

**NEW REFLECTIONS ON
AFFORDABLE HOUSING DESIGN,
POLICY AND PRODUCTION:**

Overcoming
Barriers
To Bringing
Off-Site
Construction
To Scale

By Ahmad Abu-Khalaf

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ABOUT THIS SERIES

The need for affordable housing is on the rise. Nationwide, more than 10 million renter households are severely cost burdened – that is, they spend more than 50 percent of their income on housing. Through our Expanding the Supply of Affordable Homes research initiative, the Enterprise Policy Development and Research team has identified the use of design and construction innovations as a particularly promising approach to help expand the supply, contain the cost and improve the quality of affordable housing development.

The housing industry has been eager to utilize innovative design, construction and production strategies, including off-site construction accessory dwelling units and 3-D home printing, to substantially improve the cost-effectiveness and efficiency of the housing delivery system. This white paper, which focuses on off-site construction strategies, is the first in a series that looks at opportunities and challenges to innovate around construction, design and production to bring those innovations to scale to help expand the supply of affordable homes and address cost challenges.

The objective of this research is to reframe the national conversation on construction and design innovations. It aims to shift the conversation from how those innovations could completely change how we build and deliver housing to how these tools can function effectively as part of the existing housing delivery system.

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INTRODUCTION

The concept of using off-site construction techniques as a tool to boost the cost-effectiveness and productivity of the housing delivery system has been recurring in the industry for decades. Generally, the national conversation on off-site construction has focused on how this construction strategy could completely reshape the housing delivery system by replacing traditional construction techniques.

Rather than taking a holistic look at how off-site construction techniques function within the broader delivery system and what can be improved, many efforts have sought to show how off-site construction promises to be a one-size-fits-all solution, solely able to address all cost- and productivity-related challenges in housing development. Writing from a policy-driven perspective focused on regulatory and financing systems, we aim to shift the conversation toward understanding how off-site construction techniques can function within the housing delivery system. To that end, we explore:

1. where the use of off-site construction techniques can boost the creation of subsidized housing and create cost savings for market-rate developers, which can help expand the supply of homes and ultimately enable homeowners and tenants to benefit from these benefits by lowering their housing costs, and
2. what kinds of changes to the regulatory and financing systems could scale the use of off-site construction. We will also identify the challenges that have been constraining efforts to bring off-site construction techniques to scale for years toward identifying ways to overcome those challenges.

Interest in off-site construction has surged among developers, affordable housing advocates, researchers and policymakers over the past 10-15 years due to a combination of factors. First, the industry has been searching for effective strategies to address the growing national shortage of housing, particularly the scarcity of affordable and workforce multifamily housing. Housing stakeholders also have been exploring the use of off-site construction as a means to improve the quality, cost-effectiveness and efficiency of residential construction. At the same time, the industry has been eager to produce more housing units over shorter periods of time, as well as overcome cost-related challenges like labor shortages. In addition, architects and designers have of late utilized a variety of materials, patterns, colors and fabrication techniques to improve and modernize the aesthetics and design of off-site residential development, breaking this construction method's stigma of being unsightly and making it more appealing to developers and consumers.

Finally, some of the nation's fabricators also are now able to utilize modern technology to improve the design, quality and efficiency of off-site construction. Various fabricators around the country have designed and implemented their own customized off-site construction prototypes and structural systems, a step that helped them address specific challenges and improve certain aspects of the design, fabrication and assembly processes. The modernization and customization of off-site construction have helped improve the public perception of this construction solution, as well as play a role in boosting the demand for off-site construction development across various markets.

Several jurisdictions across the country have been exploring ways to expand the use of off-site construction to help address affordability challenges. Here are three brief examples:

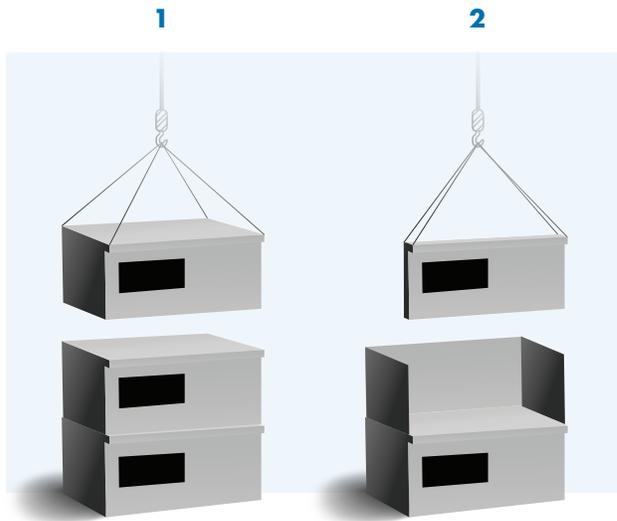
- **New York City** has released a Request for Ideas (RFI) seeking feedback from stakeholders on how to leverage modular construction to deliver affordable housing faster and more cost effectively.¹ Following this RFI, the city issued a Request for Proposals for the design, construction and management of a mixed-income and mixed-use affordable housing development on a city-owned parcel in Brooklyn, requiring the use of modular construction. The city has announced that it will partner with a fabricator and a development team to develop 167 modular units for low-income residents and individuals who are experiencing homelessness.
- **King County in Washington state** has announced three modular affordable housing developments to pilot the use of modular construction to provide more options to people seeking temporary shelter and permanent affordable housing.² This effort includes a partnership with the city of Shoreline that explores the use of modular construction for permanent affordable housing development. It is expected to result in the creation of up to 100 affordable supportive housing units with onsite case management and a health clinic.
- **San Francisco** Mayor London Breed has announced a commitment of \$100 million in city funding to purchase modular units from a new modular housing factory³ that will be built in the city in partnership with the San Francisco Building Trades. The city has selected a firm to conduct a study to ensure the financial feasibility of the modular factory that would help the city to develop its housing pipeline in a more cost-effective manner.



OFF-SITE CONSTRUCTION FOR MULTIFAMILY HOUSING DEVELOPMENT: AN OVERVIEW

While off-site construction is a fluid and broad term, this white paper interchangeably uses offsite-construction and prefabrication to refer to the production of modules or construction components at an off-site location to be assembled on-site.

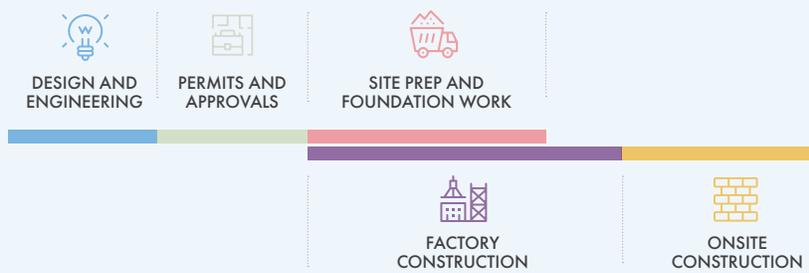
Off-site construction includes modular and prefabricated construction: 1) modular multifamily housing is developed by completing fabrication of modules at a factory or fabrication facility – each housing unit is typically referred to as a module – followed by delivery and onsite assembly processes; 2) prefabricated developments are comprised of construction components (panels) that get fabricated at a factory and then connected onsite to complete the assembly process. In addition, although mobile and manufactured homes fall under the umbrella of off-site construction, this white paper focuses on permanent, off-site multifamily construction. (See side bar, page 7)



TYPICAL SITE-BUILT CONSTRUCTION TIMELINE



OFF-SITE CONSTRUCTION TIMELINE



Using off-site construction to develop multifamily housing follows a unique timeline that can offer time-related cost savings.

The process begins with the **design and engineering phase**, which requires completing the necessary architectural and technical drawings and plans up front in a detailed manner and on a tight timeline. What is special about the design and engineering phase in off-site construction is that it requires thinking about the development in a holistic and detailed way that takes into consideration how the construction elements/panels or modules will be: fabricated (in modular construction each module gets assembled at the factory ahead of delivery); delivered to the site; assembled or stacked in the case of modular construction on-site; weatherproofed; and connected to electric, plumbing and septic systems, among other factors. Various materials can be used in off-site construction, such as steel, wood and concrete, and the level of customization offered varies from

According to HUD, a manufactured home (formerly known as a mobile home) is built to the Manufactured Home Construction and Safety Standards (HUD Code) and displays a red certification label on the exterior of each transportable section. A mobile home is a factory-built home that is built prior to June 15, 1976, when the HUD Code went into effect. Finally, HUD defines modular homes as factory-built homes that are constructed to the state, regional or local building codes.

one fabricator to another. Some fabricators offer developers more flexibility in customizing the prefabricated modules or elements, but this option typically raises the cost of fabrication and is limited by logistics like the size of the transport trailers and the structural system.

Once these drawings and plans are completed, developers seek **building permits**, which may include building, grading, plumbing, mechanical and electrical permits, for launching the **fabrication** and site work and foundation processes. Using off-site construction allows the fabrication of the elements/panels or modules, which takes place at a controlled indoor facility, to occur concurrently with the **site and foundation work**, which can accelerate the construction timeline and potentially offer time-related cost savings. These cost benefits not only can boost the creation of subsidized housing but also can create cost savings for developers, ultimately creating opportunities for homeowners and tenants. One challenge in capturing cost benefits from off-site construction is the lack of regional and market-level cost data that would enable analysts to identify and analyze accomplished savings in this strategy. (For more information on this challenge, see page 12)

Once these processes are complete, the prefabricated **elements/panels or modules get delivered** to the site for assembly. Modular construction requires paying closer attention to how the modules will be delivered (type and dimensions of transport trailers, delivery route and cost of delivery, among other factors) to the site, as well as how these modules will be protected against weather conditions and damages during the delivery process.

One of the most important phases in off-site construction is **on-site assembly**, which requires planning for logistics, such as the unloading and staging processes, the type of crane required for lifting the elements or modules, and necessary permits for ensuring that large transport trailers can access the site. Manufacturers in some cases act as the general contractor and hire local workers to conduct the project assembly process, or the developer could choose a general contractor for the on-site activities who would have to coordinate with the manufacturer. The staging process in off-site construction, particularly in modular development, is different from staging in typical construction as it requires creating strategies that would enable the delivery and assembly team to effectively and successfully unload, stage and attach the modules to the crane(s) for on-site assembly. It is important to note that in dense, urban locations, the unloading and staging processes generally follow a tight timeline due to the lack of available spacious, vacant land for staging. This requires avoiding any potential on-site issues that could cause delays and lengthen the unloading, staging and assembly (attaching the modules to the crane to lift them and stack them vertically) processes. It is important to point out that using off-site construction in urban sites can deliver valuable benefits, as it can offer a faster and less disruptive on-site construction process, which can reduce noise, traffic congestion and construction waste, compared to traditional construction techniques. In modular construction assembly, the preassembled modules are lifted by the crane and stacked vertically on top of each other (like LEGO blocks). Therefore, the on-site assembly team must ensure that the crane(s) can handle the weight of each module to successfully lift and vertically stack the modules while connecting them to each other. Following the assembly process, trade workers connect the units to the electric, plumbing and septic systems, as well as complete any necessary finishing and façade work.



OFF-SITE CONSTRUCTION OPPORTUNITIES AND CHALLENGES

Interest in utilizing off-site construction to improve the quality, cost-effectiveness and efficiency of multifamily residential construction continues to grow.

To support these efforts, we identify challenges and opportunities to using prefabrication to expand the supply of affordable homes and address cost challenges. This white paper, which was informed by a series of interviews with stakeholders, including developers, architects, fabricators and policymakers, focuses on four key elements:



FINANCING



REGULATIONS
AND LOGISTICS



DESIGN AND QUALITY



CONSTRUCTION
TIMELINE AND COST



FINANCING

OFF-SITE CONSTRUCTION

- Compared with traditional construction, often perceived as an investment with higher risk
- Generally requires at least 50 percent of the total fabrication cost upfront to cover material procurement cost

CONVENTIONAL CONSTRUCTION

- Lenders are more familiar with traditional construction timelines, and see it as less risky because they can take possession of the completed sections of development if developer fails to complete the project
- Lenders release payments in installments as construction milestones are accomplished and verified



DESIGN AND QUALITY

OFF-SITE CONSTRUCTION

- Generally requires designers and engineers to complete the planning and design process in a detailed manner upfront as fabrication requires thorough, complete drawings and plans
- Higher levels of precision, coordination and quality control required to avoid on-site technical issues, which often improve the quality of construction
- Less flexibility when it comes to carrying out on-site alterations to address technical issues during the on-site assembly phase

CONVENTIONAL CONSTRUCTION

- Designers and engineers generally have more time to finalize and complete details of the design and engineering processes as construction timeline is typically longer and starts with site and foundation work
- Offers more flexibility in making design and architectural changes during construction phase



REGULATIONS AND LOGISTICS

OFF-SITE CONSTRUCTION

- In addition to obtaining a building permit ahead of construction, developers typically required to pass factory and on-site inspections
- Majority of states require a governmental /third-party agency to complete factory inspections to ensure compliance with state codes governing off-site construction
- The assembly of developments commonly inspected by a local department to ensure compliance with local building codes

CONVENTIONAL CONSTRUCTION

- Developers required to obtain building permits from local agencies before starting construction work
- Majority of permits require one or more onsite inspections before work is considered complete and final to ensure compliance with local building codes



CONSTRUCTION TIMELINE AND COST

OFF-SITE CONSTRUCTION

- Allows for conducting site and foundation work concurrently with factory fabrication phase, which can accelerate construction timeline and offer time-related cost benefits
- Can help avoid weather-related delays as majority of construction work takes place in a controlled, indoor environment; can also reduce demand for skilled construction and trade labor
- Majority of cost benefits are in the accelerated construction timeline but permitting and approval hurdles can erase associated cost savings

CONVENTIONAL CONSTRUCTION

- Uses a linear timeline that requires the completion of site and foundation work before construction can begin
- Extreme weather conditions often delay construction phase, burdening developers with time-related costs
- Developers have reported challenges in finding skilled construction and trade workers, which can delay the construction phase and add cost-related challenges



\$ FINANCING

The financing process is generally more complicated for off-site construction, as developers often face challenges in accessing financing for modular and prefabricated housing developments.

Lenders who are not familiar with these construction methods generally see them as an investment with higher risk, which leads to more restrictive or expensive lending. These challenges are mainly driven by the location and timeline of construction activities in prefabrication. Unlike conventional construction, the majority of construction activities occurs off-site, at a factory or a construction facility, and then the fabricated modules or construction components/panels get delivered to the site for assembly toward the end of the construction timeline. Those differences can create uncertainty among lenders, making securing financing more challenging and/or requiring a substantial equity contribution.

In conventional residential construction, lenders release payments in installments (typically monthly) as construction milestones are accomplished and verified. This process limits risk in construction lending by ensuring that if the developer fails to complete construction of the project, the lender will be able to take possession of the completed sections of the building and the site and still have adequate funds to complete the development for sale. However, this process does not work for off-site construction where the fabrication phase that occurs at an off-site factory is the longest construction phase, followed by a shorter on-site assembly phase. Fabricators also typically require a large deposit upfront (typically at least 50 percent of the total construction cost) to purchase needed raw material and cover labor and overhead costs.

Generally, lenders are hesitant to release large amounts of debt upfront before they are able to track any tangible progress. This challenge necessitates identifying alternatives to traditional mortgage lending with fixed draw schedule. One example is customizing capital solutions, such as utilizing more equity and in the case of subsidized developments, public and philanthropic capital to cover upfront costs. Some fabricators understand the challenge in accessing upfront capital for off-site construction, and therefore, adjust their financial requirements and payment timeline to accommodate lenders' terms. However, this compromise can harm the financial stability of manufacturers, especially smaller manufacturers with lower financial capacity. In addition, since the fabrication of modules and construction components is typically completed on an accelerated timeline, fabricators generally require the rest of the fabrication costs within a short period of time.⁴

In addition to fabrication costs, choosing off-site construction entails transportation- and storage-related costs. While these costs are directly related to the construction and assembly processes, lenders may not take them into consideration while offering construction financing. Developers using off-site construction techniques face additional costs that arise from the delivery and assembly processes, including, but not limited to, wrapping the prefabricated modules or components to protect them from weather conditions and any possible damage, and renting transport trailers and covering the delivery costs. These costs can be more challenging when the factory and project site are located in different jurisdictions.

Moving forward, housing stakeholders can work on identifying innovative solutions to the aforementioned challenges to help boost lending for off-site construction developments. For example, lenders can hire third-party inspectors to ensure the fabrication process follows the agreed upon timeline and specifications, which would provide more certainty for lenders and possibly encourage them to release large debt installments for the fabrication process. In addition, in some markets, fabricators have been able to overcome challenges in accessing financing by offering arrangements that clarify uncertainty around the ownership of the modules or elements/panels during the fabrication process. When a fabricator assigns specific modules or components to each project (a process known as bonding), they can identify which modules and prefabricated elements belong to which project during the fabrication phase, and the title for those prefabricated components can get transferred to the developer ahead of the on-site assembly process.

Developers and fabricators can also negotiate an agreement on warranty to ensure that any loss of components or modules at the factory – due to natural or human-induced hazards – will be covered by adequate insurance. Stakeholders who are interested in boosting the use of modular and prefabricated construction, such as policymakers and affordable housing organizations, can also work with developers to identify strategies for increasing access to debt for these construction solutions. One strategy entails creating pools of private capital that can supplement construction loans by enabling developers to cover the procurement of raw material at the early stages of their projects.



DESIGN AND QUALITY

Generally, off-site construction requires higher levels of efficiency, precision and coordination throughout the design and fabrication processes.

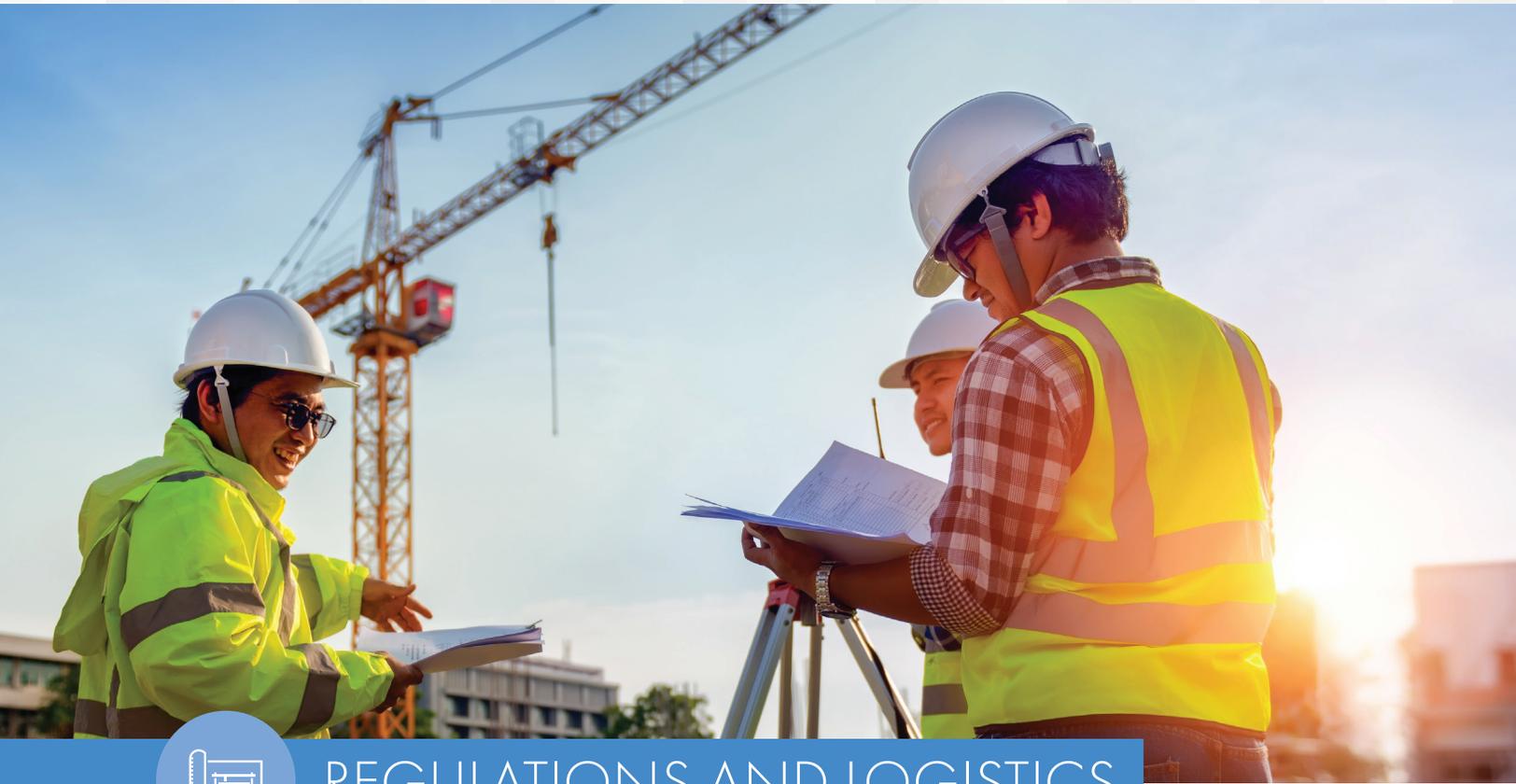
Unlike traditional construction, using modular and prefabricated construction requires architects and engineers to finalize the project's design and construction drawings in a detailed and clear manner ahead of the fabrication process while coordinating with the fabricator. This precision enables fabricators to accomplish the highest levels of quality and to avoid any future major alterations, which can be complex, costly and time-consuming. Generally, the design process in prefabrication can be challenging for architects and designers as this strategy requires completing the planning and design process upfront on a very tight timeline.

While using modular and prefabricated construction can help designers and engineers accomplish higher levels of precision and quality and minimize

construction waste, it creates unique challenges related to the flexibility of the design process. Architects and engineers often face constraints on how they can design for off-site construction developments. For example, the design process can be restricted by fabricators' standards that specify a number of components, including the dimensions of each prefabricated module or construction component/panel. In addition, designers often face restrictions imposed by several factors, such as the dimensions of the transport trailers that will deliver the modules or construction components to the site, the type of joints and tools available for assembly, the structural system, and/or the layout and the topography of the site. These factors can make the planning and design processes more complex by bringing new considerations to the table.

A guide from the American Institute of Architects and the National Institute of Building Sciences⁵ notes that using modular construction can induce some design limitations and challenges, as this strategy can inhibit manufacturers' ability to cost-effectively produce highly complex forms. Furthermore, using modular construction can result in bulkier structures, as each unit (module) has its own walls, floor and ceiling. This typically results in thicker walls and deeper floors compared to traditional construction. Unlike conventional construction, modular construction has minimum flexibility when it comes to carrying out on-site alterations to address technical issues. Therefore, it is important to plan and design modular developments with highest precision possible to avoid issues during the on-site assembly phase – in which the modules are vertically stacked and connected to each other to complete the project. These challenges include on-site alignment issues that occur when labor cannot successfully stack the modules vertically without creating gaps that can cause future water-leakage damage. Another potential on-site issue involves installing plumbing and electrical systems without causing any damage to the assembled modules. This phase is handled by trade labor after the modules get assembled on site.

Overall, upfront coordination between architects and engineers, as well as between fabricators and developers, can help improve the effectiveness, quality and precision of the design and construction processes, and therefore, mitigate on-site technical issues. The necessity of cross-team coordination may require each team to reconsider how they communicate, coordinate and collaborate with the other teams. In addition, repetition can help architects and designers identify ways to achieve higher levels of coordination and quality control to avoid on-site technical issues. Some fabricators have addressed this challenge by hiring in-house engineers and designers acting as a single design-build entity. This framework can boost the effectiveness and speed of the workflow, limiting technical issues caused by miscommunication between different teams in off-site construction.



REGULATIONS AND LOGISTICS

The regulatory framework governing the design, fabrication and assembly of modular and prefabricated developments varies from one jurisdiction to another. The majority of states have state-wide codes or programs that regulate the permitting, inspection and approval of these construction methods with various levels of flexibility and cost.

In addition to obtaining a building permit – which may include building, grading, plumbing, mechanical and electrical permits – developers of off-site construction developments are typically required to pass factory and on-site inspections. States that regulate off-site construction require a governmental or third-party agency to inspect prefabricated modules and structures at the factory to ensure that the manufacturer has followed the state’s off-site construction codes and approved design and construction drawings prior to permitting on-site assembly. Following the completion of the fabrication process, the assembly of off-site construction developments is commonly inspected by a local department to ensure compliance with local building codes.

Inspections to ensure compliance of off-site construction with state and local building codes is essential to ensuring the quality and safety of the structures. However, it is important to note that coordinating with and seeking the approval of state-level and local agencies can complicate the approval and inspection processes, extending the construction timeline and inhibiting developers from achieving time-related cost savings. Accomplishing accelerated construction timelines in off-site construction relies heavily on obtaining approvals and passing inspections within a short or at least a reasonable period of time. When states require developers to obtain permits from both state and local agencies, waiting on each agency to provide

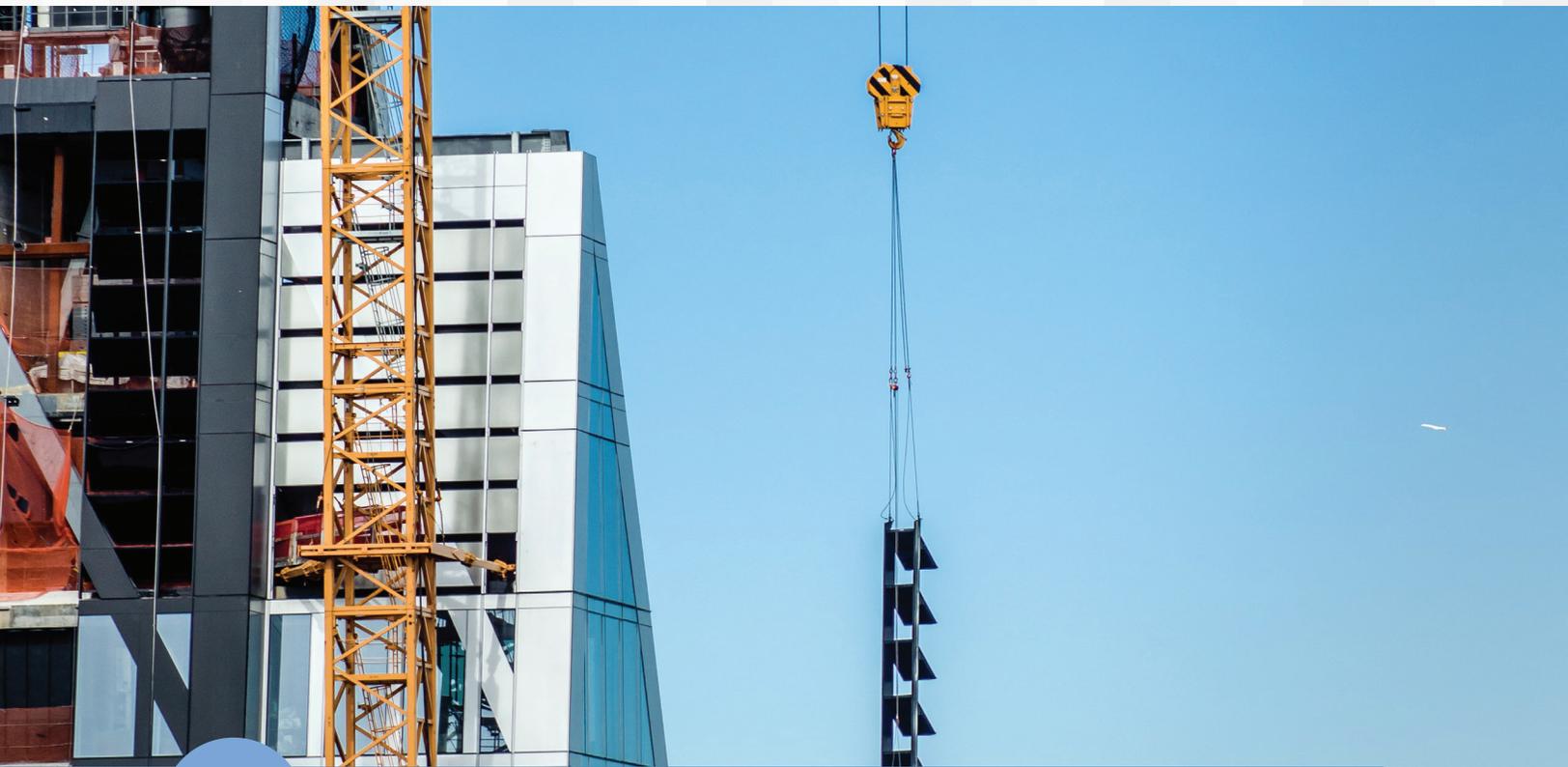
feedback and then compiling the feedback in new documents and drawings for another round of reviews can be a time-consuming task that can substantially impact the construction timeline. Generally, when local jurisdictions adopt their respective state codes or comprehensive local codes that cover the majority of the state's requirements and specifications, permitting and approval processes are typically more streamlined and efficient.

States and local jurisdictions can look into streamlining the approval and inspection processes for off-site construction developments to help developers accomplish time-related cost savings. For example, state and local jurisdictions can facilitate the use of pre-approved plans for modular and prefabricated housing to help expedite the approval and inspection processes. However, jurisdictions should avoid limiting design flexibility in the provision of a pre-approved plans for an expedited permitting process.

The factory inspection process becomes more complicated when the construction site is located in one jurisdiction and the prefabricated modules or structures are constructed at a factory located in another jurisdiction with different codes and regulations. Some states lack off-site construction factories and facilities, and therefore, any off-site construction project will require shipping prefabricated modules or elements from a nearby state or one across the country. Some states do not allow third-party inspectors to complete factory inspections, which then requires state inspectors to travel to the factory to inspect the modules. This requirement can substantially lengthen the construction timeline, especially when states have limited capacity and resources to perform factory inspections outside their boundaries.

Some developers seek to purchase prefabricated modules or elements/panels from off-shore factories for lower fabrication cost. The process, however, takes on a higher level of complexity when modules are constructed offshore, requiring innovative solutions for completing the factory inspection process. Moreover, local policymakers, governmental agencies and associations often oppose developments proposing off-shore fabrication, preferring to support local factories and fabrication facilities that generate local jobs and tax revenue.

In addition to coordinating with state and local officials to obtain permits and pass required inspections, developers of modular and prefabricated developments are typically required to coordinate with local agencies regarding the transportation and on-site storage of the modules or prefabricated components. Developers may also need to coordinate with the local department of transportation (DOT) if the temporary blockage of surrounding roads is necessary for installing large-capacity cranes on the construction site, as well as transporting, unloading and staging the modules or prefabricated components to the site. Local DOTs may also require developers to obtain vehicle-access permits to allow transport trailers to enter the project site or pass under certain bridges during the delivery process. While off-site construction can offer time- and cost-related savings, the logistics of the permitting, inspection and approval processes can create challenges that could erase desired cost and time benefits.



CONSTRUCTION TIMELINE AND COST

The cost-effectiveness of off-site construction has long been a source of debate. While modular and prefabricated construction hold the potential to reduce development costs, using these strategies does not always translate to substantial cost reduction.

The general consensus among the stakeholders we interviewed is that the majority of cost benefits are in achieving an expedited construction timeline, which can reduce soft (development) costs but does not impact hard (construction) costs. While traditional construction methods use a linear timeline that requires the completion of predevelopment, site and foundation work before on-site construction can begin, modular and prefabricated solutions allow for fabricating modules or construction components in the factory while site and foundation work is still being completed, which can help accelerate the construction timeline. In addition, the fabrication of

modules and construction components occur in a controlled indoor environment, which mitigates the effect of extreme weather conditions – such as heavy rain, snow storms and heat waves – on construction workers and construction timelines. Using modular and prefabricated construction can help developers avoid weather-related construction delays and associated costs. As previously noted, accomplishing accelerated construction timelines relies substantially on streamlined development permitting, inspection and approval processes. If a developer of a modular or prefabricated project faces regulatory hurdles throughout the

construction process, they will not be able to realize an accelerated construction timeline and thus will not benefit from any associated cost savings. While challenges in permitting and approval are not specific to off-site construction, going through an additional factory inspection and coordinating state and local requirements can induce time-related challenges that lengthen the construction timeline.

Prefabrication can also help address delays related to finding skilled construction workers, as a survey from Associated General Contractors found that 70 percent of construction firms reported having a hard time filling hourly craft positions that represent the bulk of the construction workforce.⁶ One of the promises of prefabrication is that it reduces on-site construction work and accelerates the construction timeline while minimizing the need for skilled construction labor, as the majority of the construction work occurs in the factory. It can also help provide training opportunities for newer, younger workers and better work environment for construction workers — as this construction solution does not require labor to work under harsh weather conditions, commute for long distances (depending on factory location) or follow long, irregular schedules.

However, proposals for prefabricated and modular projects typically initiate discussion between policymakers, unions and contractors as they generally raise concerns from local construction and trade unions about the number of jobs generated for their workers. Another element to consider is the application of prevailing wage requirements, including the Davis-Bacon requirements, to modular and prefabricated developments, which raises concerns among developers about the effect on the feasibility of their developments. The applicability of these requirements to off-site construction varies from one state to another. For example, while the state of Washington's prevailing wage law⁷ states that the

"offsite fabrication of non-standard items specifically produced for a public works project is considered public work," the California Department of Industrial Relations has determined that if the "subcontractor's offsite manufacturing takes place in a permanent offsite shop, it is not beholden to prevailing wages."⁸

While modular and prefabricated construction strategies can help reduce development costs by offering time and labor wage savings, there are hidden costs in off-site construction. These costs include higher transportation cost per unit volume because of the "chunking of the panels, modules, and components that are often shipped with more air than tightly packaged, on-site-erected materials and products."⁹ The transportation and on-site storage of prefabricated modules and structures also require ensuring protection against weather conditions and any possible damage from the transportation process. In addition, as discussed in previous sections, using these strategies generally requires better coordination between the design, fabrication and construction teams, which could lead to higher design fees to cover architects' and engineers' investment of time.

Currently there are no regional or market-level data that capture the cost of off-site construction, which presents challenges in identifying and analyzing cost savings in this construction strategy. Generally, developers tend to report on successful modular and prefabricated developments and are more hesitant to report projects that do not accomplish any cost savings or involve major technical challenges or schedule setbacks. Similarly, there is no data on projects that considered using modular techniques but opted for traditional construction or those that never got built at all. Overall, collecting regional and market-wide data could help stakeholders identify the construction and development factors that help realize cost savings. Data collection can identify the connections between cost savings and regional

or market-specific factors, such as common type(s) of multifamily development, permitted material and structural systems for multifamily development, construction and trade wages, availability of local fabricators, and flexibility of state and local regulatory processes governing off-site construction.

For example, a study from the Turner Center for Housing Innovation at the University of California, Berkeley,¹⁰ finds that using off-site construction in California can save up to 20 percent on the cost of construction for a three- or four-story wood frame multifamily apartment building. The availability of a state-wide off-site construction cost dataset could help analysts identify if accomplishing cost savings through

off-site construction in California can be partially explained by this construction strategy's capacity to reduce the need for skilled construction and trade workers, which can help mitigate the market's high construction labor costs, given that California's construction workers are among the highest paid in the nation.¹¹ The availability of off-site construction cost data would also help the industry examine if there are any connections between the supply of fabricators and the cost of prefabrication. There is general interest among housing developers and policymakers in the potential impact of a future rise in the number of fabricators on the cost of off-site construction development, as it could increase competition among fabricators to lower costs and boost the supply of prefabricated modules and components in the market.



KEY TAKEAWAYS

Our research offers the following six key takeaways:

OFF-SITE CONSTRUCTION IS A MEANS TO AN END

Using off-site construction is a means to an end and not the desired end, which is expanding the supply of affordable homes and containing the cost of development so that more families have the opportunity for a stable, affordable home. Using off-site construction is not always the most cost-effective and suitable strategy. Developers must take many factors into consideration when deciding if off-site construction is appropriate. These factors include the project's type and scope, site topography and layout, availability of local fabricators, flexibility of state and local codes, and potential time and cost benefits. It is important to shift the national conversation – from how off-site construction strategies could replace conventional methods to modernize and improve the housing delivery system, to how these strategies could help address the national affordability challenge within the larger housing delivery system.

COST SAVINGS ARE POSSIBLE BUT NOT GUARANTEED

Using modular and prefabricated construction holds the potential to reduce development costs, but it does not always translate to substantial cost reduction. The general consensus among housing stakeholders is that the majority of cost benefits are in accomplishing an expedited construction timeline, which can reduce soft (development) costs but does not impact the hard (construction) costs. Using off-site construction can also help developers address labor and trade shortages as it can change the needs for skilled labor. However, there are hidden costs in off-site construction, such as higher transportation costs and coordination requirements that can result in higher fees to cover the various teams' time investment. Finally, it is important to work on identifying ways to collect regional and market-wide datasets that would capture the cost of off-site construction developments. This step can help developers and policymakers examine cost benefits in off-site construction and identify the factors that help accomplish these savings.

INNOVATIVE SOLUTIONS CAN OFFSET PERCEIVED FINANCING RISKS

Financing off-site construction development is generally different from traditional construction lending, as lenders who are not familiar with these construction methods generally see them as an investment with higher risk – due to the location and timeline of construction activities in prefabrication. Off-site construction requires higher levels of upfront lending or higher equity, as fabricators typically require at least 50 percent of the total construction cost up front to purchase needed raw material and cover labor and overhead costs. They generally require the rest of the fabrication costs within a short period of time because at-factory fabrication commonly occurs on an accelerated timeline. These challenges require identifying innovative solutions to recognized challenges to help boost lending for off-site construction developments. These solutions could include hiring third-party inspectors to ensure the fabrication process follows the agreed timeline and specifications to provide more certainty for lenders, assigning specific modules or construction elements to each project to clarify any uncertainty around ownership and pre-assembly, and creating pools of private capital that can supplement construction loans by enabling developers to cover the procurement of raw material at the early stages of their projects.

JURISDICTIONS SHOULD CONSIDER STRATEGIES TO EXPEDITE APPROVAL PROCESSES

The majority of states have state-wide codes or programs that regulate the permitting, at-factory inspection and approval of off-site construction methods. Local jurisdictions typically carry out on-site inspections post the assembly phase to ensure compliance with local building codes. Since accomplishing both accelerated construction timelines and time-related cost savings in off-site construction relies heavily on obtaining approvals and passing inspections within a short or at least a reasonable period of time, jurisdictions should consider adopting innovative ways to accelerate the permitting, inspection and approval processes for off-site construction developments.

PRECISION AND COORDINATION ARE KEY

Off-site construction requires higher levels of efficiency, precision and coordination throughout the design and fabrication processes. Prefabrication generally requires architects and designers to complete the planning and design process upfront on a tight timeline. In addition, modular construction has minimum flexibility when it comes to carrying out on-site alterations to address technical issues, requiring high levels of precision and coordination to avoid facing issues during the on-site assembly phase. In prefabrication, higher levels of coordination and quality-control as well as repetition can help improve precision and quality and mitigate on-site technical issues.

MORE ANALYSIS – AND PARTNERSHIPS – ARE NEEDED

Housing advocates seeking to advance the use of modular and prefabricated construction at scale must continue to identify and analyze the challenges in off-site construction and distinguish between those that are inherent to off-site construction and those that could be reduced or eliminated. Another potential strategy for advancing off-site construction entails establishing connections and partnerships among key stakeholders in the housing industry, such as trade associations, the wood and steel industry, the green and sustainable construction industry, and construction and trade unions. Such partnerships hold the potential for the type of collaboration that could substantially advance off-site construction strategies and resolve current concerns and misconceptions among these stakeholders.

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