



Fannie Mae®

Multifamily Modular Construction Toolkit



Table of Contents

3	Introduction
5	An Overview of Multifamily Modular Construction
7	About Multifamily Modular Construction
11	The Modular Market Is Growing
13	Advantages to Modular Construction
18	Challenges of Modular Construction
20	The Manufacturing and Construction Process
23	Considerations When Choosing Modular
23	Planning for a Modular Development
26	Best Practices in Modular Construction
28	Case Study: The Stack
29	State and Local Governments Encouraging Modular
30	Conclusion
30	Appendix A: Sample Scope of Work Checklist
31	Appendix B: Additional Resources
32	Appendix C: Glossary

Introduction

The high cost of developing multifamily housing is a major contributor to the nation's affordable housing supply crisis. To try and resolve the lack of affordable housing, various cost drivers throughout the life cycle of a housing development — from pre-development planning and land purchase, to the construction phase, to projected operating expenses — are being re-evaluated to find opportunities for both time and cost savings.

Modular construction is a technique whereby the bulk of the construction of a building is done off-site at a factory, and the components, called modules or simply boxes, are transported to the construction site and assembled. Modular construction has many potential benefits, including cost savings, shorter development timelines, and an overall safer and more efficient development process.

This is one approach of many needed to address the affordable housing supply crisis. The modular construction market in the U.S. is not very big, but it is growing.

For those interested in pursuing multifamily modular construction projects, there are some important things to know before getting started, particularly since this may be the first time many are involved in such a project. Modular construction offers many benefits but is not without its challenges. The overall construction timeline is much shorter (30 to 50 percent shorter than traditional construction),¹ and there is less room for error once the project has begun, so it is vital to be fully prepared at the outset of a project. Individual modules, including finishes, come off the assembly line within days, and they ultimately need to stack together perfectly on-site.

Modular construction creates some unique planning and financing challenges. The majority of the physical construction is performed at a manufacturing plant and then delivered to the construction site. Since most of the building materials need to be purchased at the start of the manufacturing process, a higher portion of equity is needed up front than for site-built construction. The purchasing of building materials cannot be spread out over several months or years, as is done with traditional on-site construction, with construction loan draws occurring throughout the construction timeline. Because of this, most manufacturers require a substantial deposit up front. Finally, transporting the finished modules from the factory to the site creates additional logistical planning.

This toolkit offers a starting point and provides important resources for lenders, developers, and stakeholders interested in pursuing multifamily modular construction.

1 “Design for Modular Construction: An Introduction for Architects,” American Institute of Architects (2019), content.aiaa.org/sites/default/files/2019-03/Materials_Practice_Guide_Modular_Construction.pdf, p. 14.

About Fannie Mae

For 30 years, Fannie Mae Multifamily has served the secondary mortgage market as a reliable source of mortgage capital in every market, every day. We provide liquidity, stability, and affordability to the multifamily market in a disciplined fashion while maintaining our credit standards and minimizing losses.

About National Institute of Building Sciences

The U.S. Congress established the [National Institute of Building Sciences](#) (NIBS) in 1974 to bring the public and private sectors together to address building science and technology-related issues to improve the safety and performance of buildings. Today, NIBS continues to provide the opportunity for free and open discussion of issues and problems where there was once conflict and misunderstanding. It continues to assemble federal, state, and local government agencies and representatives of the private sector for open working sessions that seek a consensus solution to problems of mutual concern. NIBS also works with federal agencies on projects related to the built environment to help achieve national goals. Headquartered in Washington, D.C., NIBS' professional staff provides technical, managerial, and administrative support for the Institute's programs.

In 2013, NIBS established the [Off-Site Construction Council \(OSCC\)](#) to serve as a research, education, and outreach center for relevant and current information on off-site design and construction for commercial, institutional, and multifamily facilities. Membership in the OSCC is open to all members of NIBS.

Acknowledgements

Fannie Mae acknowledges the contribution of NIBS to this document, with subject matter expertise provided by the OSCC:

NIBS staff:

Kyle Barry, PMP, National Institute of Building Sciences

Jiqui (JQ) Yuan, P.E., PhD, PMP, National Institute of Building Sciences

OSCC subject matter experts:

Tom Hardiman, CAE, Modular Building Institute

Laurie Robert, LEED AP BD+C, NRB Inc., a Horizon North Company

Ryan Colker, JD, CAE, International Code Council

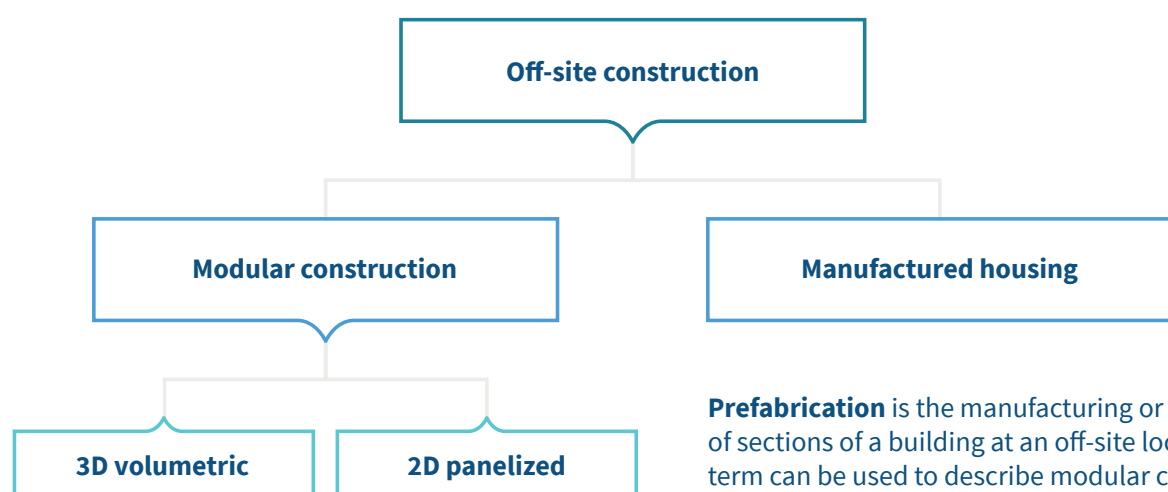
An Overview of Multifamily Modular Construction

What is modular construction?

Modular construction is a technique whereby the bulk of the construction of a building is done off-site, and the components, sometimes called modules or simply boxes, are then transported to the site and assembled. The technique is used for various real estate sectors, including hospitality, health care, and multifamily housing.

Modular construction fits under a broad umbrella of off-site construction, a category that includes a range of construction types and methods, from manufactured single-family homes to non-volumetric and volumetric commercial modular construction.

Modular housing differs from manufactured housing. Although both types of housing are manufactured in a factory and transported to their final location, they are governed by different building codes. Modular homes must conform to all state, local, and regional codes that are based on the final location of the property. The design and fabrication of manufactured housing is regulated by the U.S. Department of Housing and Urban Development (HUD) and subject to different financing requirements.



Prefabrication is the manufacturing or fabrication of sections of a building at an off-site location. The term can be used to describe modular construction and manufactured housing.

Non-volumetric (also known as panelized) construction involves the off-site prefabrication of two-dimensional building elements, such as walls and frames, that are assembled on-site. Volumetric construction involves the off-site prefabrication of three-dimensional, enclosed units that are assembled on-site to form a complete building. Later sections of this toolkit will provide more details about the modular building process and explain the various types of modular construction and their uses and advantages.

Although this construction method can be used to create temporary structures such as classrooms and emergency shelters, this toolkit is focused on permanent modular housing, which can be used to construct new apartment buildings.

The affordable housing crisis

There is a huge need for more affordable rental housing in the United States. According to the Harvard Joint Center for Housing, as of 2018, 47.4 percent of renter households in the U.S. are cost-burdened, meaning they spend more than 30 percent of their incomes on housing expenses. Additionally, 10.8 million renters are severely cost-burdened, meaning they spent more than half of their incomes for housing.² For extremely low-income (ELI) renters, the situation is worse: 71 percent of ELI household are severely cost-burdened. Nationwide, for every 100 ELI renter households, there are only 37 affordable and available homes.³ If housing costs continue to rise at a rate faster than incomes, even more households will become cost-burdened.

New construction has been more concentrated on higher-cost units, which does not meet the needs of low- and moderate-income households. The low-rent stock is decreasing every year, in large part due to single-family homes and smaller (two- to four-unit) rental buildings converting to owner-occupied. Much of the existing stock is in older buildings, making it vulnerable to loss.

The National Apartment Association and National Multifamily Housing Council published a report stating that by 2030, the U.S. needs to build more than 4.6 million new rental units for a variety of income levels.⁴ To meet this need, more units will have to be constructed per year than in previous years — an increase from 244,000 (the 2012 to 2016 annual average) to more than 325,000 units per year.

Rising development costs

It is difficult to develop new affordable housing without significant subsidies from such programs as the Low-Income Housing Tax Credit Program. However, even for new apartment properties developed with significant subsidies, development costs have increased over recent decades, making it even more challenging for developers to create new affordable units.

2 “The State of the Nation’s Housing 2019,” Joint Center for Housing Studies of Harvard University (2019).

3 “The Gap: A Shortage of Affordable Homes,” National Low Income Housing Coalition (March 2019).

4 “Vision 2030,” National Multifamily Housing Council and National Apartment Association (2017).

These costs are driven by market forces on land, labor, and materials; government entities at multiple levels; and particularly for affordable housing, the cost of layering multiple financing sources. Housing advocates and policymakers are seeking diverse solutions to address these cost drivers as a way to address our nation's affordable housing needs.

Studies have reported that hard costs comprise 65 percent to 73 percent of total development costs for a multifamily project. Modular construction has the potential to significantly impact the hard construction cost budget of a development. According to research done by the Turner Center for Housing Innovation, off-site multifamily construction has the potential to save on construction costs due to reductions in labor, time, and costs, economies of scale in material use, and procurement savings.⁵

Significant time savings is inherent in modular construction, which is a benefit in itself and something that contributes to the cost savings. Since the site preparation work and off-site construction of the modules can be done simultaneously, the overall timeline is greatly condensed. Considering these and other benefits of this technology, modular construction, if scaled up, can be an important piece of the strategy to address the affordable housing supply crisis currently taking place in the U.S.

About Multifamily Modular Construction

Overview

The National Institute of Building Sciences (NIBS) Off-Site Construction Council (OSCC) defines *off-site construction* as “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. Off-site construction is characterized by an integrated planning and supply chain optimization strategy.”⁶

5 “Building Affordability by Building Affordably: Exploring the Benefits, Barriers, and Breakthroughs Needed to Scale Off-Site Multifamily Construction,” Turner Center for Housing Innovation, UC Berkeley (March 2017).
6 “Glossary of Off-Site Construction Terms,” National Institute of Building Sciences Off-Site Construction Council, cdn.ymaws.com/www.nibs.org/resource/resmgr/OSCC/GlossaryOffSiteConstructionT.pdf.

Modular construction is a subset of off-site construction, whereby buildings are produced in “modules” that, when put together on-site, reflect the identical design intent and specifications of the most sophisticated site-built facility.⁷ Single-family or multifamily homes constructed using modular techniques and processes are not considered “manufactured homes.” Single-family manufactured homes, though also constructed off-site in a factory setting, are constructed to meet HUD standards. The HUD code includes construction and safety standards and requires manufactured homes to be constructed on a permanent chassis. In contrast, permanent modular buildings are constructed to the same local construction and building codes as all other properties in a given locality’s jurisdiction.

Modular construction practices have been available since the mid-1800s, with pre-fabricated housing products being made and sold as part of the U.S. population’s migration west. Additionally, pre-fabricated and modular housing products were used frequently during the late 1950s and were expanded beyond housing to schools, health care properties, and other large buildings during the 1960s and 1970s.⁸ Currently, modular construction is used extensively throughout Europe and has seen a growing market share in the U.S. over the last 10 years. With technological improvements, including computer aided design and manufacturing and a growing acceptance by the industry, modular is likely to expand further into all types of building construction, including multifamily housing.

Commercial modular buildings

The modular industry consists of two distinct industry segments: relocatable modular and permanent modular.⁹ **Relocatable modular**, or temporary modular, are structures that meet temporary space needs and can be leased in a short-term agreement or purchased outright. This include job site trailers, temporary classrooms, and communication pods, among other products. These structures have specific code requirements outlined in the building code.

Permanent modular construction, or PMC, the focus of this toolkit, is comparable to site-built structures meeting the International Building Code (IBC), or International Residential Code (IRC) in the case of single-family homes. As with site-built structures, a modularly constructed building must meet the local codes of where it will be located, depreciate in much the same manner, and be classified as real property.¹⁰ PMC is deployed for single-family and multifamily structures, government buildings, health care facilities, schools, hotels, and other building types. PMC production accounts for over 50 percent of the modular construction industry in commercial markets in the U.S. and represents about 4 percent of all new

7 “What is Modular Construction?” Modular Building Institute, modular.org/HtmlPage.aspx?name=why_modular.

8 “Design for Modular Construction,” p. 4.

9 Ryan E. Smith, “Off-Site and Modular Construction Explained,” National Institute of Building Sciences Off-Site Construction Council (August 2016), wbdg.org/resources/site-and-modular-construction-explained.

10 “Permanent Modular Construction Report,” Modular Building Institute (2019), p. 5.

construction starts in the U.S. PMC has been more widely adopted and utilized in other parts of the world, representing as much as 70 percent of all new construction in Sweden.

The modular project delivery method for multifamily requires early engagement, and commitment to the process is crucial, so all stakeholders must be on board with a collaborative approach. The value for a multifamily project may be different than that of a commercial or health care project if, for example, the project is for affordable housing where speed is of the utmost importance to house people and families who are otherwise displaced or cost-burdened.

Modular construction works best with some level of repeatability; therefore, arriving at an optimal suite or condo layout at the schematic level of design is important.

Methods of modular construction

In general, modular off-site prefabricated elements are constructed either as volumetric components or non-volumetric components, or some combination of both. Projects may also employ a combination of modular construction and traditional site-built elements:

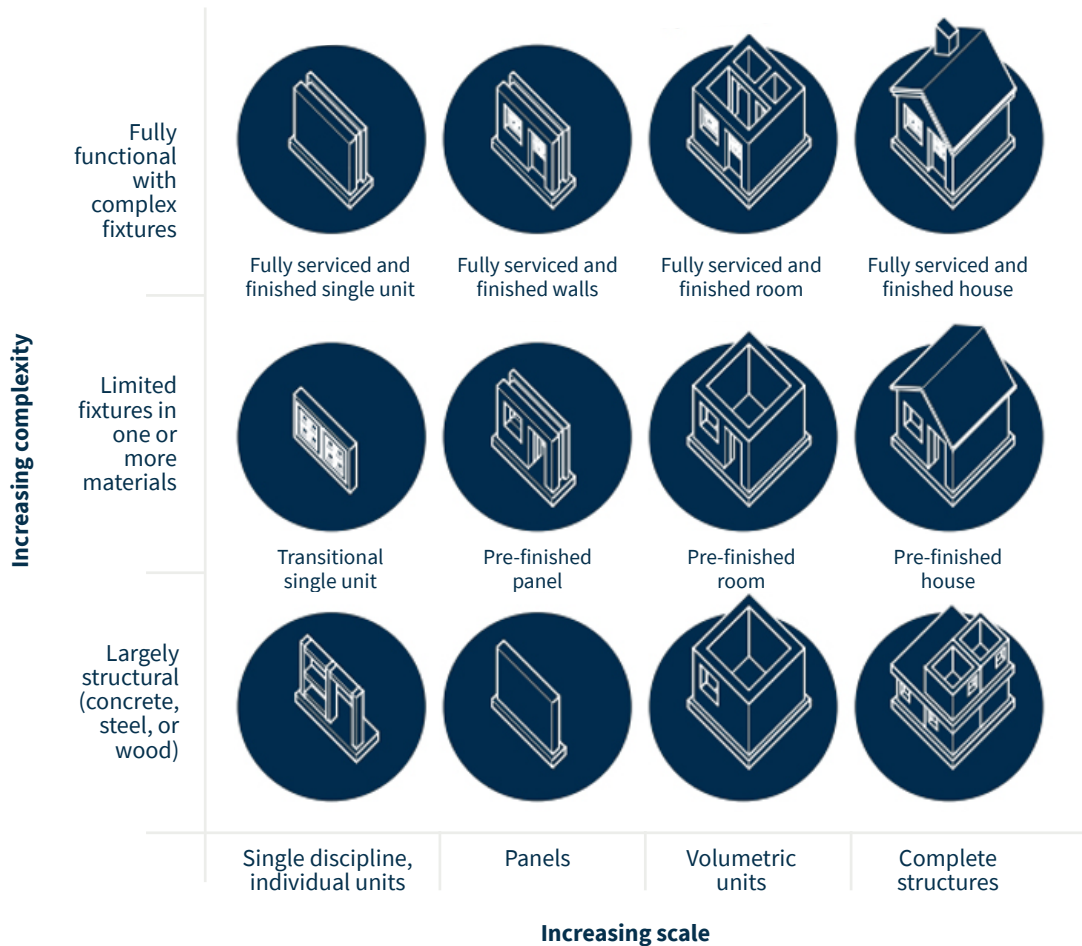
- **Volumetric (3D) modular construction** “involves the off-site pre-fabrication of individual 3D units of enclosed space that are then connected on-site to form a single building.”¹¹ This type is most often used in multifamily residential construction. Examples include pre-finished rooms or elevator cores.
- **Non-volumetric (2D) modular construction** “involves the off-site prefabrication of building elements (commonly referred to as sub-assemblies) that are then connected once on-site.”¹² Examples include wall panels, roof trusses, and sections of the building façade.
- **Hybrid (2D and 3D) construction** occurs when certain projects use a combined approach encompassing 2D panelized and 3D volumetric components. For example, a building may be constructed with completed dormitory or bathroom pods, with the rest of the building assembled via 2D components.
- **Hybrid (off-site and on-site) construction** projects may also include some components and processes constructed on-site with traditional methods and some components prefabricated off-site.

¹¹ “Design for Modular Construction,” p. 8.

¹² “Design for Modular Construction,” p. 8.

McKinsey & Company developed the below chart to detail the different methods and the resulting scale and complexity of modular projects.¹³

Complexity and scale of modular construction — comparison of approaches



Material options

According to the NIBS OSCC and the AIA, modular building components may be manufactured from a range of different materials (including steel, concrete, and wood) and can meet the requirements for Type I, Type II, Type III, and Type V construction.¹⁴ As much as 90 percent of the building systems, features, and finishes can be completed off-site prior to shipping. As a result, modular off-site construction involves a higher degree of integration than a traditional building project in the design, fabrication, and construction phases.

¹³ Nick Bertram, Steffen Fuchs, Jan Mischke, et al., “Modular Construction: From Projects to Products,” McKinsey & Company (June 2019), modular.org/documents/document_publication/mckinsey-report-2019.pdf, p. 18.

¹⁴ Building Types I – V are defined by the International Building Code and correspond to the fire-resistance of the materials used for various building elements, with Type I being the most stringent.

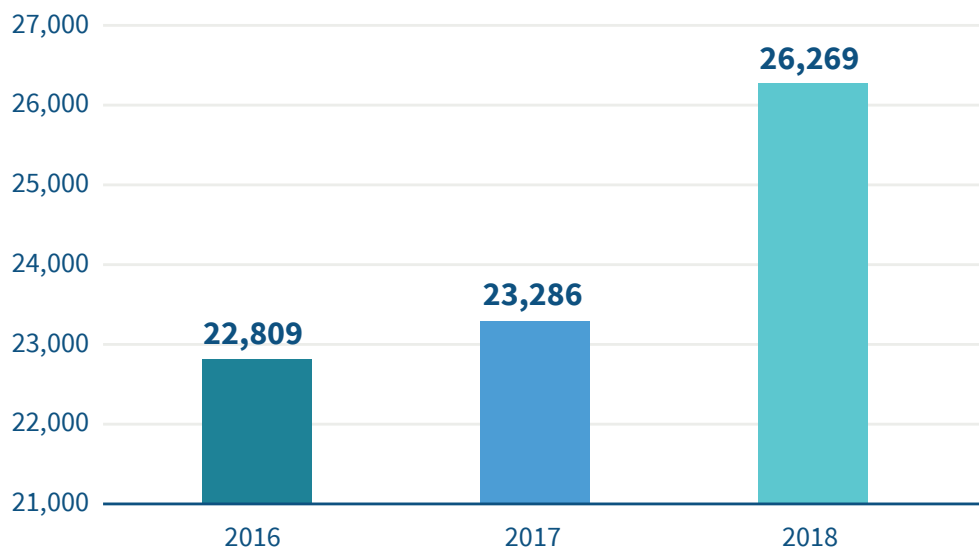
Podium base

Modular designs can be built on a slab foundation or can easily be stacked on top of site-built podiums. This is an excellent “hybrid” solution blending traditional and modular methodology and works well when expansive retail, commercial, or parking garage spaces are needed below. A multifamily mixed-use project may employ this method. Timed correctly, when the podium spaces are completed, the modules are all ready to ship to the site. This approach requires good communication and coordination between the modular builder and the general contractor if they are different entities, which can be accomplished through the implementation of a scope delineation matrix document such as the example in Appendix A.

The Modular Market Is Growing

The number of all types of commercial properties built with modular construction has been growing. To determine the size of the current U.S. market, the Modular Building Institute (MBI) obtained data from state modular administrative agencies, which are in charge of the review and labeling of PMC modules. Per the data, production of labeled PMC modules grew each year between 2016 and 2018 (see figure below).¹⁵

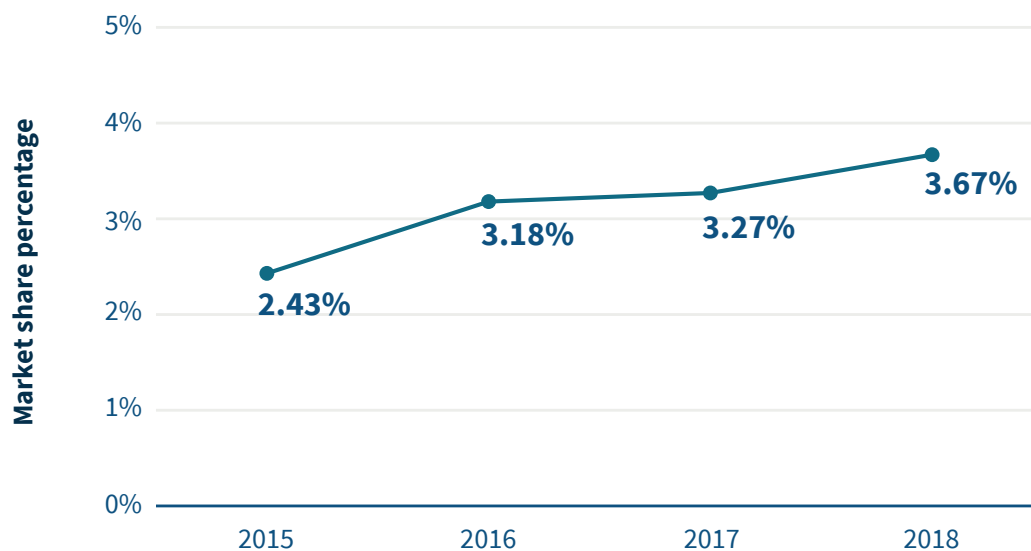
Modules produced — all commercial sectors



15 “Permanent Modular Construction Report,” p. 26.

At the aggregate level, permanent modular construction has continued to see gains in overall market share. According to data from the MBI, in six key North American market segments (multifamily housing, retail/commercial, education, health care, institutional and assembly, and office and administrative), the overall market share of PMC projects in 2018 was 3.67 percent, for a total value of all PMC projects of nearly \$9 billion.¹⁶ This represents a significant increase from 2015, which had an overall market share of 2.43 percent (approx. \$3.7 billion value).

Permanent modular construction market share



Per the MBI, the multifamily housing market was the fastest growing sector for the modular industry in 2018.¹⁷ Total production of modular multifamily housing units more than doubled from 2017 to 2018, with 2,314 modules built. Based on state-labeling data, the multifamily market accounted for approximately 8.9 percent of all industry production in 2018, up from 5 percent in 2017.

The market for modular across all sectors of the building industry is expected to continue to grow. This is due to a number of factors:

- **Demand:** There is a significant demand for new buildings on a short schedule. Many markets are facing structural supply shortages, meaning that an increase in building supply on a reduced schedule will make modular building increasingly attractive.

¹⁶ "Permanent Modular Construction Report," p. 36. (The market share percentage is derived from dividing the value of PMN projects by a three-year moving average of construction starts value.)

¹⁷ "Permanent Modular Construction Report," p. 16.

- Labor supply pressure: The building industry has a labor shortage and rising costs. As labor becomes more expensive, transitioning to modular construction allows for more cost efficient and predictable manufacturing labor to be utilized in construction. Modular construction achieves efficiencies in productivity over traditional construction due to various site and weather elements.
- Increased market acceptance/adoption and increased understanding of modular techniques and processes.
- Improving regulatory environment for modular projects. For example, the International Code Council is developing standards to support increased consistency in permitting, plan review and inspection, and ramping up educational offerings for code officials and other regulators.¹⁸
- Providing more cost certainty in projects.

Advantages to Modular Construction

When planned and executed correctly, modular construction shows some significant benefits over traditional on-site construction techniques. A survey conducted by the NIBS OSCC in 2018 indicated that the primary benefits of utilizing modular (and other off-site construction practices) were a reduced project schedule, an improved quality of the product, and more cost effectiveness.¹⁹ These and other potential advantages are explored below.

Quality

Quality control and consistency is greatly improved in the manufacturing setting through the use of precise fabrication tools, such as computer-aided design, manufacturing (CAD/CAM), and the ability to automate certain processes. This is especially beneficial “when it comes to the installation of sensitive high-tech components,” including fire safety, security systems, or sensor-based environmental controls.²⁰ Factory-produced modular components are less affected by weather and other factors present during a traditional build. Additionally, per McKinsey, modular pre-fabrication can significantly reduce rework costs, resulting in cost savings.²¹

18 “Off-Site Construction Solutions for Today’s Challenges,” International Code Council, iccsafe.org/offsite.

19 “Report of the Results of the 2018 Off-Site Construction Industry Survey,” National Institute of Building Sciences Off-Site Construction Council (2018), cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/oscc-2018surveyreport.pdf.

20 “Design for Modular Construction,” p. 13.

21 “Modular Construction: From Projects to Products,” p. 18.

In survey data published in 2020 by Dodge Data and Analytics, 90 percent of respondents reported that modular construction contributed to the improved quality of a project. Among architects and engineers, improved quality was the most commonly reported benefit.²²

Safety

Removing what is, on average, 80 percent of a construction project from the site location and transferring it to a controlled environment significantly reduces the construction hazards of a typical build by shortening on-site time, activity exposure, and hazard exposure — not just to the construction workers, but to the surrounding community. For many survey respondents, improved safety is viewed as a top benefit of modular construction. In general, modular construction results in a safer working environment for workers, due to a more controlled setting in a factory, reduced exposure to adverse weather, and other construction site dangers.²³ Additionally, work performed in the factory reduces the need for heavy machinery on-site, reducing the risk of worker injury.²⁴ Data from U.S. Bureau of Labor Statistics indicates that rates for fatal injuries are lower in manufacturing than in traditional on-site construction.

Productivity

According to McKinsey, up to 80 percent of labor activity traditionally performed on-site can be moved to an off-site manufacturing facility.²⁵ Productivity improves in the following ways:

- Per McKinsey, “The more standardized, automated, and controlled operating environment of a factory can double productivity above what can be achieved with traditional builds.”²⁶
- Additionally, according to the Bureau of Labor Statistics, “Fifty-seven percent of activities in construction are wasteful and non-value adding.”²⁷ Replacing these activities with the more efficient manufacturing process can reduce costs and schedule.

Other considerations, per the NIBS OSCC and the AIA, include reduced delays due to adverse weather and a more controlled workflow, which can all lead to increased productivity.²⁸

22 “Prefabrication and Modular Construction 2020,” Dodge Data & Analytics (2020), modular.org/documents/public/PrefabModularSmartMarketReport2020.pdf, p. 39.

23 “Design for Modular Construction,” p. 13.

24 “Modular Construction for Multi-Family Affordable Housing,” WSP (February 2018), cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/epa-modular-construction-for.pdf, p. 14.

25 “Modular Construction: From Projects to Products,” p. 14.

26 “Modular Construction: From Projects to Products,” p. 14.

27 Smith, “Off-Site and Modular Construction Explained.”

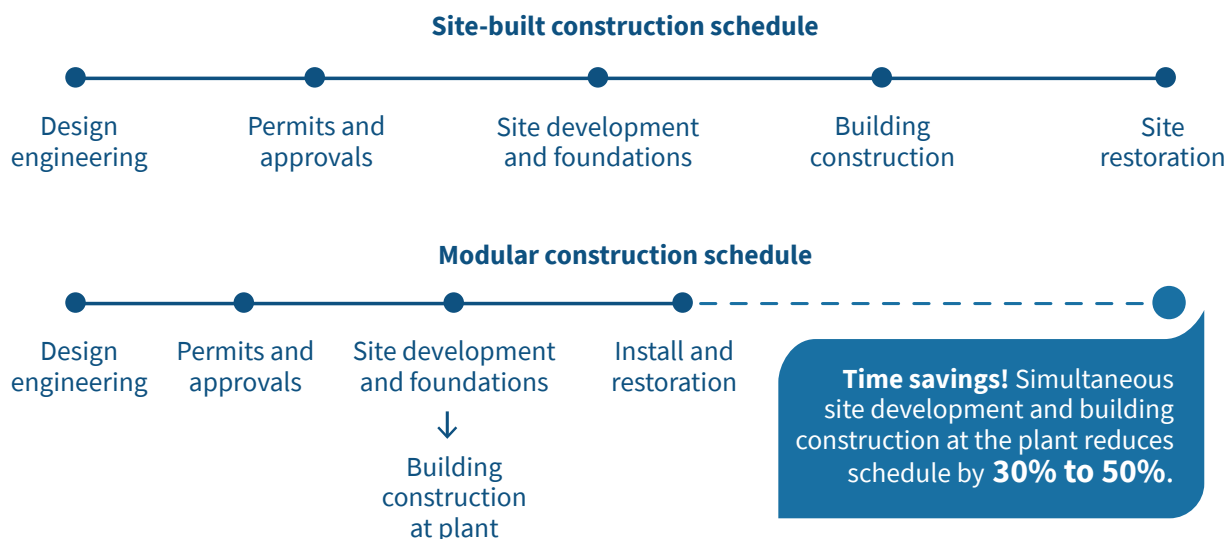
28 “Design for Modular Construction,” p. 13.

Schedule

When done properly, modular products can reduce a construction schedule by 20 to 50 percent and can “reliably accelerate projects,” per McKinsey.²⁹ These schedule advantages are due to a number of factors:

- A more predictable schedule. For example, constructing much of the building in a factory setting significantly reduces weather delays.
- The off-site manufacturing process is “far faster than the equivalent building process on-site.”³⁰ This is due in part to the factory environment and increasing levels of automation.
- While the building components are being fabricated at a plant, the site work is also happening, so that what is normally a traditional linear sequence becomes a concurrent one. This has a significant effect on the overall development timeline.
- Supply chain issues are reduced, as manufacturers may have achieved greater network efficiencies with material suppliers.
- Materials and building components are delivered “just in time,” according to when they are needed at the building site.³¹ This reduces the time spent on on-site construction.
- Reduced need for rework and enhanced quality control.

The below chart from the Modular Building Institute highlights the potential schedule savings of modular construction over traditional on-site builds.



²⁹ “Modular Construction: From Projects to Products,” p. 10.

³⁰ “Modular Construction: From Projects to Products,” p. 11.

³¹ “Design for Modular Construction,” p. 14.

Sustainability and resource reduction

Modular construction can allow for significant gains in sustainability and a reduction in the overall use of materials and other resources. Below are some of the factors that contribute to this:

- The factory setting allows for efficient control of material use, reducing waste.
- Per the AIA, much of the surplus material can be “captured and recycled back into the inventory for use on other projects.”³²
- Construction in a factory setting allows for centralized procurement and greater flexibility on sourcing for materials and products.
- Travel by laborers, fewer trucks required on-site, and other small material deliveries can reduce emissions from transportation and other sources.
- Improved operations of modularly constructed projects also impact sustainability. Improved quality of the building (such as thermal improvements or envelope performance) developed under factory conditions can improve performance and increase efficiency.
- Reusability of a modular building can extend the “cradle to grave” lifecycle. If the building is no longer needed or becomes abandoned at its current location, it can more effectively be moved with significantly more of it intact to be repurposed elsewhere, and it can be less expensive than building new.

Green building certification programs such as Green Building Initiative’s Green Globes Certification give credit toward certification for the use of prefabricated and modular building components.

Cost, cost certainty, and value

The cost comparison between a modular build and a traditional build cannot generally be measured by the cost per square foot at the time of construction. The pro formas of each approach will consider different factors:

- Modular construction will be faster than traditional, and therefore the reduced cost of construction financing must be considered in the analysis.
- Modular construction will allow a revenue-generating building to be open sooner, so the increased revenue must be considered.

32 “Design for Modular Construction,” p. 15.

- Modular construction will reduce the amount of on-site activity and time. Therefore, the cost of project management, on-site supervision, and site security will be reduced and must be considered.
- Modular construction can deliver per square foot cost savings for a project, though these savings are not guaranteed. Modular projects, with proper planning and coordination at all phases of the construction process, have yielded cost savings. However, these savings have not been consistent and often involve tradeoffs. As noted by McKinsey, the projects most likely to deliver cost savings are those that are easily repeatable and have the highest proportion of labor-intensive activities.³³ These include student housing and affordable housing.
- Cost certainty is a major contributor in the offering of modular construction. When following the “best practices and strategies” for a successful project outcome, the need for early decision making that supports the accelerated construction process will minimize or eliminate the building change orders that can cause budget overruns. It also eliminates many of the variables in pricing that can occur as a result of volatile or increased market demand in construction and the effect of those labor or sub-trade shortages and availability.

Below are some of the factors that can contribute to reduced costs on PMC projects:

- Cost savings from factory work instead of on-site work, including lower labor costs (particularly specialty labor), improved safety, resistance to adverse weather, and reduced schedule.
- Integrated processes reduce the need for subcontractors and expensive subcontractor overhead.
- Economies of scale of material stock, as orders can be placed for higher volume.³⁴
- Reduced materials and waste and increased sustainability.

Additionally, the precision and repeatability of a building constructed in a factory setting may significantly improve building performance, reducing lifecycle costs.

³³ “Modular Construction: From Projects to Products,” p. 14.

³⁴ “Modular Construction for Multi-Family Affordable Housing,” p. 11.

It should be noted that there may be instances where the cost of a project can increase when compared to conventional construction. These could include:

- When the project is not designed modular to begin with and requires re-engineering.
- If site locations cause increased road closures, transportation logistics, or restricted truck or crane access for modules.
- If decisions are not made when needed, and rework is required after production has begun.

In most instances however, any identified additional costs can either be offset by the cost benefits over the lifecycle of the project, or by following best practices established by the modular industry.

Challenges of Modular Construction

Despite the potential schedule and cost benefits made possible by utilizing modular construction, there are some challenges for those new to this process. These include both project-specific challenges as well as issues for the overall construction industry, which contribute to slowing the rate at which modular is adopted. As noted by the NIBS OSCC, “The principles of cost, schedule, labor, scope, quality, and risk represent a sliding scale of opportunity rather than definitive answers.”³⁵ It should be noted that today many of the industry challenges are a result of a lack of understanding of best practices. While the benefits are now more easily identified and understood, the “how-to” is less so and can cause hesitation in adoption or buy-in, in large part due to this lack of understanding about the process. Moreover, not understanding how to work with the modular process, which is significantly different than the conventional, can cause a modular project to fall short of the successful outcome expected by the stakeholders.

- **Increased coordination required** — Modular builds require increased coordination among the design team, the modular manufacturer, and the on-site construction management team, particularly in the early stages of the project. Per the NIBS

OSCC, “Off-site delivery and early planning are co-lateral projects.”³⁶ Though this increased coordination can be of benefit to the project, it does require early buy in and agreement from all stakeholders.

- **Greater upfront draw percentage** — The payment schedule required for modular projects requires capital earlier in the project than in traditional construction.³⁷ Manufacturers require up front capital in order to procure all materials and begin producing a design. Modular construction also does not easily allow construction lenders to assess draws based on work complete, the traditional method for providing loans during a project.
- **Regulatory overlap** — While modular project *must* be built to the same local code as traditional construction, additional requirements may result from a modular project. For example, some code agencies may require additional reviews for different project stages.³⁸ Additionally, state and local governments may have different fees and requirements for approval and transportation of modular units. While regulatory challenges are not unique to modular construction, there are some requirements specific to modular that vary from state to state, creating an inconsistent regulatory framework for the industry.
- **Technical limitations** — Per the NIBS OSCC, the below are also notable disadvantages to modular or off-site construction:
 - › Structural bulkiness: Floor-to-floor heights and wall thicknesses affected.
 - › Transportation restrictions limit module and panel size.
 - › Spans and configurations of design are somewhat restricted.
 - › Lack of transparency in overhead, profit margin, transport, setting (cranes), and associated increase in designer fees if new to the process.
 - › Flexibility and changeability of structure through future renovations becomes more difficult.

36 Smith, “Off-Site and Modular Construction Explained.”

37 “Modular Construction for Multi-Family Affordable Housing,” p. 11.

38 “The Rise of Modular Construction: Emerging Commercial and Legal Considerations,” National Institute of Building Sciences Off-Site Construction Council, cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/OSCC_Riseof-ModConstr.pdf, p. 1.

The Manufacturing and Construction Process

Traditional construction projects are typically made up of five steps:

- Design and engineering.
- Permits and approvals.
- Site developments and foundations.
- Building construction.
- Install and site restoration.

Typically, site development and foundations and building construction are performed sequentially — site development and foundations must be completed before the building can be constructed on-site. Modular techniques and processes allow for building construction to occur at the factory while the site development and foundations are completed. This can significantly reduce schedule time.

Building construction/manufacturing

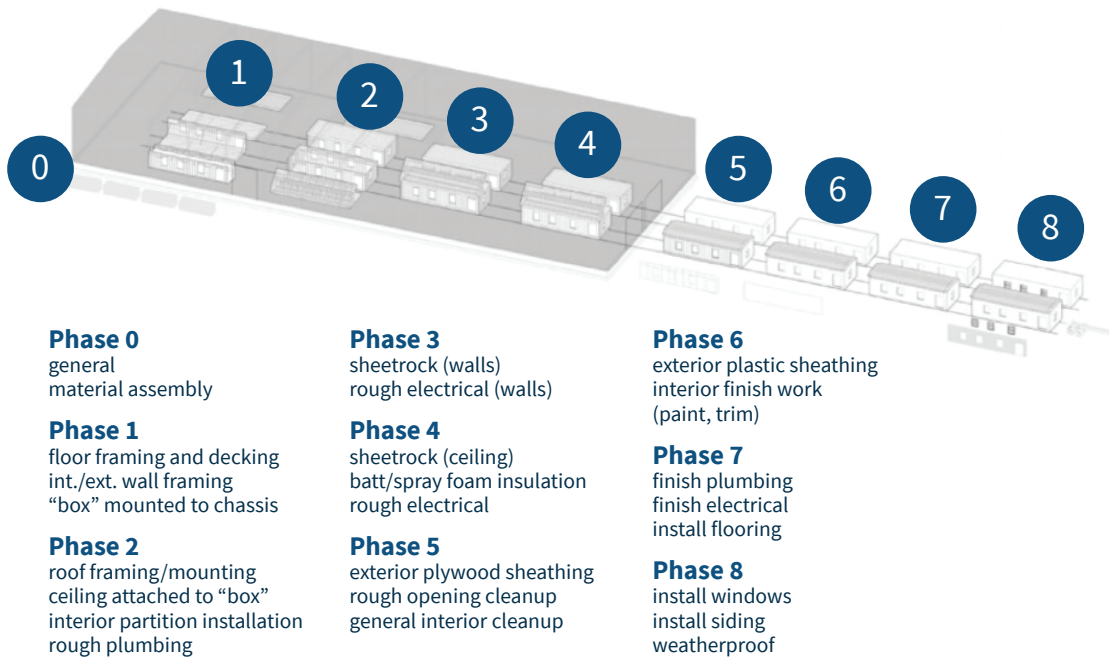
During the design phase, generally, the agreed-upon design will seek to maximize the size of the modules in order to limit the total amount to be fabricated, transported, and installed at the site. The maximum size of the modules will depend on applicable transportation regulations, which vary across states and localities and also include federal transportation rules. Per the NIBS OSCC and the AIA, “Modules typically measure between 12- to 14-feet wide, 50- to 60-feet long, and 11.5- to 13-feet high.”³⁹

Formulating and constructing the building in a factory environment are controlled by a production manager within a flow of processes and subprocesses. Often automated, the formation of building components requires enhanced utilization of information and communication technology, building information modeling, computer-aided design, and computer-aided manufacture. Off-site assemblies should be designed for manufacture and assembly utilizing “a series of standard component parts accessed from a product family architecture that can be mass-customized utilizing CAD.”⁴⁰

³⁹ “Design for Modular Construction,” p. 34.

⁴⁰ Robert Hairstans, et al., “Building Offsite: An Introduction,” UK Commission for Employment and Skills, cs-ic.org/media/1291/building_offsite_an_introductioncompressed.pdf, p. 12.

Per the AIA, “Unlike traditional on-site construction, in which the building is generally completed from the outside in, prefabricated volumetric building modules are typically constructed from the inside out.”⁴¹ The box frame of the module is completed first, with interior finish added, mechanical, electrical, and plumbing components and insulation installed, and exterior sheathing and cladding added last.



Transportation

When possible, the building team should ensure that “delivery timetables are carefully coordinated and adjusted according to the progress of the assembly process,” along with having adequate staging areas set up for delivery.⁴² The level of coordination required will of course depend in part on the size and complexity of the project. Additionally, the project team must ensure that it is in compliance with all state and local codes regarding transport and delivery, including associated fees. This is particularly true where construction and prefabrication are performed in differing localities or states. Per the NIBS, a “good rule of thumb” for distance of factory to the site is 500 miles maximum for shipping from a manufacturer to a job.⁴³

⁴¹ “Design for Modular Construction,” p. 12.

⁴² “Design for Modular Construction,” p. 36.

⁴³ Smith, “Off-Site and Modular Construction Explained.”

Stacking of modules on-site

Permanent modular construction (PMC) does not differ from traditional construction in establishing the site, including grading and drainage, soil conditioning, and utility work. As with traditional construction, the International Building Code is used to determine the type of construction. Once the foundation is established, there are different options for PMC attachments to foundation on-site (same as traditional construction).

Modular construction requires a crane to set large heavy boxes. There are two primary methods for craning modules: Use a spreader bar with belt strap slings around the belly of the modular box, or pick points on the corners of the module. In both cases, the lifting strategy needs to be accounted for in the structural design.⁴⁴

Once the modules are connected together and secured to the foundation, infill sheathing is installed at all mate lines and, depending on the level of finish completed off-site, secondary water and air barriers and exterior cladding where necessary. The level of finish applied between the plant and the site depends on the geographical region or building type. Site finish-out elements that occur simultaneously with building finish-out include drives and parking, area lighting, entrance canopies, landscaping, signage, plumbing and electrical connections, irrigation sprinklers, and low-voltage systems tests.

Roles of development team

A highly coordinated development team, and coordination with the manufacturer, is a must for modular construction deals. Having a detailed scope of work will help delineate the roles and responsibilities for each team member. The scope of work defines who does what to execute the project according to the specifications and ensures a cooperative and coordinated effort by all.⁴⁵ Appendix A is a sample scope of work (published with permission from NRB Inc.).

44 “Getting the Most Out of Off-Site Construction: Steps for Success,” National Institute of Building Sciences Off-Site Construction Council, cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/OSCC_GettingMostoutofOSC.pdf.

45 “Scope of Work Check List,” NRB Inc.

Considerations When Choosing Modular

According to the NIBS OSCC and the AIA, modular construction “has performed better on some building types, with certain building teams and in certain locations.”⁴⁶ Below are some suggested guidelines for when to choose modular:

- Projects that demand a shorter construction schedule, such as buildings that must be operation quality, or retail units that demand an increased return on revenue.
- Repetitious projects, such as identical classrooms, single-family tract housing, laboratories, office units, or high-tech facilities.
- Projects that employ unique forms, unique sustainability requirements, or a higher degree of control in the end project.
- Availability of an experienced modular or off-site construction team.
- Sites that are difficult to access for traditional on-site construction, such as remote sites or densely populated urban areas.
- Sites with limited access to affordable materials or expensive labor.
- A building locality that is accommodating of off-site building processes.
- In disaster recovery areas, modular construction can be mobilized quickly to provide people with shelter or permanent housing.

Planning for a Modular Development

The key to success in a multifamily modular deal is having a high degree of coordination among the development team and everyone involved in the development. The pace at which manufacturing moves leaves little room for error. Early decision-making is essential for things that, in a traditional site-built deal, can be decided much later in the process.

46 Smith, “Off-Site and Modular Construction Explained.”

For many markets, modular is still new and unfamiliar, so part of preparing for the development will be educating key players and stakeholders. Making the time to arrange for some meetings solely for this purpose, and even having stakeholders tour the factory, will help everyone involved feel more comfortable with modular construction.

Choosing a manufacturer

As the market in North America grows, there are more modular and off-site construction manufacturers starting up, and there are some that have existed for decades. These manufacturers serve various commercial real estate markets, including multifamily housing. Performing due diligence on a manufacturer is not unlike the process for another contributor to a development; however, their level of involvement is so great (similar to that of a general contractor or builder) that doing a thorough evaluation is essential. Due diligence for a modular project should include an assessment of the manufacturer's portfolio to see what type of work they have completed, review of the manufacturer's history and capacity, site visits to developments at various stages of completion, and a tour of the manufacturing facility to learn about the company's process.

Manufacturers offer a range of services and can provide expertise throughout the planning, design, construction, and on-site assembly processes. It is important to establish up front the scope of work of the manufacturer and the roles of all members of the development team, including coordination between the architect and manufacturer early on.

Site considerations

Site preparation for a modular development does not differ greatly from on-site construction. The developer needs to have a plan for where the modules will be delivered and staged for construction and for the positioning of the crane. The site will also need to be conducive to the delivery of the modules from the factory, so take into consideration the maneuverability of the delivery trucks at the site, the weight of the load on the streets and areas surrounding the site, and any local road weight and transportation restrictions.

Insurance and ownership

When planning for a development, establish with the manufacturer when their liability for the modules begins and ends. Ensure that the modules are covered at all stages of the process: in the factory during manufacturing, while being loaded for transport, while being transported, the unloading from trucks to the site, while the modules are on the site, and while they are being stacked with a crane. By establishing these parameters, it will be clear who is responsible for loss or damage at every moment of the development process.

The developer and manufacturer should similarly stipulate when transfer of ownership of the modules occurs, including during the transportation process — loading, travel, and unloading. There is not currently an industry standard for this piece of the modular process, so agreeing on and documenting these parameters is very important.

Budget, contracts, and financing

One of the key differences between modular construction and site-built construction is the need for a significant amount of capital at the front end of the deal. This is because the manufacturing process happens so quickly that materials for apartment finishes like paint and flooring need to be at the factory almost on day one. The manufacturer will likely require a significant deposit up front to cover the cost of the materials and other expenses.

In addition to having a contract with a general contractor, as with a site-built development, the developer will also have a contract with the manufacturer for the off-site portion of the development. In some cases, the developer may have one general contractor for the initial site work and a second for the stacking and finishing of the modules. The contract with the manufacturer will specify how progress will be assessed for the purposes of construction loan draws, or draw from an escrow account, depending on the manufacturer's preferred process.

Developers and manufacturers need to work with their lenders to work on a schedule and structure for construction loan draws that fits with the manufacturing process. This may be based on the number of modules completed and ready for shipment or some other agreed upon metric, which is outlined in the manufacturer's contract. With modular construction, counting the completed modules as they come off the production line is one option for measuring percentage completed.

State and local government planning considerations

Modular multifamily construction is required to meet all the same state, local, and regional building codes that are applicable to site-built construction. (This contrasts with single-family manufactured housing, which is required to meet standards set by the U.S. Department of Housing and Urban Development.) Most states have an agency or division that is responsible for inspections and approvals of modular buildings, often within the same agency responsible for building codes. Developers should check with their state building agency for approval requirements.

Inspections required by state and local governments will take place both on the development site and at the manufacturer. This will take advanced planning and coordination for timing so as not to disrupt the production flow at the factory.

Transportation considerations

It is important to consider the distance of the manufacturer from your work site and identify the exact route for delivery of the modules. This means accounting for tunnels, bridges, weather that may cause transportation delays, and other logistics. By nature of the process, the size of the modules is limited to what can fit on a truck, both in terms of dimensions and weight. During the planning process, review the route for weight limits and other transportation regulations.

Manufacturers vary in the level of service they provide, but many coordinate the delivery of the modules from the factory to the work site. This means having the manufacturer and general contractor doing the site work being highly coordinated in terms of timing of the completion of site work and delivery of the modules.

Best Practices in Modular Construction

Perhaps the most critical element to a successful project is an early commitment to both planning and taking all necessary steps to ensure collaboration, decision-making, and project approach are agreed to at the outset of the project. Additionally, the NIBS OSCC has developed a number of best practices that help ensure a successful modular project and assist in overcoming traditional barriers. A selection of these best practices is listed below:⁴⁷

1. Conduct pre-construction research.

- Research the industry for capability and capacity of the PMC factory.
- Identify the factory locations that are in proximity to the job site to minimize transportation costs.

2. Establish a collaborative team approach.

- The project stakeholders should use collaborative thinking and integrated design coordination.
- Effective communication, coordination, and cooperation throughout the project process are essential.

47 “Getting the Most Out of Off-Site Construction: Steps for Success.”

- The design team and modular manufacturer are co-owners of the structural building design.
- The modular builder should work with the design team to resolve potential design efficiency issues and plans to meet the accelerated schedule enabled by modular construction.

3. Timing is everything.

- Project schedules should establish a reasonable but finite time for final design, coordination, review, and approvals.
- Decisions *must* be made earlier, and the modular footprint needs to be frozen in order for turnaround times related to approvals to be shortened.
- Changes to the scope during construction should be avoided through effective communication between all stakeholders.

4. Define a clear scope of work and schedule.

- Ensure clear responsibility for each project component to ensure cooperation and a coordinated effort as well as to ensure that no gaps, overlaps, or double handling occur.
- Each PMC project must be tailored to suit the team's agreed approach, roles, and responsibilities.

5. Ensure that the appropriate project delivery method is used.

- Project delivery methods include design-bid-build (low cost), design-bid-build (value-based), project delivery CM or EPCM, and design-build.

6. Modular certification and labeling.

- Ensure that all state and local authorities having jurisdiction requirements are met. Thirty-one states have a preemptive statewide program that involves the submittal, review, and approval of building drawings for modular construction.

7. Transportation and logistics.

- As transportation regulations vary greatly from region to region, the scope document should determine who is responsible for handling modules from completion in the factory to final finishing on-site.

Case Study: The Stack

Located in the Inwood neighborhood of Manhattan, The Stack is a 28-unit, seven-story high-rise apartment building. The Stack was built in 2014 and was the first modular high-rise building in its market. The building comprises 56 volumetric steel and concrete modules.

The Stack benefits from New York City's 421a Tax Exemption program, which, in exchange for a property tax exemption, requires at least 20 percent of the units to be affordable for households at or below 60 percent of the area's median income. Permanent financing for The Stack was provided by Fannie Mae, and the deal qualified for Fannie Mae's Special Public Purpose (SPP) program due to the affordability restrictions.

In addition to providing high-quality homes for its residents, The Stack has also provided space to support Inwood's active arts community.

DEVELOPMENT TEAM

Developers:

Jeffrey Brown and Kim Frank

Architect:

Gluck+

General contractor:

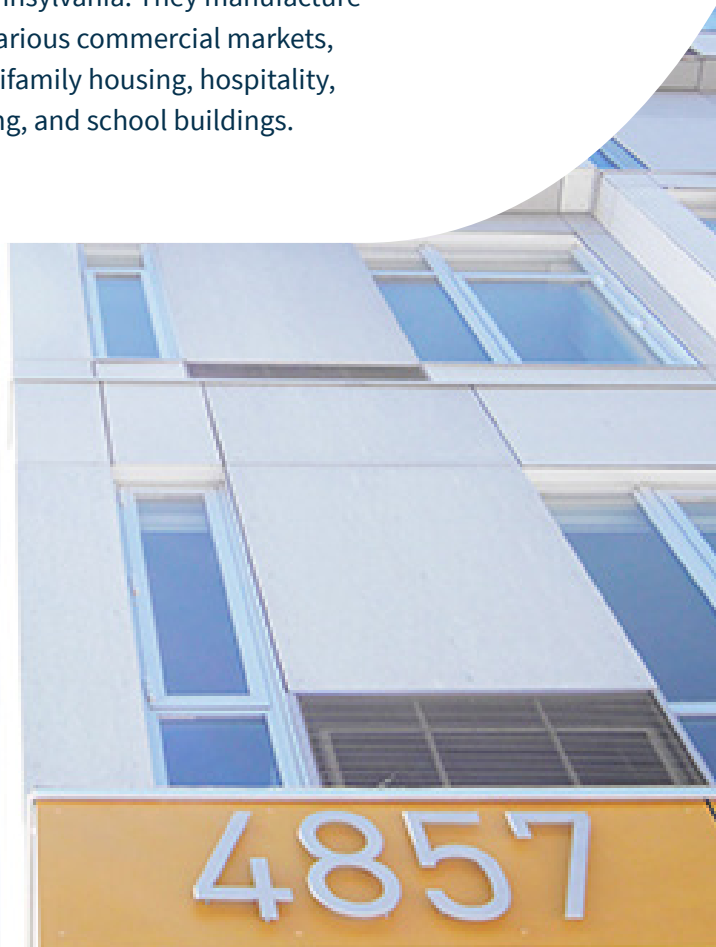
Locust Construction

MANUFACTURER

The off-site manufacturing of the modules was done by Deluxe Modular, a company based in Berwick, Pennsylvania. They manufacture buildings for various commercial markets, including multifamily housing, hospitality, military housing, and school buildings.

KEY TO SUCCESS

The key to success in developing The Stack was a highly coordinated development team. The developers, architect, and general contractor were involved in every stage of development, both on the building site and at the manufacturing facility. The entire process was extremely hands-on, and the developers/owners ended up with a very high-quality building as a result.



State and Local Governments Encouraging Modular

There are examples around the country of state and local government initiatives that incentivize and encourage the use of modular construction specifically for affordable housing. These programs can raise the profile of modular construction as one solution to the need for more affordable housing and be a learning opportunity for jurisdictions. By no means an exhaustive list, the following examples demonstrate a few different ways modular construction can be encouraged.

New York City

In its “Housing New York 2.0” plan published in 2017, New York City highlighted the use of modular construction as a way to reduce the time and cost of construction and develop much-needed affordable housing. In response to the plan, in 2018, the New York City Department of Housing Preservation and Development (HPD) issued an RFP for the design, construction, and management of a mixed-income, mixed-use, affordable housing development using modular construction. The selected project will have 167 affordable apartments.

Virginia Housing Development Authority

In its Qualified Allocation Plan (QAP) for Low-Income Housing Tax Credits, the Virginia Housing Development Authority states that tax credits can be awarded outside of their competitive process for developments that incorporate innovative construction methods to reduce construction time and cost. The QAP is not prescriptive about the type of innovative method required, but modular construction would be a good fit for this funding due to the potential for time and cost savings.

San Francisco

In 2018, the City of San Francisco committed \$100 million in funding to purchase modular affordable housing manufactured by a facility in San Francisco. The city is working with an international design firm on a feasibility study to build a new modular housing factory. The \$100 million commitment will help ensure the financial viability of the new factory while efficiently getting affordable housing units to the market.

Washington State Department of Commerce

The Washington State Department of Commerce administers the state Housing Trust Fund, which makes funds available for affordable housing products. In 2019, they issued a Notice of Funding Availability (NOFA) for affordable projects using modular construction. The Washington State Legislature appropriated \$10 million for this NOFA. The units funded through this process will serve people experiencing homelessness.

Conclusion

Modular construction is an innovative and growing technique in the multifamily market. With its potential to reduce cost and time, modular is a fitting potential solution of the many needed to tackle the affordable housing supply crisis in the U.S. Although the possibilities of modular are exciting, this construction method is still very new to most markets in the U.S., and requires significant coordination, planning, and due diligence beyond what is required for a traditional on-site construction development. As the market grows, housing practitioners and stakeholders will need to stay abreast of emerging technologies and market trends. The following appendices provide further resources on modular construction.

Appendix A: Sample Scope of Work Checklist

[Click here](#) to view a sample scope of work checklist from NRB Inc.

Appendix B: Additional Resources

“2019 Permanent Modular Construction Report,” Modular Building Institute (2019).

“Design for Modular Construction: An Introduction for Architects,” American Institute of Architects (2019), content.aia.org/sites/default/files/2019-03/Materials_Practice_Guide_Modular_Construction.pdf.

Harvey M. Bernstein, et. al., “Prefabrication and Modularization: Increasing Productivity in the Construction Industry,” SmartMarket Report, McGraw-Hill Construction (2011).

Nick Bertram, Steffen Fuchs, Jan Mischke, et al., “Modular Construction: From Projects to Products,” McKinsey & Company (June 2019), modular.org/documents/document_publication/mckinsey-report-2019.pdf.

Robert Hairstans, et al., “Building Offsite: An Introduction,” UK Commission for Employment and Skills, cs-ic.org/media/1291/building_offsite_an_introductioncompressed.pdf.

“Getting the Most Out of Off-Site Construction: Steps for Success,” National Institute of Building Sciences Off-Site Construction Council, cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/OSCC_GettingMostoutofOSC.pdf.

“Glossary of Off-Site Construction Terms,” National Institute of Building Sciences Off-Site Construction Council, cdn.ymaws.com/www.nibs.org/resource/resmgr/OSCC/GlossaryOffSiteConstructionT.pdf.

“Improving Construction Efficiency & Productivity with Modular Construction,” Modular Building Institute (2010), modular.org/marketing/documents/Whitepaper_ImprovingConstructionEfficiency.pdf.

“Modular Construction for Multi-Family Affordable Housing,” WSP (February 2018), cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/epa-modular-construction-for.pdf.

“Prefabrication and Modular Construction 2020,” Dodge Data & Analytics (2020), modular.org/documents/public/PrefabModularSmartMarketReport2020.pdf, p. 39.

“Report of the Results of the 2018 Off-Site Construction Industry Survey,” National Institute of Building Sciences Off-Site Construction Council (2018), cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/oscc-2018surveyreport.pdf.

“Scope of Work Check List,” NRB Inc.

Ryan E. Smith, “Off-Site and Modular Construction Explained,” National Institute of Building Sciences Off-Site Construction Council (August 2016), wbdg.org/resources/site-and-modular-construction-explained.

“The Rise of Modular Construction: Emerging Commercial and Legal Considerations,” National Institute of Building Sciences Off-Site Construction Council, cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/OSCC_RiseofModConstr.pdf.

Appendix C: Glossary

(All terms and definitions pulled from NIBS Off-Site Construction Council [Glossary of Terms](#), unless otherwise noted.)

Term	Definition
Building information modeling (BIM)	A digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition. (Source: National BIM Standard)
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. (Source: Louisiana Industrialized Buildings Program)
Compliance insurance industry	An architect or professional engineer, or an organization, specially qualified by reason of facilities, personnel, experience, and demonstrated reliability to investigate, test, and evaluate modular buildings; to list such buildings complying with standards; to provide adequate follow-up services at the point of manufacture to ensure that production units are in full compliance; and to provide a label as evidence of compliance on each manufactured section or module. (Source: Virginia Industrialized Buildings Program).
Component	Uniquely identifiable input, part, piece, assembly or subassembly, system or subsystem, that (1) is required to complete or finish an activity, item, or job, (2) performs a distinctive and necessary function in the operation of a system, or (3) is intended to be included as a part of a finished, packaged, and labeled item. Components are usually removable in one piece and are considered indivisible for a particular purpose or use.
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.
Erection/ installation/set	The process of blocking, leveling, and anchoring a modular building unit on the building site upon delivery.

Term	Definition
Label	Identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an approved agency and that indicates that the representative sample of the product or material has been tested and evaluated by an approved agency. (Source: IBC)
Modular building label/insignia/seal	Label affixed to a unit by the manufacturer as evidence that the building was inspected by an approved agency and meets all the applicable local code requirements.
Off-site 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. Off-site construction is characterized by an integrated planning and supply chain optimization strategy. (Source: OSCC)
Permanent modular construction (PMC)	An innovative, sustainable construction delivery method utilizing off-site, lean manufacturing techniques to prefabricate single- or multi-story 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 turn-key solution and can be delivered with MEP, fixtures, and interior finishes in less time, with less waste and higher quality control compared to projects utilizing only traditional site construction. Also referred to as volumetric construction, particularly in the U.K.
Prefabricated	The manufacture or fabrication of sections of a building at an off-site location, which are delivered to and assembled at the building site.
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.



Fannie Mae[®]

fanniemae.com

© 2020 Fannie Mae