2023

PERMANENT MODULAR CONSTRUCTION REPORT

MODULAR BUILDING INSTITUTE

MODULAR BUILDING INSTITUTE'S

Key Findings and Best Practices for Successful Modular Projects

About the Modular Building Institute— The Voice of Commercial Modular Construction™

The Modular Building Institute (MBI) is the only international nonprofit trade association serving the commercial modular construction industry. For 40 years, MBI has promoted the advantages of modular construction while advocating for the removal of barriers that limit growth opportunities. Through its long-standing relationships with member companies, policymakers, developers, architects, and contractors, MBI has become the industry's go-to resource for reliable information for the commercial modular construction industry.

HISTORY

Founded in 1983 to serve the global modular construction industry, today MBI has more than 500 member companies, including manufacturers, contractors, relocatable building fleet owners, architects, developers, and material and service providers.

MISSION

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

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WORKFORCE MODULAR COMPANY

Image courtesy of DJR Architecture.

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2023 PERMANENT MODULAR CONSTRUCTION REPORT

Cover Image: Alvera Apartments. Built by RISE Modular. Winner, Permanent Multifamily Over 10,000 Sq. Ft.

The images in this report represent some of the winners of the Modular Building Institute's 2023 Awards of Distinction. To see the complete list of winners and learn more about each project, visit. modular.org/awards.

EXECUTIVE SUMMARY

The permanent modular construction (PMC) industry topped $12 billion in North America in 2022, accounting for 6.03 percent of all new construction starts. This continued market share growth is impressive, considering it has nearly tripled since 2015, when market share was 2.14 percent.

The reasons for continued growth are numerous, including cost and schedule predictability and savings, environmental advantages, and worker safety, all of which are detailed in this report.

MBI gathers data from this report from two primary sources:

1. Direct financial and production data from modular manufacturers
2. Project data from case studies submitted to the Modular Building Institute (MBI)

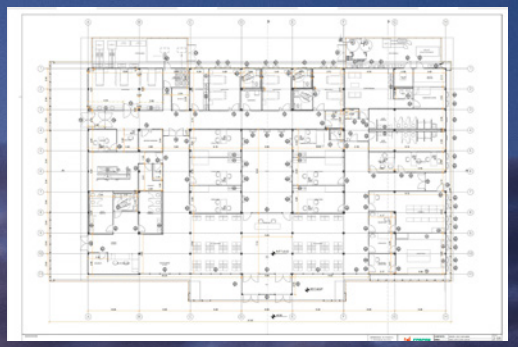
MBI estimates that there are 255 modular manufacturing companies in North America generating some portion of revenue from the commercial modular industry. This figure does not include modular factories that generate no revenue from the commercial sector (i.e., revenue derived exclusively from the single-family modular home and/or manufactured housing sectors).

In 2022, 24 modular manufacturers reported total production of 8,123,554 square feet, for an average of 338,481 square feet each. MBI estimates the projects utilizing modular construction accounted for approximately 6.14 percent of the total square footage for new construction in 2022.

MBI also analyzed 62 modular projects completed in 2022. The average size for projects completed was 24,057 square feet, consisting of an average of 37 modules each. The average time to complete each project from approval to occupancy was just 309 days, while the average total cost of these projects was $6,708,142, for an average cost per square foot of $278.84.

For the third year in a row, the multi-family sector was the largest market for the modular industry, accounting for about one-third of all factory output. Other key markets include office and administrative, institutional and assembly, and education.

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

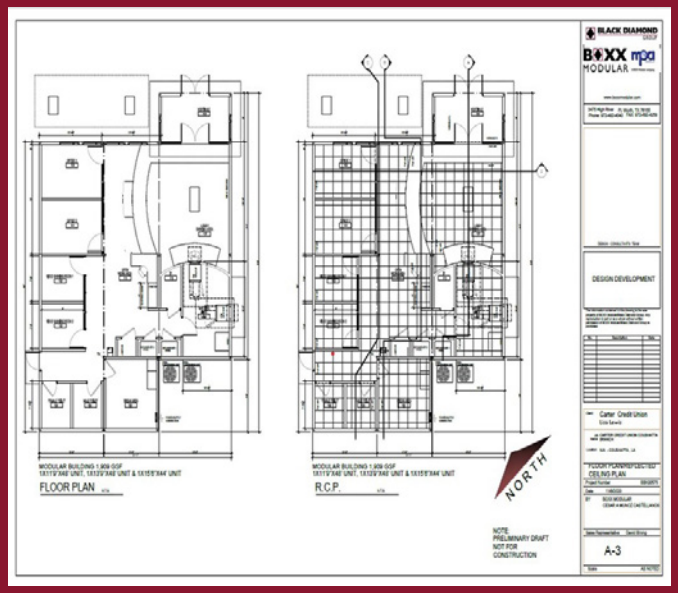


Adquisición de Centros
Modulares de Salud.
Built by ECOSAN S.A.
Winner, Permanent Healthcare
Over 10,000 Sq. Ft.

OVERVIEW OF THE MODULAR INDUSTRY

The modular construction industry is regulated at the state and local levels by building-code administrators and authorities having jurisdiction. As with site-built structures, a building constructed using the modular process must meet the local codes where the building will be placed. Unlike federal manufactured housing products built in accordance with U.S. Department of Housing and Urban Development standards, there is no specific "modular building code," nor are there exceptions for a building constructed utilizing the modular construction process—it is simply a more efficient process to construct building components at an offsite facility, then transport and assemble those components at the final building site.

Modular construction can be used for a variety of purposes, including residential, commercial, and industrial applications. MBI represents the commercial sector of the industry.



Carter Credit Union.
Built by Black Diamond Group.
Honorable Mention, Permanent Retail
Under 10,000 Sq. Ft.

Commercial modular buildings are nonresidential, factory-built building components and structures designed to meet all applicable building codes. Commonly, these buildings are constructed in accordance with the International Building Code (IBC) in the United States, the National Building Code in Canada, or a local version modeled after these codes. In this context, prefabricated mechanical, electrical, or plumbing (MEP) systems are not included for industry revenue and production figures.

The commercial modular building industry is composed of two distinct divisions, both represented by MBI.

Relocatable buildings, as defined in the IBC, are partially or completely assembled buildings designed and constructed to be reused multiple times and transported to different building sites. This segment of the industry maintains fleets of relocatable buildings offered for sale or lease to customers.

Permanent modular construction (PMC) is an innovative, sustainable delivery method utilizing offsite, lean manufacturing techniques to prefabricate single- or multistory whole building solutions in deliverable volumetric module sections. Manufactured in safe, controlled settings, PMC buildings 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 MEP, fixtures, and interior finishes in less time, and with less waste and higher quality control than projects utilizing only traditional site construction.

PMC buildings are subject to the same building codes and requirements as site-built structures, depreciate in much the same manner, and are classified as real property. This segment of the industry provides construction-related services for the successful design, manufacturing, delivery, installation, and finish-out of commercial and multifamily buildings.

ABOUT PERMANENT MODULAR CONSTRUCTION

Numerous industries, including schools, banks, restaurants, hospitals, hotels, medical clinics, and housing developers, regularly use PMC. The industry categories that utilize our services most frequently (as measured by the North American Industry Classification System), include:

236116 New Multi-family Housing Construction
236220 Commercial and Institutional Building

Construction
The term "modular" describes a construction method or process in which individual modules stand alone or are assembled to make up larger structures. Unlike relocatable buildings, PMC structures are intended to remain in one location for the duration of their useful life (hence the term "permanent"). Permanent modular buildings may be wood-frame, steel, or concrete and can have as many stories as applicable building codes allow.

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

MBI member surveys—Each year, MBI asks all member companies for data regarding their annual revenues, sources of revenue, markets served, production, capacity, and total 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.

Construct Connect 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 (in the U.S. and Canada), and corporate websites.

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

Key Advantages
- Cost Savings and Certainty
- Schedule Savings and Certainty
- Quality Control
- Reduced Environmental Impact
- Improved Worker Safety

Sydney International Speedway. Built by Fleetwood Australia. Winner, Permanent Special Application Over 10,000 Sq. Ft.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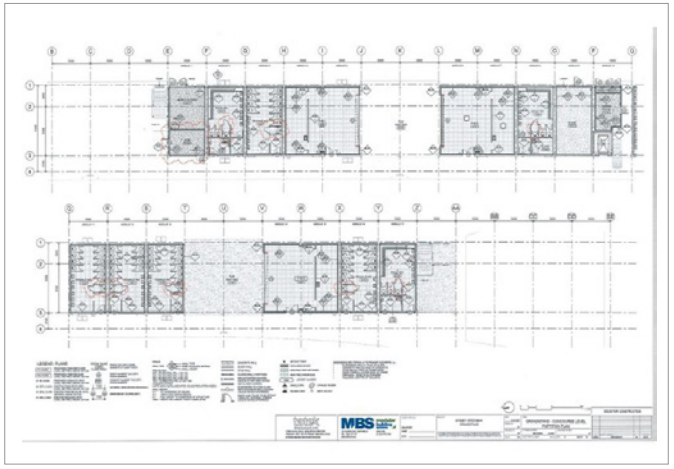


Design Considerations: Best Practices for Architects

Design for Modular Manufacturing

In 2019, MBI worked with the American Institute of Architects to help develop a new guideline called the "Modular and Off-Site Construction Guide." This guide, which serves as a primer on the modular approach for architects, includes:

- Value and opportunities of modular design,
- Pitfalls designers should be wary of, and
- Case studies that exemplify successes and obstacles.
- The document can be downloaded for free at: ***https://www.aia.org/resources/6119840-modular-and-off-site-construction-guide.***

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 nominal widths that are typically 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, Type II, and Type 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, a growing number of projects have exceeded 10 stories in recent years, including a 32-story project in Brooklyn, NY.
- 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.

New Contract Eases Use for Prefab and Modular Buildings

The ConsensusDocs Coalition has just published the industry's first standard contract document to address one of the most important and growing trends in the design and construction industry: prefabricated construction. ConsensusDocs has been working with industry leaders for two years to offer a standard prefabricated construction contract document. MBI recently joined the ConsensusDocs Council as a result of the successful work conducted by the working group. The new ConsensusDocs 753 Standard Prefabricated Construction Contract addresses the most common use case scenario of prefabricated construction, in which a constructor, general contractor, design-builder, or construction manager contracts with a prefabricator to fabricate a component offsite and later install that component on a project worksite.

While prefabricated construction or modular buildings have been around for decades, important contractual and legal issues have remained unaddressed in most construction contracts. Finally, with the leadership of ConsensusDocs, there is now an off-the-shelf solution that defines important new industry definitions and scenarios that are unique to prefabricated construction. Importantly, using a typical construction subcontract or purchase order for prefabricated construction can be costly and carry significant risks.

"As someone who often represents general contractors and prefabricators, I have written several custom agreements to address the unique risks presented by modular building and prefabricated construction generally," comments Ron Ciotti, a partner at Hinkley Allen and chair of the ConsensusDocs Prefab Working Group. "The new ConsensusDocs prefabricated construction contract provides some desperately needed understanding of risk allocation, with prefabricated construction revolutionizing the way construction will occur in a postpandemic construction world."

Brian Perlberg, ConsensusDocs executive director and senior counsel, comments: "This is one of the most anticipated contracts in the history of ConsensusDocs because there is a glaring need to address the growing trend of prefabricated construction or modular building, and current contracting practices simply do not cut it."

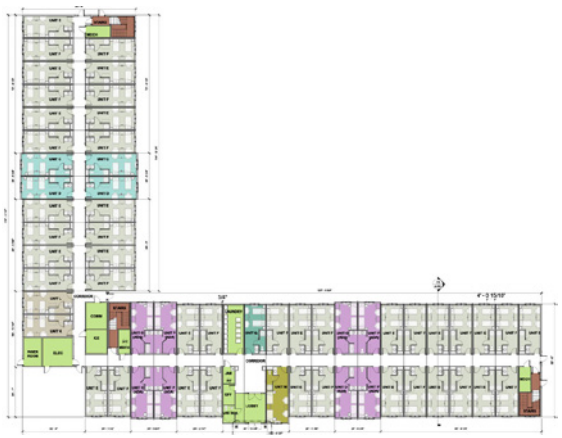
COST SAVINGS AND CERTAINTY

Dodge Data & Analytics' Prefabrication and Modular Construction 2020 Smart Market Report captured the impact of modular construction on project budget performance.

According to the report, 91 percent of all general contractors reported modular construction as having a favorable impact on project budget performance, with 48 percent indicating that costs decreased by more than 10 percent. More than two-thirds of respondents (68 percent) cited better than a 5 percent positive budget impact.

Beyond cost savings, cost predictability is increasingly cited as a benefit of modular construction. Due to the method's shortened construction schedule; upfront materials purchases; and steady, reliable labor, modular projects provide a hedge against construction market uncertainty.

Prefabricated Modular FLETC. Built by Sustainable Modular Management, Inc.
Honorable Mention, Permanent Hotel Over 10,000 Sq. Ft.



Hospitality Industry Embraces Modular Construction, Due to Shorter Schedule, Quicker Occupancy, and Accelerated Return on Investment.

Prior to the COVID-19 pandemic, many hotel brands were investing heavily in modular construction. As of late 2019, Marriott International had built 50 hotels featuring prefabricated guest rooms or bathrooms—including a 354-key hotel in Hawthorn, CA, for which the method saved a year in construction time, according to Jennifer Abuzeid, senior director, global design strategies for Marriott.

Some of the direct cost-saving benefits of modular cited by the hospitality sector include consistent product quality, elimination of change orders, and reduction of punch lists and job site waste. The key factor for using modular, however, is the shortened construction schedule and quicker occupancy. Marriott estimated that modular production and assembly shaved anywhere from three months to eight months off of a hotel's construction time, leading to "heads in beds" much sooner than with conventional construction.

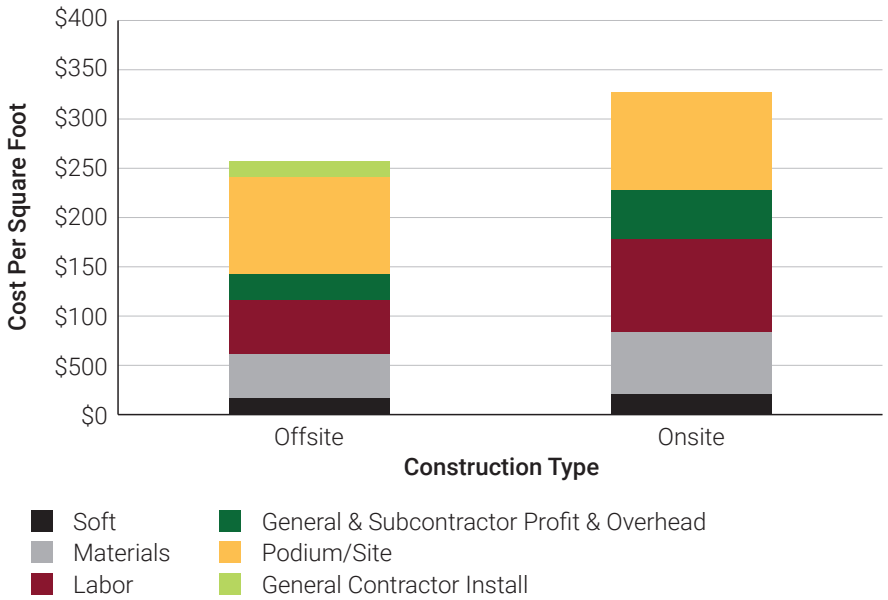
Capital Projects and Infrastructure Modular Construction: From Projects to Products—McKinsey & Company, 2019

Savings in construction costs come from several different areas. First, the integrated processes involved in modular construction remove the need for subcontractors and the margins they include in their quotes. Next, the primary trade-offs are between savings in onsite labor against potentially higher costs for materials and the increase in logistics costs. Modular projects also tend to have higher upfront design costs against lower costs for rework and redesign.

Given these trade-offs, the projects most likely to deliver the greatest cost savings are those that have the highest proportion of labor-intensive activities and the greatest levels of repeatability. Therefore, student accommodations, hotels and affordable housing, for instance, offer high opportunity for savings, while significant savings are currently harder to achieve with structures such as high-end apartments and office buildings.

Building Affordability by Building Affordably: Exploring the Benefits, Barriers, and Breakthroughs Needed to Scale Offsite Multifamily Construction—Terner Center, March 2017

The benefits of modular construction, detailed in this report, include reductions in construction costs of at least 20 percent, shortening of construction times by up to 40 percent, and minimization of impacts on neighborhoods surrounding construction sites. Evidence from developers suggests that offsite construction, as it is currently practiced, can save up to 20 percent on the cost of construction for a three- or four-story wood-frame multifamily apartment building, translating to significant savings for consumers. These savings are achieved primarily in reductions in labor time and costs, economies of scale in material use, and procurement savings.



Source: Galante C., Draper-Zivetz S., Stein A. Building Affordability by Building Affordably: Exploring the Benefits, Barriers, and Breakthroughs Needed to Scale Off-Site Multifamily Construction. (2017) Terner Center for Housing Innovation, University of California, Berkeley.

Because the offsite construction process is more controlled, labor and production efficiencies can be achieved. The production environment is enclosed, meaning all equipment and workers are in the same place (rather than moving to, from, and within a construction site) and are less vulnerable to weather-related delays or impediments.

Further, much of the work in offsite construction is done via assembly lines and automation, maximizing production efficiency and requiring fewer specialized skills. A less skilled and less expensive labor pool can complete work offsite that would require costly subcontractor labor onsite.

The efficiency of material supply chains also greatly influences the cost of construction. In offsite methods, because many design components and materials are standardized across projects, orders can be placed with greater consistency and at higher volumes, driving down costs in both respects. Purchasing also originates with the manufacturer rather than with subcontractors, meaning that material suppliers aren't working with middlemen, and therefore

Case Study—How Moving to Modular Made a Project Possible

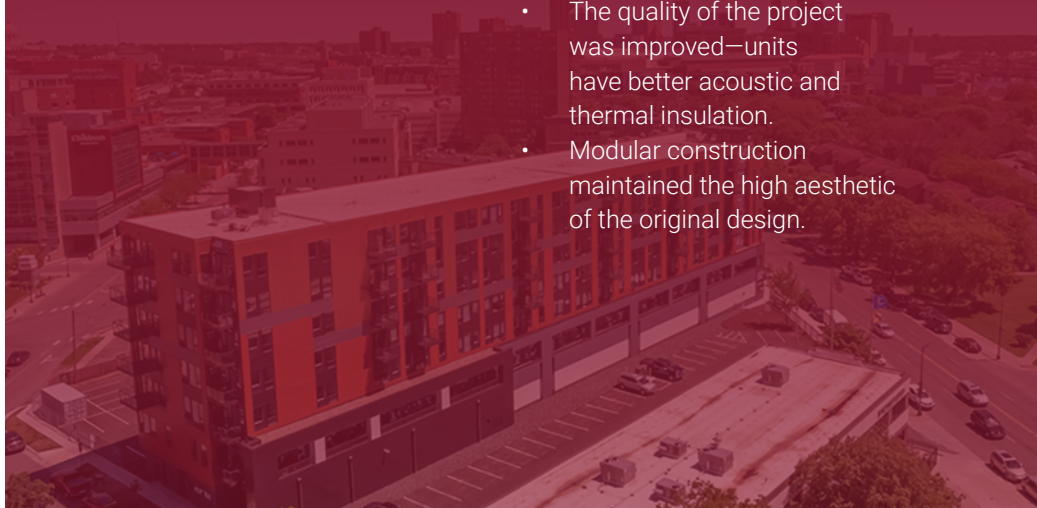
Type: Modular Multifamily
Location: St. Paul, MN
Project Type: Market-Rate

Barriers to Onsite Construction:
Budget: Proforma did not work. Schedule was 18-24 months conventionally.

- *Tight urban site:* Cranes and scaffolding would have been incredibly challenging.
- *Logistics:* There was no area near the site for staging or material storage.
- *Quality:* Onsite construction would have required sheer walls and gypcrete.
- Modular construction offered higher acoustical and thermal insulation ratings.

Moving to Modular Construction:
Construction Duration: 12 months
Number of Modules: 155
Number of Units: 193
Project Status: Completed 2021
Results/Benefits:

- Modular construction maximized the site to achieve the unit count and make the project happen.
- ***The timeline was reduced from 24 months to 14 months.***
- Modular methods worked with a tight site, so the developer did not have to invest in multiple staging sites.
- Neighborhood impact was lessened, with a 22-day mod-set, fewer workers onsite, less traffic, and a significantly shorter construction timeline.
- The quality of the project was improved—units have better acoustic and thermal insulation.
- Modular construction maintained the high aesthetic of the original design.

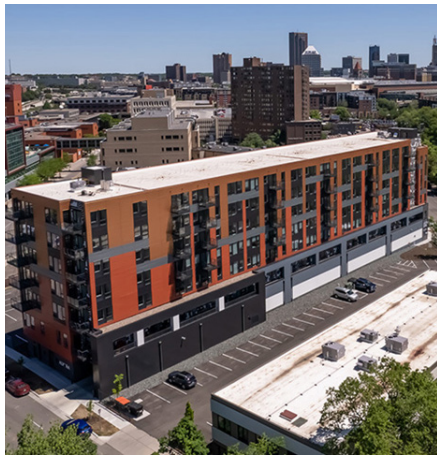


subcontractor overhead and profit are substantially reduced or eliminated.

Case Studies Demonstrating Cost Savings

Source: WSP—Modular Construction for Affordable Housing (February 2018)

Holliday Development's 5830 Third St. in San Francisco, containing 136 units, was the largest factory-built housing project at the time of its completion in 2016. Holliday demonstrated a 20 percent cost savings over conventional construction.



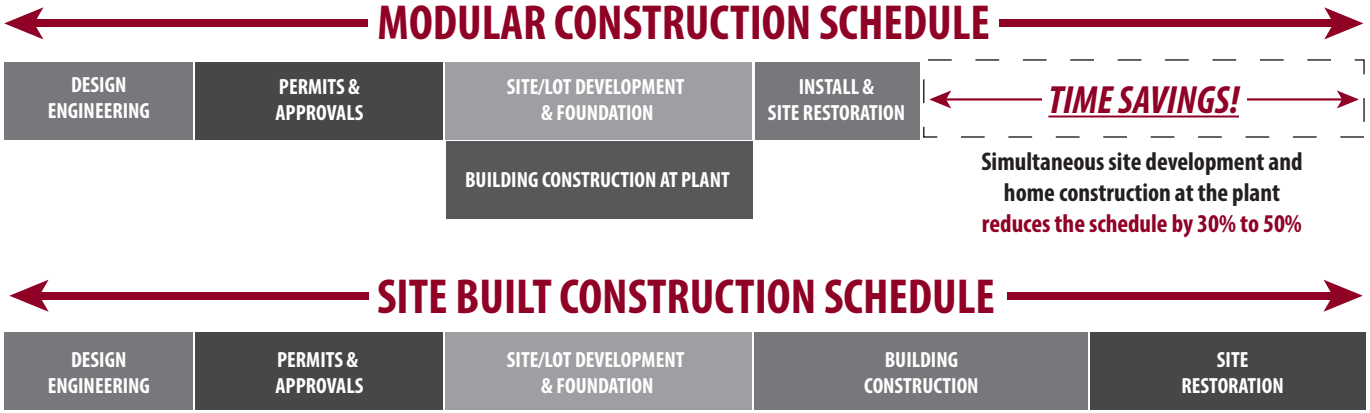
Lowney Architects priced a project in 2017 for a 96-unit supportive housing project in San Francisco. The firm asked for a site-built price and a factory-built price, and the factory price was 15 percent less.

Broad Sustainable Buildings (BSB) reports higher savings. In its T30 high-rise, BSB saw around 30 percent savings, at $93 per square foot, compared to $130 per square foot for the average traditionally constructed Chinese high-rise.

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. However, recent modular projects have, in contrast, established a solid track record of accelerating project timelines by 20-50 percent.

Construction of modular building components occurs simultaneously with site work, allowing projects to be completed in less time than with traditional construction. Additionally, 60-90 percent of construction is completed inside a factory, mitigating the risk of weather delays. Buildings are occupied sooner, creating a faster return on investment.



QUALITY CONTROL AND ASSURANCE

The North American modular industry is currently made up of more than 250 regional manufacturers building everything from construction-site offices to single-family homes and hotels. 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 includes four stages:

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

Design Approval by the End-User and Regulating Authorities

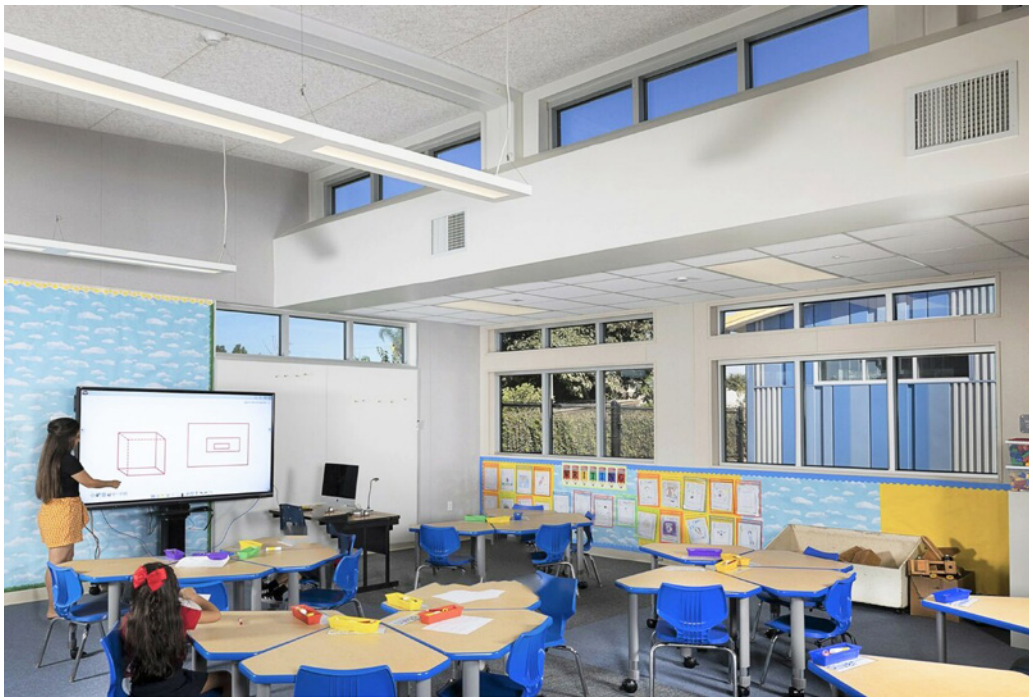
Buildings constructed using the modular process must comply with all applicable building code requirements, including wind, snow, and seismic conditions, where the building will ultimately be located—not at the fabrication location.

Because 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 among state and local authorities.

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

Fabrication of Module Components in a Controlled Factory Environment

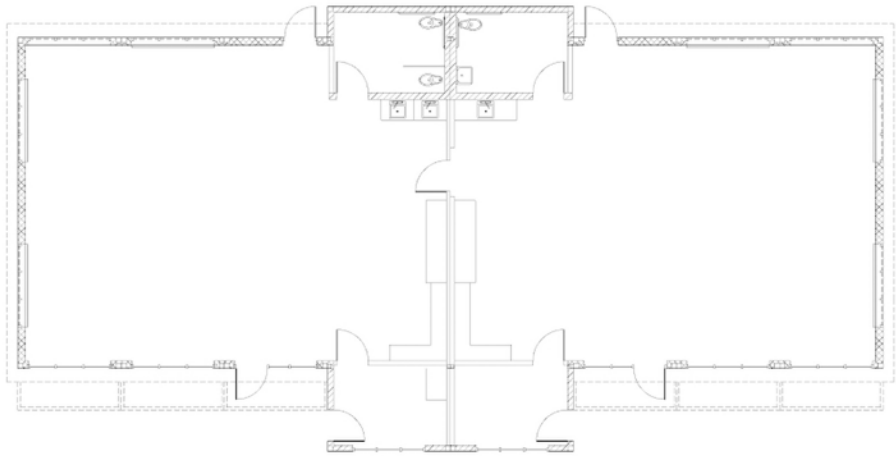
Once the plans are approved, the building components can be fabricated. One of the key advantages of modular construction is that building modules can be inspected by the staff quality assurance/quality control manager at each station (framing, electrical, plumbing, drywall, etc.), with any mistakes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



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. Attached to each modular component is a data plate containing identifying information, 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

Sierra Preparatory Academy.
Built by Silver Creek Industries, LLC.
Winner, Permanent Education
Under 10,000 Sq. Ft.



to the modular component, indicating that it has been constructed to meet or exceed the applicable building code requirements.

These steps are necessary so that the local code official has assurance that the building has been inspected and will meet all local requirements, thus avoiding destructive inspections of the component onsite.

Assembly of Modular Units Onsite to Form the Finished Building, and Approval by Local Authorities

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; and building setback, 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, and module connections.

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

It is of critical importance to the success of any project utilizing modular construction to have a clear scoping document spelling out roles and responsibilities at each point in the process. For instance, who is liable for any damage to the module in the factory, during transport, and once onsite? Who will be responsible for the onsite storage of the modules prior to assembly? Will the factory or the general contractor be responsible for assembling the modules?

MBI worked with the ConsensusDocs Coalition to publish the industry's first standard contract document for prefabricated construction. The ConsensusDocs 753 Standard Prefabricated Construction Contract addresses the most common use case scenario of prefabricated construction in which a constructor, general contractor, design-builder, or construction manager contracts with a prefabricator to fabricate a component offsite that is later installed on a project worksite.

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ENVIRONMENTAL IMPACT

Making the Case for Modular

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 through 2027. This surge of investment—amounting to roughly $130 trillion —will flood into projects to decarbonize and renew critical infrastructure. Notably, 93 percent of chief executive officers say sustainability issues are important for the future success of their business, and 54 percent expect sustainability to be embedded within the core business strategies of most companies within 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
- Relocate, renovate, and repurpose
- Greater energy efficiency/tighter building envelope

Waste Reduction

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

But it does not have to be that way. Several studies have been conducted and reports produced globally on the impact modular and prefabrication have on overall waste reduction. According to the groundbreaking "Prefabrication and Modular Construction 2020" report by Dodge Data and 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.

In terms of academic research, the results are also undeniable.

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

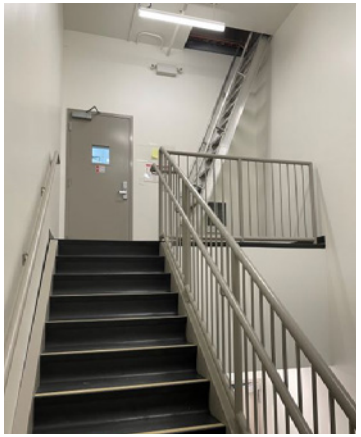
This paper focuses on modular construction as an offsite production system and proposes a framework to compare and quantify differences in waste generation between modular and conventional, in-situ construction methods. The framework relies on a comprehensive literature review to estimate the waste rates 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.*

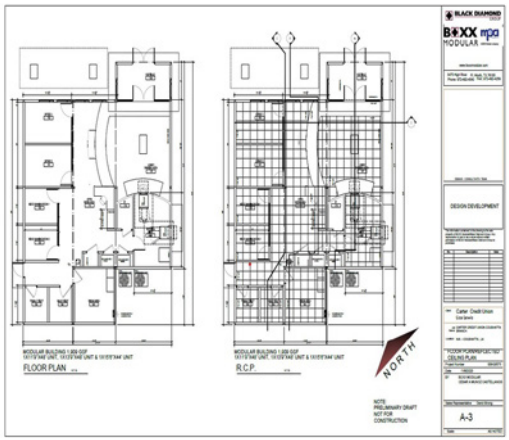
Qualitative comparisons asserting that prefabrication reduces waste have also been verified. For quantitative comparisons, the results show greater waste reductions than most previous studies. *Quale et al., Jaillon et al. Kim, Jaillon and Poon, and Hosseini et al. showed waste reductions of 20.1 percent,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

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.

Oak Ridge National Laboratory.
Built by Satellite Shelters, Inc.
Honorable Mention, Permanent
Office Over 10,000 Sq. Ft.





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 construction. *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. Jaillona, C.S. Poon, and Y.H. Chiang

Since Hong Kong is a compact city with high land prices and limited available land, the construction of high-rise buildings is prevalent. In addition, the construction industry produces a significant amount of building waste, and landfill space in Hong Kong is scarce. 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, including 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 when using prefabrication, compared with conventional construction. The average waste-reduction level was about 52 percent, implying that a wider use of prefabrication could considerably reduce construction

Renovated Reuse Case Study

Aries Building Systems utilized five 12x60 modular units and four 12x64 units that were originally three different buildings, all built by different manufacturers, with three totally and uniquely different floor and roof systems. Taking three buildings, for a total of nine modules, Aries created a single 6,672-square-foot office space in just 70 days.

The interior of the building consists of a tegular acoustic ceiling system to provide further depth and texture to the ceiling plane, commercial-grade carpet tiles in all offices, and wood-plank flooring in the conference room and common areas. The exterior of the building consists of a stucco roof fascia and a stacked-stone wainscot, separated by vertical wood siding. Architectural-grade insulated windows and doors were used. Aries also installed indoor fire-suppression and alarm systems to bring the building up to 2019 code and local jurisdictional requirements.

This renovation also brought the structure into compliance with 2019 building codes, as well as Cal Green and Title 24 energy conservation requirements, making use of high-efficiency heat pumps and LED lighting. Light harvesting was also implemented into the design to collect and utilize natural daylight in the interior of the buildings, reducing the need for energy-consuming artificial lighting. The building also features a reflective white membrane roof system.

waste generation in Hong Kong and alleviate the burdens associated with its management.

Lower Carbon Footprint
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 carbon dioxide 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 for modular construction.

Relocate, Renovate, and Repurpose
One opportunity modular construction provides to reduce negative environmental impacts is the ability to design for the relocation of an entire building. Since modular buildings are constructed in modules, they can be more easily "deconstructed" and used for secondary purposes.

During the 2010 Vancouver Winter Olympics, for example, city officials had the forethought to consider what would be done with the structures used to house athletes after the games ended. The Vancouver Olympic Village, a mixed-use complex costing nearly $1 billion that housed athletes during the 2010 games, was built in an abandoned industrial area (mostly covered in parking lots) at the southeast corner of False Creek near the Olympic Village SkyTrain station. Today the LEED-Gold certified project has 1,100 living units, of which almost one-third are designated as affordable rental or ownership.

As another result of the 2010 Olympics, seniors across British Columbia now have much-needed affordable living accommodations. Following an agreement between the provincial government and the Vancouver Organizing Committee, 320 modular housing units from the Olympic Village at Whistler were relocated and converted into permanent, affordable apartments in six communities across the province.

Greater Energy Efficiency/ Tighter Building Envelope
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
This multiyear field study targeted four climate zones in three states (California, Pennsylvania, and Washington) and documented the 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, compared to comparable site-built construction.

WORKER SAFETY
AND QUALITY OF LIFE ISSUES

Worker Safety and Quality of Life Issues

Fact: 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 from the U.S. Bureau of Labor Statistics (BLS) at BLS.gov.]*

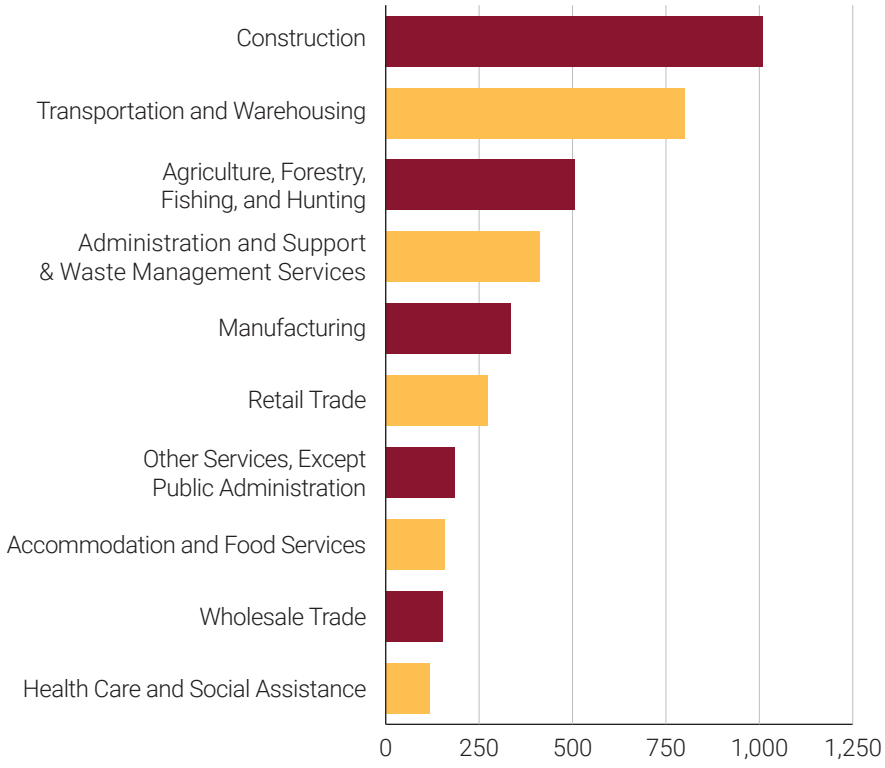
In 2020, the latest year for which construction safety data is available, the construction industry accounted for about one in five of all workplace deaths—the highest number of fatalities of any industry reported and nearly three times the number of the manufacturing sector.

Modular construction has demonstrated the ability to provide a safer environment for the construction workforce. Simply by shifting large portions of building construction to an offsite manufacturing setting, the BLS data suggests that the number of construction-related fatalities would drop significantly.

Of those thousand-plus annual construction industry deaths, more than a third are attributable to fall hazards. Using modular methods, the ability for 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.

The BLS also reports that 65.8 percent of construction and extraction occupations are exposed to heights on the job site (a worker is considered to be exposed to heights when their center of gravity is more than 5 feet off the ground and the worker is at risk of injury from falling, meaning walls or railings do not surround the worker to prevent falling). While personal protective equipment (PPE), which typically includes safety

Number of Fatal Work Injuries, Selected Private Industries, 2020



Source: U.S. Bureau of Labor Statistics

harnesses or tethers, mitigates some of the risk of exposure to heights, only 38 percent of construction laborers use PPE. Among construction laborers, only 31 percent use PPE.

In addition to actual job site risks, there is also apparently a lack of a culture of safety within large portions of the construction industry, given that only about half of all workers use PPE.

Nearly 93 percent of construction laborers are required to use medium or heavy strength. BLS measures the strength levels needed for each occupation based on the weight a worker needs to lift, the time needed to lift or carry the weight, and the time spent standing and walking. There are five strength levels: sedentary, light, medium, heavy, and very heavy. Construction laborers typically require either heavy or medium levels of strength. Heavy strength (frequently lifting 26-50 pounds) is required for 38.8 percent of construction laborers, making it one of the largest proportions of occupations to require this level of strength. Another 54 percent of construction laborers require medium strength. By comparison, 8.9 percent of all civilian workers require heavy strength, and 28.2 percent require medium strength. A large majority (85 percent) of "production workers" fall in the medium-strength category, frequently lifting 11-25 pounds. On average, construction laborers are required to lift or carry 58.8 pounds, compared to the average for all occupations of 26.3 pounds.

Nonfatal incidence rates due to exertion are higher for construction laborers than for related occupations. Injuries or illnesses from overexertion can result from events involving movement of the body or excessive physical effort (such as overexertion in lifting or lowering). In 2020, the incidence rate of overexertion and bodily reaction for construction laborers was 48.3 cases per 10,000 full-time workers. Construction laborers experienced 3,950 nonfatal injuries or illnesses resulting in at least one day away from work due to overexertion in 2020.

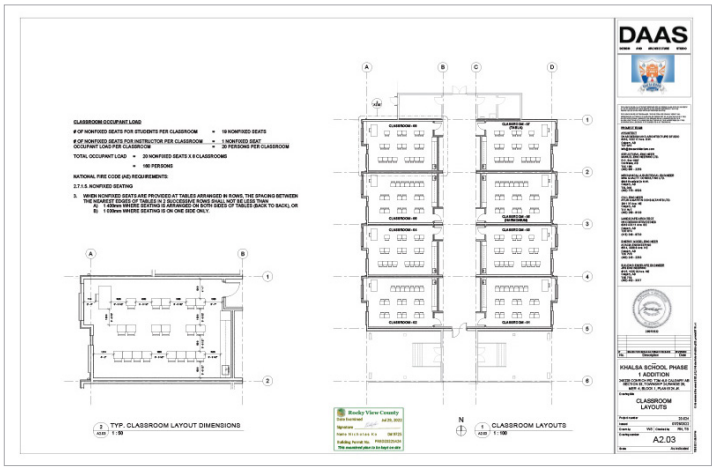
Additionally, nearly all construction laborers work outdoors—in fact, 94 percent of workers in construction and extraction occupations have outdoor exposures. Eighty-one percent of construction laborers work outside constantly, defined as more than two-thirds of the time. According to the U.S. Centers for Disease Control and Prevention, physical hazards to outdoor workers may include extreme heat, extreme cold, noise, and sun exposure. Extreme heat can cause heat stroke, heat cramps, heat exhaustion, heat rash, and other problems. Extreme cold can cause hypothermia, frostbite, and other issues.

The 2020 Dodge Smart Market Report of Modular Construction and Prefabrication 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 are even more dramatic among large contractors with revenues of more than $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 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—those that might not be able to meet the physical demands on a job site over a long period of time. It also 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 longevity and higher productivity.

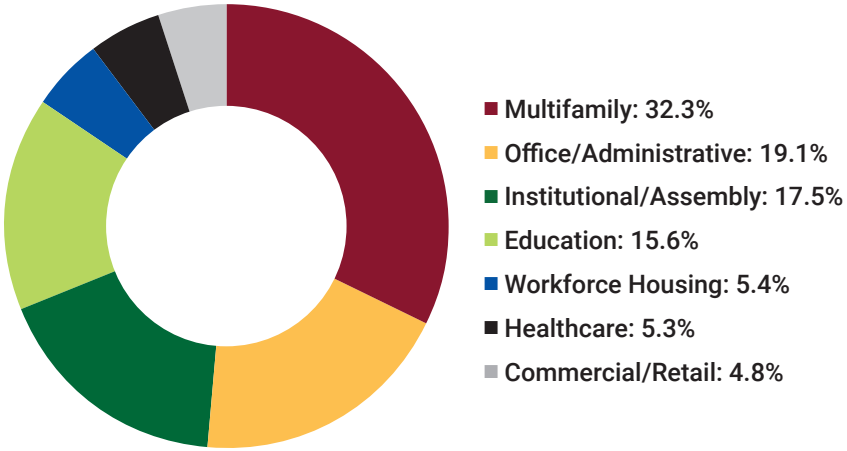
Khalsa School. Built by NRB Modular Solutions. Honorable Mention, Permanent Education Under 10,000 Sq. Ft.



INDUSTRY PRODUCTION DATA

In 2022, 24 modular manufacturers reported total production of 8,123,554 square feet, for an average of 338,481 square feet each. MBI estimates the total output for North American modular manufacturers at 86,312,655 square feet. According to Construct Connect, the total square footage of all new nonresidential construction put in place in North America for 2022 was 1,405,422,212 square feet. Projects utilizing modular construction therefore accounted for approximately 6.14 percent of the total square footage for new construction in 2022.

Modules were built for the following markets:



This is the third consecutive year that the multifamily market was the largest for the industry, growing from 21 percent in 2020 to 24 percent in 2021 to 32 percent in 2022.

Project Analysis

Of the 62 projects reviewed, nine were in Canada, and the remaining 53 were in the U.S. Of the U.S.-based projects, 15 were in California; five were in Washington; and three each were in Massachusetts, Pennsylvania, Tennessee, and Texas. Two of the projects were in Indiana, and there was one project each in numerous states, including Alabama, Alaska, Arkansas, the District of Columbia, Maryland, Michigan, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Jersey, New York, and North Dakota.

The average size for projects completed in 2022 was 24,057 square feet, consisting of an average of 37 modules each. The average days to complete each project from approval to occupancy was just 309 days. The average total cost of these projects was $6,708,142, for an average cost per square foot of $278.84.

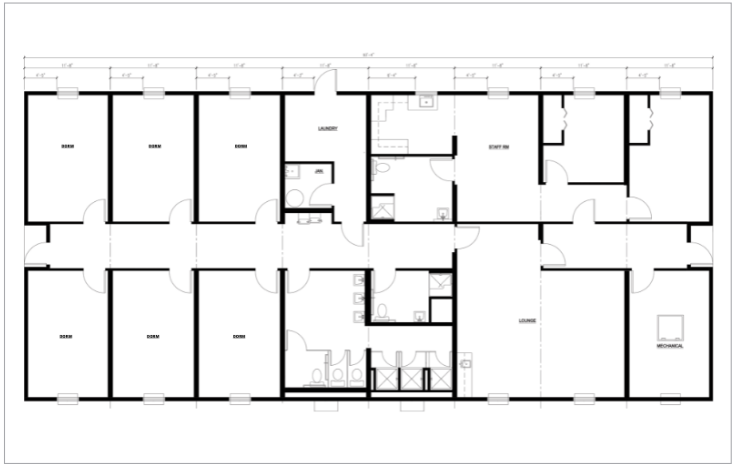
Most of the projects MBI analyzed contained one, two, or three stories. Nine of the projects were four stories or taller, with the tallest project at 10 stories.

The project delivery method was identified for 29 projects. Not surprisingly, the majority (22) were design-build projects, the preferred method on many modular projects. Five projects were identified as design-bid-build, one as integrated project delivery, and one as public-private partnership. A best practice for projects utilizing modular construction is to involve the modular manufacturer as early in the decision-making process as possible.

Of the 62 projects, 38 provided information on primary structural material. Of those, 20 were wood-frame structures, 16 were steel structures, and two were concrete structures. Historically, about 70 percent of modular projects in North America have been wood-frame, 25 percent steel and 5 percent concrete modules.

As multistory projects became more common in the industry, initially there was about a 5 percent shift toward steel-frame modules. In recent years,

Holderness Dormitory. Built by VESTA Modular. Honorable Mention, Permanent Dormitory Under 10,000 Sq. Ft.



however, taller wood-frame projects have become more common and accepted in the building codes, and the trend toward steel has leveled off. One of the biggest shifts in the modular industry over the past 10 years has been the integration of modules into "traditional" projects. In the past, a project was either modular or site-built. As general contractors, architects, and developers became more familiar with the advantages of modular construction, more hybrid projects emerged.

MBI obtained cost data on 31 projects completed in 2022, including total cost and the cost for the modular portion of the projects. The average modular cost of these projects was 43 percent of the total project cost. In the past, 80-90 percent of the total value of a project was modular. Now, more than half of a project's total cost is site-related work.

This is a key point for a number of reasons:

1. Organized labor groups continue to be resistant to modular construction's offsite work, as that work occurs out of their local jurisdiction. MBI's data demonstrates that a significant amount of work—in fact most of the work—still needs to be done locally onsite. However, many traditional projects simply do not "pencil" during the pro forma stage; in such cases, the project stalls and the work does not happen. By shifting to modular, which shortens the overall schedule and advances the occupancy date, the same project may now get built, making a compelling case that modular construction creates MORE local site-related work.
2. With the decrease in skilled construction labor projected to continue for the near future, shifting half the work to a more predictable factory setting will allow elected officials and policymakers to finally make good on promises to address housing shortages.
3. At an average cost per square foot of $279 across all markets and all geographies, there is evidence to suggest that cost savings can be realized when compared to traditional commercial project costs. Of course, total project costs depend upon a number of variables, including local labor costs, when and where materials are purchased, and the types and locations of projects being constructed.

Projects by Market

Multifamily—Fifteen projects completed on average in 380 days. Average of four stories and 59,718 square feet, consisting of 81 modules. Cost data on five projects had an average $9.8 million total cost, with $4.2 million (43 percent of the total cost) for the modular portion.

Education—Twelve projects at an average size of 18,424 square feet, consisting of 32 modules. Nine were one-story, and three were two-story projects. Projects were completed on average in 225 days. Cost data obtained on seven projects had an average total cost of $4.5 million, with $2.4 million (53 percent of the total cost) for the modular portion.

Office—Eleven projects with an average size of 8,883 square feet, consisting of 14 modules, with an average of 296 days to complete. Six were one-story projects, while five were two-story projects. Cost data on four projects had an average total cost of $13.5 million, with $6.3 million (47 percent of the total cost) for the modular portion.

Retail—Eight projects with an average size of 2,103 square feet, consisting of 4.5 modules each, with an average of 383 days to complete. Cost data on five projects had an average total cost of $1.6 million and an average modular cost of $562,000, or 35 percent of the total. The higher average days to complete figure, compared with other markets, can be attributed to smaller portions of these projects completed offsite and correspondingly larger portions completed onsite.

Other markets: Institutional and Assembly (5), Healthcare (5), Hospitality (2).

Secwépemc Child and Family Services (SCFS) Agency Office Building. Built by NRB Modular Solutions. Winner, Permanent Office Over 10,000 Sq. Ft.

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 home 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.

The map on the right shows where MBI's North American manufacturers are located.

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

MBI uses a three-year average construction start value from Construct Connect Insights 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 PMC projects.

For the average building project using PMC, the factory portion of the total project's value was approximately 43 percent in 2022. This figure was determined by reviewing 30 completed PMC projects in 2022 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 2022.

MBI collected and analyzed revenue data from 95 manufacturers engaged in PMC in North America, totaling $1,972,370,853 in revenue—ranging from a high of $220 million to a low of $500,000. The average revenue of these manufacturers was $20,761,798.

When divided by 0.43 and multiplied by the total number of industry participants, the total value of modular building construction projects for 2022 can be estimated at $12,312,229,315. As a result, the modular industry market share is estimated to be 6.03 percent of new starts.

- (Average manufacturing revenue/0.43) x 255 companies = total value of modular projects put in place.
- Total value of modular/total construction start value = modular market share.

PMC Market Shares

Year	PMC Firm Revenue	Value of PMC Projects (divide by .55)	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%

(US $000s) • Source: Modular Building Institute, Construct Connect

Disclaimers:
In preparing this report, certain variables, adjustments, and calculations are necessary to arrive at the final numbers.

MBI is aware of multiple PMC 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.

FREQUENTLY ASKED QUESTIONS

To what building codes are modular buildings constructed?
It is helpful to think of "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, then transported to the final site for assembly. As such, a building constructed in this manner still must meet all the same building codes and requirements as if it were built onsite—most commonly a version of the International Building Code in the U.S. or the National Building Code in Canada.

Do modular buildings last as long and have the same quality as site-built construction?
A building constructed using modular methods will last as long, if not longer than, a traditional site-built structure. Again, the building is constructed to the same building codes and must meet the same wind, snow, and seismic conditions. While there is limited research to prove this point, one such study does exist. Following Hurricane Andrew in 1992, FEMA commissioned a study called "Building Performance: Hurricane Andrew in Florida" comparing site-built, modular, and manufactured housing. In that report, FEMA found: "Overall, relatively minimal structural damage was noted in wood-framed modular housing developments. The module-to-module combination of the units appears to have provided an inherently rigid system that performed much better than conventional residential framing."

Is modular construction less expensive?
Generally speaking, yes. There are lots of variables with a modular project, just as there are with a conventional construction project, with availability and cost of onsite labor being 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.

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

McGraw-Hill published a Smart Market Report titled "Prefabrication and Modularization: Increasing Productivity in the Construction Industry." Through an internet survey of hundreds of architectural, engineering and construction professionals, the report found: "Sixty-five percent report that project budgets were decreased—41 percent by 6 percent or more."

Perhaps as significant as cost reduction is the cost certainty associated with modular projects. Early communication and integration of the entire construction team typically lead to fewer change orders and a more predictable budget.

Isn't this a new, untested method for construction?
Far from it! In fact, a report from 1670 indicates a prefabricated building was shipped by boat from England to what is now the United States.

In the 1800s, demand for modular housing increased as the country expanded westward. During the California Gold Rush of 1849, for example, more than 500

preassembled homes were shipped from factories in New York to destinations in California.

In the 1920s, Sam Kullman began manufacturing the popular "Kullman Diners" along the Northeast coast. In 1933, Arthurdale, West Virginia, was established as the first of Franklin Roosevelt's New Deal communities. Numerous types of modular structures were shipped there, including post offices, stores, homes, and schools.

In the 1940s, the industry began to expand into commercial projects, with the founding of industry giants Williams Scotsman (now WillScot), and ATCO in Alberta.

After World War II, modular construction offered quickly constructed, low-cost homes to returning servicemen.

In 1969, Zachry Construction utilized modular construction techniques to complete a 21-story modular hotel on the Riverwalk in San Antonio. The hotel, still in operation, was the tallest modular building in North America, until the recent completion of the 32-story Pacific Park building in Brooklyn, NY.

In 1972, Disney Corporation completed its Contemporary and Polynesian Resorts, constructed by U.S. Steel.

So, there is a long history of innovative companies successfully utilizing modular construction techniques.

I have heard about "pop-up" or project-specific manufacturing plants. Is that the same as a modular factory?

The modular factories detailed in this report are not project-specific plants. Rather, these companies build for several clients within a given geographic region (typically about a 500-mile radius from the factory). MBI has seen some examples of general contractors renting vacant warehouses near larger project sites and using these "pop-up" factories for some preassembly work, materials staging, and coordination. However, these are not automated plants and often do not incorporate assembly-line processes or lean manufacturing techniques—often these locations are just extensions of existing job sites.

Do prevailing wages apply for work done in a modular factory?

No. Davis-Bacon rates and state prevailing wages laws typically are limited to work performed "at the site." By definition, work done in a modular factory is "offsite." That said, there are many considerations and nuances to understand about the applicability of prevailing wages. State laws often vary on this subject, so when in doubt, seek a legal opinion. Also, if a factory is established for a specific project and intended only to serve that project (see the pop-up example above), it will be considered an extension of the job site, and prevailing wages will likely apply.

So, why hasn't modular construction caught on before now? Why the sudden interest?

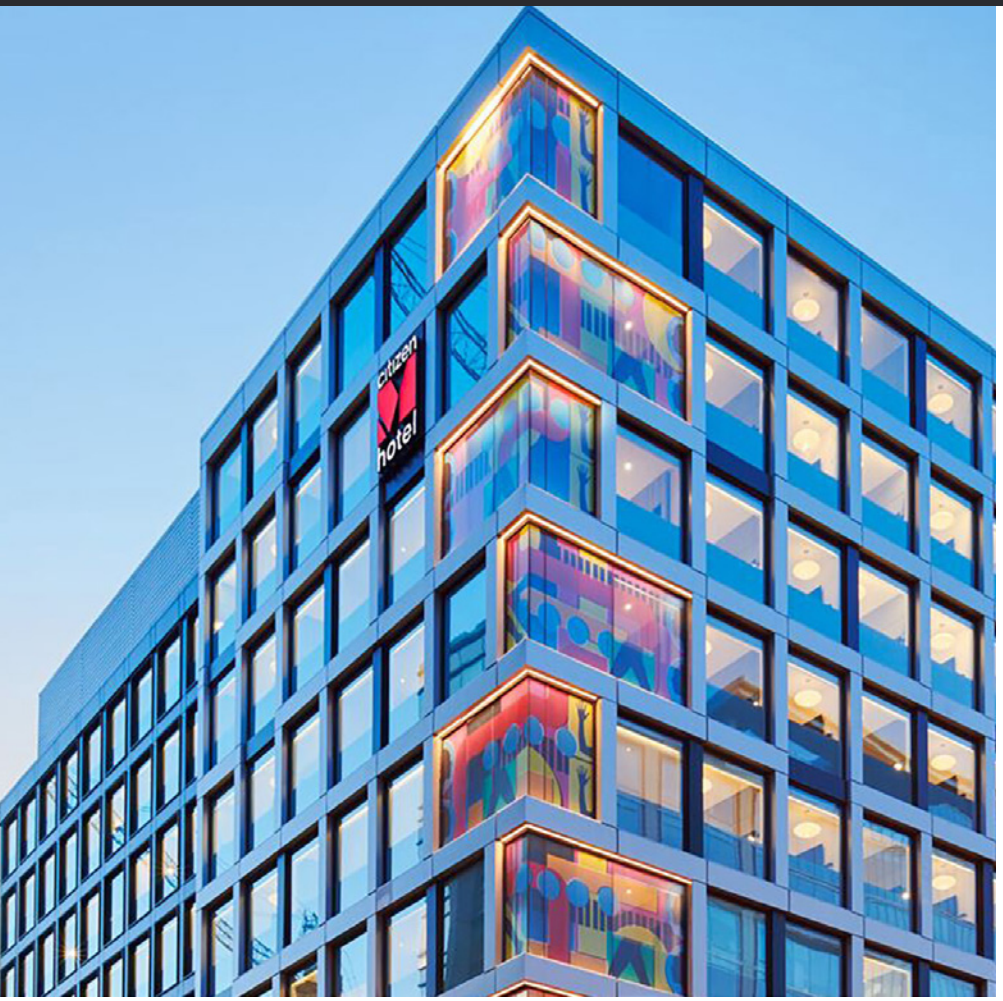
Until recently, developers and contractors seemed content with the status quo, regardless of the inherent and understood inefficiencies. For many, planning and preparing for those inefficiencies seemed easier than learning a different way of building.

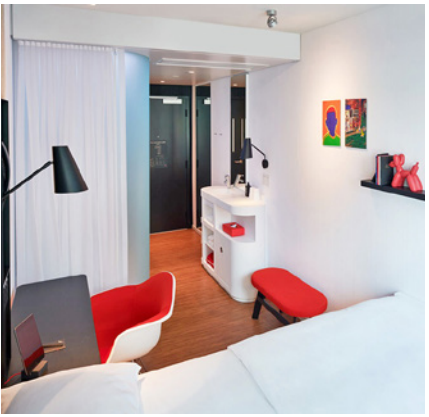
Today, developers and owners are facing a "perfect storm" in the construction sector, including:

- a widely recognized shortage of skilled labor that will not likely get better anytime soon;
- high housing costs and low housing availability in urban areas—a condition that is worsening;
- a widely documented lack of productivity in construction; and
- the increasing need for shorter construction schedules.

Due in large part to those factors, the construction industry has more fully embraced innovations and technologies that are leading toward more of an "industrialized construction process."

More environmentally conscious customers are also increasingly demanding greater accountability regarding wasted resources and the massive amount





CitizenM Washington DC NoMa. Built by Volumetric Building Companies. Winner, Permanent Hotel Over 10,000 Sq. Ft.

of construction debris that ends up in landfills annually. Modular construction is a proven solution to help reduce construction waste.

Where is the industry headed? What other trends do you anticipate? Will this interest lead to greater adoption of modular construction?

If history is any indication, we will see a significant shift toward modular and offsite construction techniques over the next five years as more of the skilled labor force retires. The construction industry will (and must) evolve into a more industrialized and automated process—it is just inevitable. Every major industry has undergone this same transformation. The construction industry is the last holdout, clinging to a lost cause. Companies that build using modular methods now and build these techniques into their strategic plans will be more successful more quickly than those who put off making the transition to modular.

In North America, the modular movement has begun. We are seeing large general contractors and developers establish their own modular divisions, while others partner with existing modular manufacturers.

How many square feet does the typical manufacturer produce in a year?

This is where the averages can be misleading. The number of modules a particular manufacturer produces each year depends on a few factors, such as the type of project the company is building, the level of customization involved in the project, and the scope of the manufacturer's contract (i.e., whether the customer wanted certain work to be completed onsite). Based on overall data obtained from 76 manufacturers in the U.S. and Canada, the average production per manufacturer in 2020 was 202,496 square feet.

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, as well as the National Institute for Building Sciences.

Accessory Dwelling Unit. 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. 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. The physical separator between the interior and the exterior environments of a building that 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 building codes for occupancy and use by groups other than residential for one or more families.

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

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

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 to a modular building by the manufacturer or installer, or a modular component that contains identifying information enabling 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 a building or structure, or portion thereof, apart 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 built in one or more modules, or constructed using one or more modular components, 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, constructed in one or more modules using one or more modular components, built at a location other than 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 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 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, which are then delivered to and assembled at the building site.

Quality Control. Controls and inspections implemented by the manufacturer, as applicable, to ensure 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 code. A third-party inspector works under the direction of a third-party inspection agency.

Tiny Houses. A dwelling that is designed and constructed in accordance with the International Residential Code (IRC), with additional requirements as specified in the IRC Appendix Q.

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2023 PERMANENT MODULAR CONSTRUCTION REPORT

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