacturer. That number is then multiplied by the total number of North American manufacturers engaged in permanent modular construction (PMC) projects.

For the average building project using PMC, the factory portion of the total project's value was approximately 43 percent for 2023. This was determined by reviewing completed PMC projects in 2023 across all markets and geographies. Consequently, to obtain the total value of projects using PMC, modular factory revenues were divided by 0.43 to make an apples-to-apples comparison with the total value of all commercial construction projects put in place in 2023.

MBI collected and analyzed revenue data from 49 North American manufacturers with an average revenue of $23,474,970. This revenue constituted an average of 43 percent of the total value of projects utilizing modular construction in 2023. When divided by 0.43 and multiplied by the total number of industry participants, the total value of modular building construction projects for 2023 is estimated at $14,576,318,000. As a result, the modular industry market share is estimated to be 6.64 percent of new starts.

The Modular Building Institute includes over 100 manufacturers from across North America

# PMC Market Shares

| Year | PMC Firm Revenue | Value of PMC Projects | Construction Start Value | Annual PMC Market Share |
|---|---|---|---|---|
| 2015 | $2,040,500 | $3,710,000 | $173,729,905 | 2.14% |
| 2016 | $3,301,664 | $6,003,025 | $244,509,444 | 2.46% |
| 2017 | $3,979,680 | $7,235,782 | $246,089,662 | 2.94% |
| 2018 | $4,943,067 | $8,987,396 | $243,316,997 | 3.69% |
| 2019 | $5,025,355 | $9,137,010 | $255,013,842 | 3.58% |
| 2020 | $4,496,791 | $8,175,984 | $186,315,485 | 4.39% |
| 2021 | $4,379,159 | $10,303,904 | $186,653,947 | 5.52% |
| 2022 | $5,294,258 | $12,312,229 | $204,344,212 | 6.03% |
| 2023 | $6,267,816 | $14,576,318 | $219,603,352 | 6.64% |

*(US $000s) • Source: Modular Building Institute, ConstructConnect*

# **CANADIAN** MARKET

*(All figures are in U.S. dollars.)*

MBI received revenue data from 12 of the 21 Canadian modular manufacturer members, with an average revenue of $26,514,794—higher than the overall North American average of $23,474,970.

MBI estimates that there are 40 total modular manufacturers serving Canada. Based on this estimate and using the same 43 percent figure mentioned above, the total Canadian modular market is approximately $2.5 billion, in line with the percentage of markets MBI members regularly serve.

MBI also analyzed 13 Canadian projects completed in 2023. On average these projects contained 36,043 square feet (3,348 square meters), consisted of 47 modules, and took an average of 331 days to complete. A majority (eight) of these projects were for the multifamily market, with one each in the retail, office, correctional, education, and workforce housing markets.

While new housing starts across Canada remained relatively stable at around 140,000 units, there was a noticeable shift from single-family detached homes to apartment complexes from year-end 2022 to year-end 2023. Regionally, this difference in this shift from single-family homes to apartments was greatest in Vancouver at 43 percent, Calgary at 16.6 percent, and Toronto at 15 percent. Montreal and Edmonton saw a decline in overall apartment construction. Various levels of government have implemented or announced new programs to stimulate the supply of new rental housing, and there was a high takeup of these programs by developers (source: Canada Mortgage and Housing Corporation Housing Supply Report, Spring 2024).

The top three markets for Canada in 2024-25, as forecast by ConstructConnect, are multifamily, healthcare, and educational facilities, combining for approximately $33-35 billion annually.

## Disclaimers:

In preparing this report, there are variables, adjustments, and calculations that are necessary to arrive at the final numbers.

MBI is aware of multiple permanent modular construction projects that were fabricated by companies outside North America and incorporated into projects here. While the value of these projects is most likely captured in the overall new construction starts (baseline measurement), MBI did not attempt to include this production and revenue data for the purposes of this report. MBI included only revenue and production data from North American manufacturers.

Using the averages provided by the MBI survey and manufacturers' input of data, it is possible to estimate certain information about the industry as a whole. The calculated information is reliable only to the extent that the data provided by industry participants is accurate. Nonetheless, MBI's data comes directly from its modular manufacturer members and represents the most comprehensive and accurate industry information available in North America.

## Where can I learn more about modular construction?

MBI's website, www.modular.org, is loaded with case studies, research, articles, and links to companies in your area.

# DEFINITIONS

**MBI adopted the definitions contained in the ICC/ANSI standard 1200 and 1205 for consistency. Sources for other terms not used in the standard include state administrative programs and the National Institute for Building Sciences.**

**Accessory dwelling unit (ADU).** A smaller, independent residential dwelling unit located on the same lot as a stand-alone (i.e., detached) single-family home. (Source: American Planning Association).

**Authority Having Jurisdiction (AHJ).** Organization, political subdivision, office, or individual charged with the responsibility of administering and enforcing the provisions of the applicable building code. The authority having jurisdiction shall include a state agency or local building department.

**Building Envelope.** As the physical separator between the interior and exterior environments of a building, the building envelope serves as the outer shell to help maintain the indoor environment (together with the mechanical conditioning systems) and facilitate its climate control. Building envelope design is a specialized area of architectural and engineering practice that draws from all areas of building science and indoor climate control.

**Building Site.** A lot, the entire tract, subdivision, or parcel of land on which industrialized housing or buildings are sited.

**Building System.** The design and/or method of assembly of modules or modular components represented in the plans, specifications, and other documentation, which may include structural, electrical, mechanical, plumbing, fire protection, and other systems affecting health and safety.

**Certification Label.** A decal, insignia, or alteration decal.

**Closed Construction.** A building, component, assembly, subassembly, or system manufactured in such a manner that all portions cannot be readily inspected at the installation site without disassembly or destruction thereof.

**Commercial Structure.** An industrialized building classified by the building codes for occupancy and use groups other than residential for one or more families.

**Compliance Assurance Program.** Procedures that state the guiding principles and define the framework for ensuring that construction documents approved by a design review agency, or that modular buildings inspected by a third-party inspection agency, comply with the applicable building codes.

**Compliance (or Quality) Control Program.** The manufacturer's system, documentation, and methods of ensuring that industrialized housing, buildings, and modular components, including their manufacture, storage, handling, and transportation, conform with this chapter.

**Component.** A subassembly, subsystem, or combination of elements for use as a part of a building system or part of a modular component that is not structurally independent, but may be part of structural, plumbing, mechanical, electrical, fire protection, or other systems affecting life safety.

**Data Plate.** A plate attached by the manufacturer or installer to a modular building or modular component that contains identifying information, allowing code officials or end-users to determine if the structure is suitable for installation in their jurisdiction, location, or project.

**Decal.** The approved form of certification issued by the authority having jurisdiction, to be permanently attached to the modular building, modular component, or panelized system, indicating that it has been constructed to meet or exceed the applicable building code requirements.

**Deconstruction.** The process of taking apart a building or structure, or a portion thereof, with the intent of repurposing, reusing, recycling, or salvaging as many of the materials, products, components, assemblies, or modules as possible.

**Design Package.** The aggregate of all plans, designs, specifications, and documentation required by these sections to be submitted by the manufacturer to the design review agency or required by the design review agency for compliance review, including the compliance control manual and the onsite construction documentation. Unique or site-specific foundation drawings and special onsite construction details prepared for specific projects are not a part of the design package.

**Erection/Installation/Set.** The process of blocking, leveling, and anchoring a modular building unit on the building site upon delivery.

**Industrialized Building.** A commercial structure constructed in one or more modules, or constructed using one or more modular components, that is built at a location other than the commercial site and designed to be used as a commercial building when the module or modular component is transported to the commercial site and erected or installed.

**Industrialized Housing.** A residential structure designed for the occupancy of one or more families that is constructed in one or more modules or constructed using one or more modular components, and is built at a location other that the permanent site and designed to be used as a permanent residential structure when the module or modular component is transported to the permanent site and erected or installed on a permanent foundation system.

**Insignia.** The approved form of certification issued by the authority having jurisdiction to the manufacturer to be attached to the modular building, modular component, or panelized system, indicating that it has been constructed to meet or exceed the applicable building code requirements.

**Manufacturer.** The entity responsible for the manufacturing of assemblies, panelized systems, modular buildings, or modular components.

**Manufacturing Plant.** The location, other than the building site, at which modular buildings, modular components, modules, panels, or tiny houses are assembled or manufactured prior to transport to the final construction site.

**Marriage Wall/Crossover Connections.** The joint between the modules in a complex, commonly called a mate-line or mod-line.

**Modular Component.** A subassembly, subsystem, or combination of elements, including panelized systems, building shells or bathroom pods, for use as a part of a modular building that is not structurally independent, but is a part of structural, plumbing, mechanical, electrical, fire protection, or other systems affecting life safety.

**Offsite Construction.** The planning, design, fabrication, and assembly of building elements at a location other than their final installed location to support the rapid and efficient construction of a permanent structure. Such building elements may be prefabricated at a different location and transported to the site or prefabricated on the construction site and then transported to their final location. Offsite construction is characterized by an integrated planning and supply chain optimization strategy. (Source: National Institute of Building Science)

**Open Construction.** A modular building, modular component, panelized system, or tiny house manufactured in such a manner that all portions can be readily inspected at the building site without disassembly, damage, or destruction thereof.

**Permanent Modular Construction (PMC).** An innovative, sustainable construction delivery method utilizing offsite, lean manufacturing techniques to prefabricate single- or multistory whole building solutions in deliverable module sections. PMC buildings are manufactured in a safe, controlled setting and can be constructed of wood, steel, or concrete. PMC modules can be integrated into site-built projects or stand alone

as a turnkey solution, and can be delivered with mechanical, electrical, and plumbing (MEP); fixtures; and interior finishes in less time, and with less waste and higher quality control than projects utilizing only traditional site construction.

**Prefabricated.** The manufacture or fabrication of sections of a building at an offsite location that are delivered to and assembled at the building site.

**Quality Control.** Controls and inspections implemented by the manufacturer, as applicable, to ensure that the material provided and work performed meet the requirements of the approved construction documents and referenced standards-applicable building codes.

**Registered Design Professional.** An individual who is registered or licensed to practice their design profession, as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

**Relocatable/Industrialized building.** A partially or completely assembled building that complies with applicable codes and state regulations and is constructed in a building manufacturing facility using a modular construction process. Relocatable modular buildings are designed to be reused or repurposed multiple times and transported to different sites.

**Site or Building Site.** A lot, the entire tract, subdivision, or parcel of land on which industrialized housing or buildings are sited.

**Third-Party Inspector.** An approved person determined by applicable statutory requirements to be qualified by reason of experience, demonstrated reliability, and independence of judgment to inspect modular buildings, and portions thereof, for compliance with the construction documents, compliance control program, and applicable building codes. A third-party inspector works under the direction of a third-party inspection agency.

**POSCO Gwangyang Giga Town.** Built by POSCO A&C. Honorable Mention, Permanent Modular Dormitory.

**Location:** Gwangyang-si, Jeollanam-do, South Korea

**Gross Size of Project:** 87,194 Sq. Ft.

**Days to Complete:** 626

# 2024 PERMANENT MODULAR CONSTRUCTION REPORT


**MODULAR BUILDING INSTITUTE**

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