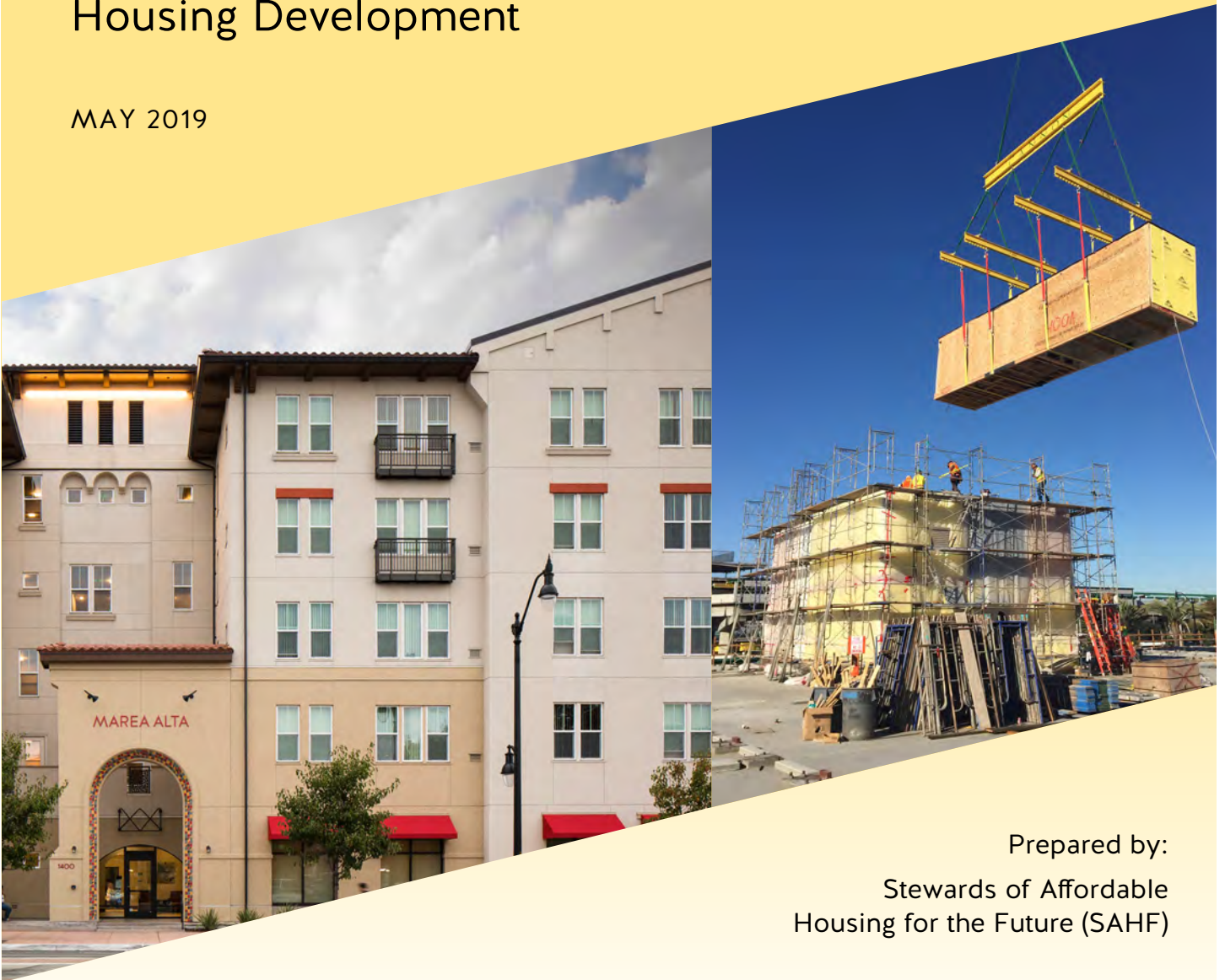


# Faster, Better, More

## Promising Construction and Technology Approaches for Accelerated and Efficient Affordable Housing Development

MAY 2019



Prepared by:  
Stewards of Affordable  
Housing for the Future (SAHF)

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*Prepared for*

**BRIDGE Housing**  
600 California St, Suite 900  
San Francisco, CA 94108  
[www.bridgehousing.com](http://www.bridgehousing.com)



BRIDGE Housing Corporation, a leader in the field of affordable housing, has 35 years of real estate development, property management, and asset-portfolio management experience. BRIDGE's mission is to strengthen communities and improve the lives of its residents, beginning—but not ending—with affordable housing. Since inception, BRIDGE has believed that an apartment with an affordable rent should be a stepping stone for advancement.

*Prepared by*

Andrea Ponsor, COO and Executive Vice President, Policy  
Adam Cohen, Policy and Program Associate

**Stewards of Affordable Housing for the Future (SAHF)**  
750 9<sup>th</sup> Street, Suite 650  
Washington, DC  
[www.sahfnet.org](http://www.sahfnet.org)



Stewards of Affordable Housing for the Future (SAHF) is a collaborative of thirteen exemplary multi-state nonprofit affordable housing providers who own more than 140,000 rental homes. SAHF members are committed to long-term affordability, sustainability and expansion of rental housing that makes a difference in people's lives. SAHF's mission is to advance the creation and preservation of healthy, sustainable affordable rental homes that foster, equity, opportunity and wellness for people of limited economic resources.

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# I. Introduction

As the nation has continued to recover from the most recent recession, housing costs nationwide have risen sharply. Increased costs for constructing and preserving housing have driven rising rents that have left approximately half of all renters paying more than the recommended 30% of their income toward rent. Among the lowest income households, more than 80% are rent burdened.<sup>1</sup> The challenges of cost and rent burden are even more severe in high-cost markets like San Francisco and Seattle, with California having the highest concentration of rent-burdened households of any state in the country. In this environment, the need for quality affordable rental housing is greater than ever, but consistent with the broader market, the cost of creating and preserving affordable rental housing units has also increased.<sup>2</sup> Increased costs pose threats to the efficacy of developers and to political support for programs that support affordable rental housing, including the low income housing tax credit (LIHTC or Housing Credit).

For more than 35 years, BRIDGE Housing has paid close attention to the double bottom line of financial and social return on investment as it carries out its mission of strengthening communities through the development of high-quality, affordable homes for families and seniors. This emphasis on impact means that BRIDGE focuses on both the quality and quantity of homes it develops, which makes cost containment an essential strategy for BRIDGE and other mission-driven housing providers. BRIDGE has led the way in exploring new approaches to constructing quality affordable homes with cost in mind and has asked Stewards of Affordable Housing for the Future (SAHF) to provide this overview of cost drivers and promising approaches to construction that may offer cost savings.

Before identifying strategies for containing costs and increasing impact, it is helpful to understand key cost drivers and how they have changed in the past decade. This paper will briefly explore cost drivers in four broad categories: land, materials, labor and regulation. While both land and regulation and their related community issues can be significant drivers of cost, this paper will focus primarily on strategies that impact materials and labor costs. We have focused on technologies and strategies that are available and potentially impactful in controlling costs in California, Oregon and Washington, but unless otherwise noted, these strategies are applicable or scalable to other markets.

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<sup>1</sup> *The State of the Nation's Housing 2018*, (Cambridge: Joint Center for Housing Studies of Harvard University, 2018),

[http://www.jchs.harvard.edu/sites/default/files/Harvard\\_JCHS\\_State\\_of\\_the\\_Nations\\_Housing\\_2018.pdf](http://www.jchs.harvard.edu/sites/default/files/Harvard_JCHS_State_of_the_Nations_Housing_2018.pdf)

<sup>2</sup> Jeffrey Lubell and Sarah Wolff, *Variation in Development Costs for LIHTC Projects* (Rockville: Abt Associates, 2018), [https://www.ncsha.org/wp-content/uploads/2018/09/Final-LIHTC-Costs-Analysis\\_2018\\_08\\_31.pdf](https://www.ncsha.org/wp-content/uploads/2018/09/Final-LIHTC-Costs-Analysis_2018_08_31.pdf).

## II. Rising Costs

The costs of constructing multifamily buildings has steadily increased in recent years, with costs for some building types having risen as much as 20 percent in just a few years.<sup>3</sup> This trend is unlikely to go away soon: indices show that from 1Q 2017 to 1Q 2018 alone, costs rose somewhere between 4 and 5.6 percent.<sup>4</sup> Affordable housing developments have not been spared from rising costs. Recent research from Abt Associates and the National Council of State Housing Agencies found that the cost of producing Housing Credit units has increased in line with the average growth of construction costs nationwide, which was about 8.4% for the period between 2011 and 2016.<sup>5</sup> Cost increases are driven by escalation in both hard and soft costs and are observed across all building types and areas of the country. However, increases are even greater in large, coastal metropolitan areas. Between January 2011 and January 2016, construction costs rose by 12.6 percent in San Francisco and 13.6 percent in Los Angeles.<sup>6</sup>

### A. Land Costs

Land costs vary widely across the nation and have been volatile over the last decade, which makes it difficult to ascertain their impact on total development costs.<sup>7</sup> Anecdotal evidence suggests that land accounts for five to ten percent of development cost on average<sup>8</sup>; however, this may be greater in coastal cities where land costs are high and there is limited developable land.<sup>9</sup> One study found that only 2.72 percent of land in San Francisco is developable, compared to 17.34 percent in San Diego, 9.08 percent in Los Angeles, 19.92 percent in Seattle and 9.67 percent in Portland, OR.<sup>10</sup> These cost increases have left many developers seeking strategies to reduce land costs, including increasing density, partnering with government entities and increasing density on underdeveloped land already in their portfolios. Policies that leverage

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<sup>3</sup> "Multifamily Construction Costs Still Escalating," Fannie Mae Multifamily Market Commentary: March 2017,

[http://www.fanniemae.com/resources/file/research/emma/pdf/MF\\_Market\\_Commentary\\_031517.pdf](http://www.fanniemae.com/resources/file/research/emma/pdf/MF_Market_Commentary_031517.pdf).

<sup>4</sup> Dees Stribling, "Construction Cost Increases are Unrelenting," *Bisnow*, June 27, 2018.

<https://www.bisnow.com/national/news/construction-development/construction-cost-increases-are-unrelenting-90067>.

<sup>5</sup> Lubell and Wolff, *Variation in Development Costs for LIHTC Projects*.

<sup>6</sup> Carol Galante, Sara Draper-Zivetz, and Allie Stein, *Building Affordability by Building Affordably: Exploring the Benefits, Barriers, and Breakthroughs Needed to Scale Off-Site Multifamily Construction* (Berkeley: UC Berkeley Turner Center for Housing Innovation, 2017),

[http://turnercenter.berkeley.edu/uploads/offsite\\_construction.pdf](http://turnercenter.berkeley.edu/uploads/offsite_construction.pdf).

<sup>7</sup> "A Lingering Housing Shortage," Fannie Mae Multifamily Market Commentary: August 2018,

[http://www.fanniemae.com/resources/file/research/emma/pdf/MF\\_Market\\_Commentary\\_081618.pdf](http://www.fanniemae.com/resources/file/research/emma/pdf/MF_Market_Commentary_081618.pdf).

<sup>8</sup> Lubell and Wolff, *Variation in Development Costs for LIHTC Projects*.

<sup>9</sup> David Albouy, Gabriel Ehrlich, and Minchul Shun, "Metropolitan Land Values,"

[http://davidalbouy.net/landvalue\\_index.pdf](http://davidalbouy.net/landvalue_index.pdf), (2017), cited in Richard Florida, "The Staggering Value of Urban Land," *CityLab*, November 2, 2017, <https://www.citylab.com/equity/2017/11/the-staggering-value-of-urban-land/544706/>.

<sup>10</sup> Pete Saunders, "Land Developability and Its Impact on Housing Costs," *Forbes*, June 25, 2018, <https://www.forbes.com/sites/petesaunder1/2018/06/25/land-developability-and-its-impact-on-housing-costs/#11f3665c5e34>.

publicly owned land for affordable housing, community land trusts and density bonuses for properties that include affordable units are among a number of strategies that may help reduce land costs or maximize the housing produced on a parcel, driving down the per unit costs.

## **B. Materials Costs**

While very recent changes in U.S. trade policy have generated increased attention to raw materials costs, studies show that material costs were already increasing prior to these changes. According to the Associated General Contractors of America (AGC) construction data, the costs of materials used in construction increased 7.4 percent over the past year. From April 2017 to April 2018, the producer price index jumped by 11.9 percent for aluminum mill shapes, 11.0 percent for lumber and plywood and 7.4 percent for steel mill products. Ready-mix concrete and gypsum products have also increased, 6.9 percent and 7.5 percent respectively.<sup>11</sup> New tariffs and quotas threaten to further push up costs for many of the steel, aluminum, and wood products used in construction. The National Association of Home Builders has identified approximately 600 products that are connected to home construction or tools used in construction that would be subject to the latest round of tariffs and estimates that the impact on housing could be a cost increase of around \$1 billion.<sup>12</sup>

Not only are the costs of raw materials rising, the costs of transporting materials for fabrication and to job sites have also increased. According to AGC data, the cost of diesel fuel increased 41.6 percent year over year and the truck transportation costs of freight have increased 6.0 percent. Diesel fuel is used not only for transportation, but also for operation of heavy equipment and generators used for site-built construction, further inflating the costs of construction. Given rising costs for both materials and transport, opportunities for cost containment may include efficient use of materials, alternative materials and design and construction approaches that minimize the transport of materials.

## **C. Labor Costs and Productivity**

Shortages of skilled labor have increased competition for a limited number of workers, driving up labor costs and creating delays in construction that create additional expenses. Between 2006 and 2011, when the recession slowed construction, the U.S. lost 2.3 million construction jobs.<sup>13</sup> As a result, the number of residential construction workers is 23 percent lower today than it was in 2006, while the number of higher-skill trade workers like plumbers, carpenters and electricians

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<sup>11</sup> "Construction Material Costs Increase 7.4 Percent as Contractors Continue to be Squeezed by Tariffs and Rising Fuel Prices," Associated General Contractors press release (Arlington, VA, October 10, 2018), <https://www.agc.org/news/2018/10/10/construction-material-costs-increase-74-percent-contractors-continue-be-squeezed>.

<sup>12</sup> Diana Olick, "Trump's latest Chinese tariffs are a \$1 billion tax on housing," CNBC, September 18, 2018, <https://www.cnbc.com/2018/09/18/lower-lumber-prices-hold-builder-sentiment-steady-for-now.html>, citing National Association of Home Builders and Wells Fargo, Housing Market Index (Washington DC: National Association of Home Builders, October 30, 2018).

<sup>13</sup> Jeffrey Sparshott, "Where Did all the Construction Workers Go?" *Wall Street Journal*, June 9, 2015, <https://blogs.wsj.com/economics/2015/06/09/where-did-all-the-construction-workers-go/>.



are down close to 17 percent. An industry-wide survey administered by AGC found that 80 percent of construction firms report having a hard time finding employees for the skilled positions that constitute most of the construction industry and that both union and non-union firms report difficulty filling craft labor positions.<sup>14</sup> The challenge is even greater in some markets: 89 percent of Washington state respondents reported challenges filling hourly positions. Nationwide more than 80 percent of all respondents also thought that in the next year it would be as hard or harder to hire hourly craft personnel.<sup>15</sup>

Despite their hiring challenges, many firms report plans for increasing hiring or expansion in the coming year. 93 percent of responding firms say they plan to hire new hourly craft personnel, with more than three quarters of respondents reporting plans to expand their headcounts. According to the survey, the five toughest craft positions to fill are pipelayers, sheet metal workers, carpenters, concrete workers and pipefitters/welders and the five toughest-to-fill salaried jobs are project managers/supervisors, engineers, estimating personnel, quality control personnel and BIM personnel.<sup>16</sup> Many developers have offered higher wages and benefits to attract new workers, but this has not been sufficient to meet demand.<sup>17</sup>

Firms are also seeking to address hiring challenges and rising costs with new methods and technologies. According to the AGC survey, 25 percent of firms report they are adopting methods to reduce on-site worktime. Methods employed include Lean Construction techniques, virtual construction tools like Building Information Modeling (BIM) and doing more off-site prefabrication. Firms also report using more labor-saving equipment, including drones, robots and 3-D printers, though uptake of new methods are higher among larger firms.<sup>18</sup>

To effectively meet the high commercial and residential demand for construction labor, the current and future labor force will have to significantly improve productivity. The improvements needed are more than just incremental. The global construction productivity rate has lagged behind other sectors growing at barely one percent per year and in the United States, construction productivity has been essentially flat since 1945. By comparison, other sectors such as agriculture, manufacturing, and retail saw their productivity rates surge by as much as 1,500 percent.<sup>19</sup>

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<sup>14</sup> *2018 Workforce Survey Results* (August 29, 2018), distributed by Associated General Contractors of America, and Autodesk,

[https://www.agc.org/sites/default/files/Files/Communications/2018\\_Workforce\\_Survey\\_National.pdf](https://www.agc.org/sites/default/files/Files/Communications/2018_Workforce_Survey_National.pdf).

<sup>15</sup> "2018 Worker Shortage Survey Analysis," Associated General Contractors of America and Autodesk, 2018, [https://www.agc.org/sites/default/files/2018\\_Worker\\_Shortage\\_Survey\\_Analysis.pdf](https://www.agc.org/sites/default/files/2018_Worker_Shortage_Survey_Analysis.pdf).

<sup>16</sup> *Ibid.*

<sup>17</sup> Over 60 percent of construction firms report they have increased base pay rates for craft workers because of the difficulty in filling positions, 24 percent have improved employee benefits for craft workers and one-in-four report they are providing incentives and bonuses to attract craft workers.

<sup>18</sup> "2018 Worker Shortage Survey Analysis," Associated General Contractors of America and Autodesk.

<sup>19</sup> Filipe Barbosa et al., *Reinventing Construction: A Route to Higher Productivity*, <https://www.mckinsey.com/~media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20through%20a%20productivity%20revolution/MGI-Reinventing-construction-A-route-to-higher-productivity-Full-report.ashx>, (2017).

Conditions and practices in the U.S. construction industry have failed to incentivize innovation and productivity. On the developer/purchaser side, the vast availability of suburban and even urban redevelopment land has helped keep overall costs low, meaning that cost-motivated calls for innovation have been few and far between. From the contractor- and construction-industry side, profit margins are relatively small, leaving little room for investment in deep or sustained innovation. Additionally, the process of subcontracting out specialized work to ensure that quality benchmarks and deadlines are met brokers risk in a way that further disincentivizes significant innovation or shifts in process.<sup>20</sup>

Rising costs and labor shortages are now creating an urgency and interest around innovation and productivity. Increasing and balancing the construction labor force is essential for efficiently meeting current and future housing needs and for broader economic stability, but this will require leveraging technology and public and private investment in infrastructure and training and will take time to accomplish. To begin impacting cost and delivery time now and to make the future workforce more efficient, the industry must also align risk and reward in a manner that incentivizes real innovation and cost savings. One opportunity to better align risk and incentivizes in Integrated Project Delivery discussed below.

## D. Regulatory Burden

Regulatory requirements can be the least tangible of costs related to the construction and preservation of affordable multifamily rental homes, but are no less significant of a cost driver. New construction of an affordable apartment complex is likely to require permits, zoning approvals and compliance with labor and wage (Davis Bacon)<sup>21</sup>, health and safety (OSHA)<sup>22</sup>, environmental (NEPA)<sup>23</sup> and accessibility requirements. Recent research by the National Multifamily Housing Council (NMHC) and the National Association of Home Builders (NAHB) found that regulations imposed by all levels of government accounts for an average of 32.1% of total development costs and in some cases accounts for more than 42% of total development cost.<sup>24 25</sup> This research found that over 90% of multifamily developers incur hard costs both in obtaining zoning approvals and again to obtain construction approval. Further, more than 90%

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<sup>20</sup> Conor Dougherty, "Piece by Piece, a Factory-Made Answer for Housing," *New York Times*, June 7, 2018, <https://www.nytimes.com/2018/06/07/business/economy/modular-housing.html>.

<sup>21</sup> See Davis-Bacon and Related Acts, <https://www.dol.gov/whd/govcontracts/dbra.htm>.

<sup>22</sup> See Occupational Safety and Health Administration, <https://www.osha.gov/>.

<sup>23</sup> See National Environmental Policy Act, <https://www.epa.gov/nepa>.

<sup>24</sup> *Regulation: Over 30 Percent of the Cost of a Multifamily Development* (Washington DC: National Association of Home Builders and National Multifamily Housing Council, 2018), <https://www.nmhc.org/research-insight/research-report/regulation-over-30-percent-of-the-cost-of-a-multifamily-development/>.

<sup>25</sup> The NAHB/NMHC survey is heavily weighted by developers who most frequently develop garden development in the suburbs (72 percent), which may not represent the dominant mode of recent development by BRIDGE, however building types and locations more relevant to BRIDGE's core markets were also included.

Mid-rise projects were the next common, with 35 percent building mid-rise developments in urban areas, and 37 percent building similar projects in inner-ring suburbs. About one-quarter (26 percent) of developers reported that they typically build high-rise apartments in urban settings.

incur costs because of delays caused by lengthy approval processes, development standards that exceed standard practice, changes to the building code and OSHA requirements.

While some regulatory requirements advance important public policy and safety goals, the NMHC/NAHB research and the experience of developers around the country suggest that greater efficiencies could be realized in balance with significant policy objectives. Notably, the research found that the development of 98% of multifamily properties required zoning approval, which accounted for over 4% of total development costs for the properties and that 95% of properties were subject to development requirements that go beyond the ordinary and comprise an average of 6.3% of total development costs.<sup>26</sup> This significant contribution to development costs suggests that stakeholders seeking to reduce costs should consider approaches that streamline zoning and development requirements.

Another potential cost driver that is sometimes related to local regulation is community opposition. While community input can be a valued and welcomed element of new development, prolonged local opposition can add costs and create delays. Local processes and regulations that encourage opposition or facilitate litigation or other delays can significantly add to development costs. The NAHB/NMHC research found that 85% of survey respondents had incurred costs and/or delays related to community opposition.<sup>27</sup> The unique nature of communities and development projects make it difficult to assess the typical cost added by community opposition and equally as challenging to develop scalable strategies to reduce opposition and costs. At a minimum, other cost containment strategies should consider factors that may help build community support.

### III. Addressing Cost

While there are numerous levers for reducing or containing costs, given that hard costs comprise the greatest portion of total development costs, materials and labor may offer the greatest and in some cases most immediate opportunities for savings. Strategies to reduce land costs and regulatory burden require significant actions by policymakers that can require significant amounts of time and vary across jurisdictions. While new approaches to construction and labor may have regulatory implications, developers like BRIDGE are able to more quickly drive innovation in materials, labor and process since these selections are typically controlled by the developer and are repeated in each transaction. For this reason, we have focused on approaches related to hard costs.

Under the broader umbrella of hard costs, labor, materials and process are often closely linked and therefore new or alternative construction methods typically yield savings or efficiencies across all three. Some of these approaches are outlined below and include a summary of how each may impact the cost drivers outlined above.

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<sup>26</sup> Ibid.

<sup>27</sup> Ibid.



## A. Offsite Construction of Housing and Components (OSC)

BRIDGE, like several other leading developers of multifamily affordable housing, has identified offsite construction (OSC) as a potential strategy for reducing construction costs and accelerating production. OSC can range from two-dimensional panelized components to nearly complete volumetric modules that are stacked and finished on-site with a range of hybrid options in between.<sup>28</sup> OSC can generate savings through reductions in materials waste and lower materials costs, as well as through time saved, which can drive down labor, financing and other costs. The potential savings will vary by the method and project, but manufacturers boast cost savings of up to 20% and time savings of up to 50%, which can drive additional cost savings.<sup>29</sup> In our discussions with manufacturers, developers and contractors, we heard that at this time the bulk of realized cost savings come from time savings rather than savings on materials or other costs. Some manufacturers anticipate that as their operations scale, more significant costs savings on materials and labor costs could be realized.

Through the research for this paper, we found that direct cost comparison between manufacturers can be challenging. To compare the costs and potential savings using different offsite construction methods, we asked multifamily manufacturers and offsite construction firms to provide pricing estimates for a sample project (Project S) located in the Los Angeles, California metropolitan area. Project S is a five story affordable residential building comprised of 80 units. The building was conceived as Type V-A construction over one story of Type 1-A podium. Project S was chosen for its relatively flat site and the opportunity for a building siting and contour that was conducive to modular. For cost comparison purposes only, firms were provided with design drawings. Most firms declined to provide even rough order of magnitude pricing. The primary challenge to obtaining estimates was the design stage of the project and how it matched with the business model of the manufacturers. As discussed throughout this paper, cost and time savings can be maximized by selecting an OSC approach prior to the completion of schematic designs. For some firms, such as RAD Urban and Sustainable Living Innovations, the project type and site of Project S were not a match for their model, which focuses on Type I and Type II construction. For more traditional volumetric modular manufacturers, including Guerdon, Factory\_OS and Blokable, the design for Project S was assessed as unsuitable for their approach or simply too far along to realize the savings and advantages of their systems or development approaches. While comparison based on Project S was not successful, we were able to identify per square foot costs for some systems and discuss these metrics below. As BRIDGE evaluates other transactions in its pipeline, there may be an opportunity for a more direct comparison by engaging manufacturers before and during the development of schematic designs.

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<sup>28</sup> See WSP, *Modular Housing Construction for Multifamily Affordable Housing*, Figure 1. <https://cdn.ymaws.com/www.nibs.org/resource/resmgr/oscc/epa-modular-construction-for.pdf>

<sup>29</sup> See appendices for advertised material and time savings costs of each manufacturer.

## i. Broad typologies of OSC

There are a range of factory built-components and modules being used in affordable housing. Three general typologies are outlined below.<sup>30</sup> In each typology, the foundation and podium as well as site infrastructure are built on-site, but some or all elements of the structure are built and inspected offsite. Profiles of manufacturers utilizing each approach with greater detail about their methods and products are included in Appendix 1 and are current as of April 2019.<sup>31</sup>

**Panelized or grid systems**, like Prescient (Appendix 1D) and Katterra (Appendix 1E), utilize grids of panels constructed and carefully designed to assemble the structure on-site. Panels are typically constructed of steel or cross laminated timber. Panelized components offer some time savings and may be easier to implement using stronger materials more appropriate for Type I high rise construction than fully volumetric modules. Panels can be flat-packed which allows them to transport more easily than complete modules, reducing costs and making it feasible to work with manufacturers in other markets. Panelized approaches may also require less staging area making them a potentially better fit for infill projects than volumetric modular. However, these systems often require more on-site assembly. In addition to time spent assembling the panelized components, on-site time is needed for completion of the interior units once erected.

**Hybrid profiles** create a partial unit, with fewer than six sides that are transported to and assembled on-site (see RAD Urban Appendix 1C). This model may offer additional time savings over a panelized approach since more construction is completed in a controlled environment and less work has to be completed on-site. Hybrid modules may also maximize height and floor area ratio limitations by reducing the double walls found in full volumetric modules. Transportation and assembly of larger units may require more time and staging area. Hybrid models may also be at greater risk of damage during transit or staging since the unit is not fully enclosed and will need to be carefully wrapped to avoid weather or other intrusions.

**Volumetric** and complete modules arrive on-site with six walls of a unit constructed (See Factory\_OS Appendix 1A and Guerdon Appendix 1B). The units are essentially stacked and the exterior finished on-site. In some systems and building types, multiple modules may be combined to create a single dwelling unit or common area. In the most complete modules, fixtures may even be included before they arrive on-site. Volumetric and complete modules are most often used in Type III modified or Type V construction, built on a foundation or podium. This approach minimizes on-site construction time, but may present design limitations and the most significant challenges in meeting inspection requirements. Fully volumetric units may also require the most staging area, at least for the short term, and the most challenging delivery logistics. BRIDGE staff have reported that despite the benefits of a potentially shorter construction time and cleaner site, this makes volumetric modular a challenging approach for infill sites where staging area is limited.

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<sup>30</sup> For a more detailed discussion of typologies, see WSP, *Modular Construction for Multifamily Affordable Housing*.

<sup>31</sup> Profiles are based on vendor marketing materials, published articles and interviews and written exchanges with vendors.

## **ii. Process**

In all of the OSC models explored in this paper, components or entire units are manufactured offsite; however, manufacturers vary in approaches to design. Most are pursuing some level of vertical integration of design and engineering services using in-house or a small field of contracted architects and, in some cases, working from a catalog of standardized designs for units. As discussed below, developers interested in exploring modular or off-site options should research the point in the schematic design process at which they must meet with manufacturers in order to arrive at a design that could still potentially utilize OSC. Both panelized and volumetric modules create some limitations on building siting and design that must be considered. The standardized designs used in many OSC models may limit OSC options for sites requiring unusual building shapes or properties with a diverse unit configuration. Once a developer has selected a manufacturer, very detailed designs are created, typically with close collaboration between design and engineering. Units or components are then manufactured. In the case of volumetric modules, units are covered with protective layers and loaded onto trucks in their full volumetric form. Once completed, they are transported to the sites, stacked on the foundation or podium that was constructed concurrent with the manufacture of the modules, and “stitched” together. Component or panelized approaches develop panels that are flat-packed, transported to site, and assembled into volumetric structures in a faster yet more traditional manner. For instance, Prescient utilizes a grid system and specialized software to develop clearly labeled components and precise instructions for assembly of components on-site.

A key consideration in any OSC project is who will serve as the general contractor and how the manufacturer will engage with them. Most manufacturers that we interviewed prefer to directly hire local assembly crews. For instance, RAD Urban’s vertical integration model includes working as the general contractor for the complete projects so that they can ensure a seamless completion of site work and smooth assembly. Similarly, Blokable is a “self-performing” system where the manufacturer also serves as the fee-based developer (for non-profits)/development partner (for profit) throughout the process. Sustainable Living Innovations has addressed the challenge of coordination by serving as turnkey developers selecting their own contractors to develop both on land identified by the customer and on parcels that SLI has selected. Other manufacturers, such as Guerdon, use a more flexible approach that may allow a developer to select their own general contractor and coordinate with the manufacturer’s team.

## **iii. Benefits and Potential Cost Savings from Offsite Construction**

In all of the typologies presented above, all or a portion of a unit of housing is manufactured in a controlled production environment with standardized processes, which offers several opportunities for savings. The table below summarizes key areas for savings and countervailing issues and is followed by a more detailed discussion of how OSC may impact many of the key drivers of construction costs.

Area for Savings	Advantages of OSC	Challenges and Potential Expense with OSC
<b>Materials</b>	<ul style="list-style-type: none"> <li>- More efficient use of raw materials</li> <li>- Innovative design and manufacturing</li> <li>- Manufacturers that are purchasing at scale and/or are vertically integrated may pass on savings</li> </ul>	<ul style="list-style-type: none"> <li>- Foundation costs may increase with added weight of modular units</li> <li>- Skin and stitching – costs of connecting modular units may increase gross cost</li> <li>- Transit from factory adds cost</li> </ul>
<b>Time</b>	<ul style="list-style-type: none"> <li>- Potential labor savings by dual tracking site work and unit construction</li> <li>- Shorter construction period reduced construction loan interest cost and opportunity costs of development staff</li> </ul>	<ul style="list-style-type: none"> <li>- Transit from factory adds time</li> <li>- Duplicative inspection processes and entitlements processes unfamiliar with OSC can add time</li> </ul>
<b>Labor</b>	<ul style="list-style-type: none"> <li>- Potentially lower wage rates in factory and consistent working conditions can reduce costs for constructing modules</li> <li>- Some systems require fewer skilled trades for assembly on site also lowering onsite costs</li> </ul>	<ul style="list-style-type: none"> <li>- Learning curve for assembly and onsite labor can erode time savings</li> <li>- Factory wage rates and use of non-organized labor can conflict with local hire and prevailing wage requirements and create mission and regulatory conflicts</li> </ul>

## 1. Materials

Several manufacturers tout relationships with suppliers as an avenue for savings. Some manufacturers, such as Katerra, are seeking to vertically integrate their supply chains to reduce costs and also control materials availability and the consistency in the type and quality of materials used. Savings in materials costs are more likely to be achieved as manufacturers reach scale and can aggregate consistent demand for materials. Some manufacturers are pursuing deeper materials savings by using international suppliers, such as steel from China, or even manufacturing modules overseas. These models can be particularly vulnerable to fluctuations in trade policy and can be politically sensitive for projects where local hire and wage requirements apply. We have generally excluded such firms from our review, with the exception of firms that we understand to be using Canadian lumber suppliers.

In the short term, some savings may be realized through more efficient use of materials. The manufacturing focus on standardization and efficiency together with limited material types and unit designs and controlled weather conditions can mean less waste in the construction process. Manufacturers, including Prescient, tout reduced materials needs due to precise engineering and manufacturing processes and less cut waste than site-built wood construction. In addition to the potential for savings on the volume of materials used, OSC may offer an opportunity to scale the use of healthy and sustainable building materials.

As noted elsewhere, our cost comparisons are based on estimates provided based on design drawings when the full cost savings and benefits of OSC may not be realized. In the comparisons, we found that materials cost efficiencies from OSC approaches for things like framing and windows were offset by other expenses like concrete when a heavier foundation was needed to support a modular design. By considering modular and panelized approaches at the concept stages, some of these cost increases may be avoided. Further, as some manufacturers grow, they anticipate that their increased purchasing power may create additional cost savings. This may be particularly true for manufacturers that are vertically integrating with their suppliers.

## *2. Labor*

By manufacturing some or all components of a building in a factory setting, manufacturers can realize significant labor efficiencies over site-built construction. A manufacturing approach can reduce the number of different trade professionals needed to complete construction using automation and by cross-training workers within a factory. Without the need for deep specialization, manufacturing firms may also be able to attract labor at lower wages. While workers in a factory setting may be paid a lower hourly wage on average, they often have work that is safer, more consistent and in a single location, which may allow them to more easily connect with transit, child care and additional educational opportunities. By employing a full-time manufacturing staff, vendors can reduce delays attributable to subcontractors who are in high demand or otherwise difficult to schedule. In the event of a demand surge, factories have the option of adding additional shifts to increase productivity. Further, manufacturing/construction performed inside the factory is not impacted by weather.

Offsite construction may also allow developers to benefit from lower construction wages in the market where the housing is manufactured. However, when manufacturing occurs in another city or state, these savings can be quickly offset by transit costs for completed units and can also raise questions for mission-oriented developers that see themselves as stewards of not only housing assets, but also of the economic opportunities that construction and development may create for the communities where they work. Moving construction work to other jurisdictions could be seen as disadvantaging the workforce in the city where the housing will ultimately be placed; however, in a tight labor market like the current environment, utilizing manufacturing capacity in other markets may help build critically needed affordable homes faster.

In some jurisdictions, including San Francisco, unions have pushed back on the use of offsite construction, particularly for projects with government funding.<sup>32</sup> While many manufacturers still use non-union labor, some including Factory\_OS and RAD Urban have negotiated with carpenters' unions to use union workers in their factories. Many OSC manufacturers that we interviewed are amenable to contracting with union labor to assemble the factory-made components on-site even if union labor is not used in their factories, but their initial cost and savings estimates do not necessarily include prevailing wage for installation crews. Agreements such as those between Factory\_OS and RAD Urban and the carpenters' unions begin to address labor concerns; however, other construction industry unions such as electricians and plumbers may continue to be threatened by potential job losses. Where funding sources apply local hiring

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<sup>32</sup> Dougherty, "Piece by Piece, a Factory-Made Answer for a Housing Squeeze."



requirements, there are open questions around how those requirements should apply to offsite construction. These factors should be considered when selecting a manufacturer.

### 3. *Timing*

Building a significant portion of a unit off-site and in a controlled environment can generate significant time savings. Not only are weather delays avoided, but developers can also benefit from concurrent site-work and avoid sequencing related delays. All projects require some amount of site preparation work such as clearing the site, addressing infrastructure needs and constructing the foundation and podium. However, in a stick-built construction project, the building cannot be framed or constructed until the site prep and foundation work is complete. Using offsite construction, those processes can occur concurrently, which can save months of construction time.

Time savings generated from OSC approaches can result in direct cost savings. With a shorter construction period, the general contractor fee should be lower and priced more accurately than in traditional methods, resulting in lower interest costs for construction financing. For Project S, assuming costs are otherwise equal, for a hypothetical twelve-month construction period, a 40% savings in time reducing the construction period to approximately 7 months could yield construction loan interest savings of approximately \$177,700 to \$213,000, based on the lowest and highest initial cost estimates.

**Project S Estimated Construction Interest Savings**

	Stick Built	Modular	Savings
Construction Loan (55% hard cost, avg 50% outstanding)	\$19,555,088	\$19,555,088	
Interest rate	5.25%	5.25%	
Construction (months)	12	7	
Stabilization (months)	6	6	
Total Interest	\$1,026,642.11	\$812,758.33	\$213,883.77

Savings resulting from a faster delivery aren't limited to interest costs; materials costs are also less likely to rise during a short construction period. Therefore, a faster construction time may offer a competitive advantage for developers in securing a site or funding for development. Finally, a shorter and less disruptive on-site construction process may help with public support and community opinion since disruption to neighbors will be shorter lived.

### 4. *Land Costs*

On its face, offsite construction does not save in overall land costs; in fact, some volumetric modular approaches may use height and floor area ratio in a less maximizing way. However, during the construction process, land needs for staging areas may differ. Modular may require more staging area, but for a shorter period of time. Given that a significant amount of the cutting and constructing is completed off-site, dust, noise and construction debris are reduced.

These benefits lessen the impact on close neighbors and could make off-site construction a particularly attractive solution for infill projects if the staging area needs can be addressed.

## *5. Regulatory*

As discussed below, off-site construction may introduce some new regulatory challenges and does not necessarily eliminate any existing regulatory cost drivers. However, as manufacturers meet scale and develop designs that satisfy local requirements, there may be efficiencies in standardized designs and inspection processes that could generate modest cost savings.

### **iv. Challenges and Considerations for Offsite Construction**

While off-site construction offers potential savings in time and cost, it also presents some challenges for developers that will have to be addressed before its use can reach scale and the full potential savings realized. Below is a discussion of some of these key challenges.

#### *1. Design and Timing*

Modular construction, particularly hybrid and volumetric models, work best in buildings with modular-specific designs, which may be limited in their configurations on sites of unusual shape or topography. BRIDGE and other developers have reported that if schematic designs are fully developed and then bid as both stick-built and modular construction, the full efficiency of modular construction is typically not achieved. We observed this in the side by side comparisons of stick-built and both volumetric modular and Prescient's steel grid system. (see Appendix 2B) For sites where developers are interested in exploring both traditional and off-site construction methods, identifying the design threshold at which different methods (i.e. traditional vs. OSC) and options (i.e. panelized vs. modular) should be assessed will be important. As discussed above, some manufacturers are pursuing an integrative design approach to maximize efficiency. These approaches assume that the project is designed as modular from inception. For projects that will explore both conventional and off-site construction, it has been suggested that the schematic designs should be presented to manufacturers for bid no later than 50% of the schematic design point.

#### *2. Capacity and Capitalization of Manufacturers*

At the moment, the production capacity of OSC manufacturers is a significant limitation. While there is growing interest in off-site construction, there are relatively few manufacturers and they are limited in the number of units that they can produce due to capital, physical and labor constraints. As discussed below, financing can be a significant challenge since manufacturers need funding for materials and labor costs up front. This means that manufacturers typically require up to 50% of costs up front, a large deposit that is at odds with traditional affordable housing lending practices where funds are advanced on a draw basis as work is completed. Even with a large deposit, manufacturers are still spending to cover materials and labor costs far in advance of when they will be paid in full for construction transactions. This payment lag can easily deplete working capital and jeopardize the manufacturer's stability. This mismatch in payment timeline contributed to the demise of manufacturer ZETA Design + Build, one of the first

modular home manufacturers that closed shop in 2016.<sup>33</sup> Further, this significant working capital needed may limit a manufacturer's ability to make capital investments that increase capacity as demand rises. As interest in OSC rises and models are refined, many of the manufactures profiled in the appendices have succeeded in significant capital investment to help facilitate growth and consistent operations.

The location of OSC manufacturers also matters. Beyond adding transportation costs, off-site factories that use off-site labor in external jurisdictions may pose moral and political challenges for policymakers and mission-oriented developers. On the other hand, in high cost areas like San Francisco and Seattle, wages and retention rates for employees may make it difficult to expand to the needed capacity.

### 3. *Transit*

In addition to transportation costs associated with shipping completed units or panels from the factory to the building site, transit logistics can limit the size of module that can be used and can create additional damage or weatherization risks. If units are not properly wrapped and protected during transit and while awaiting installation, rain and other elements can cause significant damage to the shell and interior of the unit that may not be covered by insurance. Further, while panels or units can be delivered as they are needed for installation, coordinating delivery of dozens of truckloads of panels can be an added logistical challenge, especially in population dense or traffic-congested areas. Given the size of the components and modules, street closures may be required, which can be costly and erode community support. Further, their size means that even a few days' delay on-site can require significant staging area. Use of a more local manufacturer and an integrated contracting team may help reduce the risk during travel and the potential staging time, but this must be carefully managed in any project.

### 4. *Financing*

The need for up front capital is a significant challenge for off-site construction of affordable multifamily housing. Manufacturers need a significant portion of their fees up front to order materials, support design work and reserve a place in their schedule. If the manufacturer fronts these expenses and experiences the long lags that are common with affordable housing, they risk their own financial viability. On the other hand, assembling up to fifty percent of manufacturing and design costs early in a project is challenging for developers. Traditional construction lenders are accustomed to advancing funds on a draw basis for work that is completed on-site, where the lender is able to inspect progress and where its security interest is clear. With OSC, it is more difficult to assess the level of work completed and potentially more challenging to perfect the lender's security interest in the unit. Where possible, self-financing can ameliorate some of these issues.

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<sup>33</sup> Galante, Draper Zivetz, and Stein, *Building Affordability by Building Affordably: Exploring Benefits Barriers and Breakthroughs Needed to Scale Offsite Multifamily Construction*.

As OSC becomes more commonplace, lenders and developers are identifying new approaches for financing construction of the units. One lender is reportedly using web cameras to inspect or monitor progress on an affordable housing property during manufacturing. The Turner Center has proposed other solutions including digital tracking of materials and lender underwriting based on the overall capitalization of the manufacturer.<sup>34</sup> While the sector emerges, there may also be a role for philanthropy in providing an enhancement or guarantee to help address the perceived risk during manufacturing. State or local governments can also play a critical role in helping to create solutions, particularly where the manufacturer is located in the same jurisdiction as the ultimate location of the units.

## *5. Insurance*

Evolution is also needed in the insurance sector in order to fully scale the use of OSC. Insurers with limited experience in OSC may limit or exclude builders' risk (course of construction) coverage for units during the course of manufacture and transit. Negotiating sufficient coverage is a key consideration in identifying a manufacturer and assembling financing sources. Both lenders and owners that self-finance their investments will want coverage of the units and their investment.

## *6. Entitlements, Code/Inspection*

Another significant challenge to realizing the full potential time savings of off-site construction is the code and inspections process. Off-site construction may be subject to both state and local codes, in addition to any standards required under financing programs through the Federal Housing Administration or state housing finance agency. In jurisdictions where multifamily modular has not been used, developers report delays in zoning approvals and permits as local officials get comfortable with new approaches and technologies. Zoning, permitting and other reviewing officials may request changes or modifications that aren't consistent with the constraints of modular design or that would reduce or eliminate the time or cost savings. Building code inspectors typically want to inspect at different stages throughout construction to ensure that systems are properly functioning and installed. This is not always practical in a manufacturing context where assembly may happen quickly and, in some cases, the units or components arrive on-site with walls closed and mechanical, electrical and/or plumbing components inside and in some cases units substantially complete.

In California, OSC – both at the factory and on-site– is regulated by the state Department of Housing and Community Development while the foundation podium, roof, building skin and any site-built components are still regulated and inspected at the local level. This dual regulatory structure requires two sets of drawings and permits, imposes two sets of requirements and two inspection timelines. Most manufacturers that we interviewed with experience in California indicated that the dual regulatory structure was navigable and that the state's third party inspectors are knowledgeable of OSC approaches. In states that have devolved regulatory and inspection authority to the localities, processes may be less standardized and more education of local officials may be required.<sup>35</sup> It is critical that all local officials with inspection and approval

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<sup>34</sup> Ibid.

<sup>35</sup> Rock, Mike (Construction, Katerra), Interviewed by Andrea Ponsor, (December 2018).

authority understand that the offsite and manufactured nature of modules and panels mean that modifications after construction, including improvements for accessibility or conformance with local requirements, may be infeasible. All parties must carefully collaborate to thoroughly review and approve designs and any initial construction prototypes to avoid significant delays or other issues with changes after modules are delivered. Standardization of processes and development of best practices at the state and local level could help expedite the inspection process in states with both centralized and devolved regulatory structures. States and localities should also clarify the process for inspecting units or components manufactured out of state.

## **B. Alternative Materials and Components – Mass Timber and Tall Timber**

Broader use of more cost effective and sustainable wood materials and components may offer another opportunity for cost or time savings without some of the limitations and challenges of OSC. Potential code changes and a growing body of experience with mass timber products in North America may make next generation wood products the next frontier for cost savings and more sustainable design. Mass timber is a category of framing styles that typically uses large solid wood panels for wall, floor and roof construction. The term mass timber is often understood to include Heavy Timber, which is where wood is used instead of steel or concrete as the structural component in type IV construction, as well as solid sawn timber, glue-laminated members, and composite wood members. Mass timber also includes engineered products such as cross laminated timber (CLT), which are not yet referenced in the International Building Code (IBC).<sup>36</sup> Unlike the light wood frame construction commonly assembled on-site in Type III and Type V construction, mass timber is often built into components off-site and then assembled on-site.<sup>37</sup>

### **i. Tall Timber**

Much of the current interest in mass timber focuses on high rise construction. Currently, the IBC limits heavy timber construction to 85 feet without special approvals and the code guidance around other mass timber elements can be a patchwork that requires special approvals or alternative approaches. In response to rising construction and housing costs, as well as concerns about the carbon impact of construction and the built environment, there is increased interest in high rise wood construction as an efficient and lower carbon impact approach to construction. However, given limitations in the IBC and local building codes, there are few examples of tall timber buildings in the United States and we have not identified any completed examples of affordable housing produced as tall timber. In Appendix 3, we have profiled a residential and commercial timber building, as well as Framework, a planned wood skyscraper in Portland that has been put on hold because of financing challenges. Tall timber is increasing in popularity in

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<sup>36</sup> Michael Kilkelly, "Support for Tall Timber Reaches New Heights in the Building Code," *Architect Magazine*, October 25, 2018, [https://www.architectmagazine.com/technology/support-for-tall-timber-reaches-new-heights-in-the-building-code\\_o](https://www.architectmagazine.com/technology/support-for-tall-timber-reaches-new-heights-in-the-building-code_o).

<sup>37</sup> Think Wood, "Light-Frame Construction," <https://www.thinkwood.com/products-and-systems/light-frame-construction>.



British Columbia and is frequently used in Australia and New Zealand. In Australia, the largest residential timber building is affordable rental housing.<sup>38</sup>

## ii. Types of Mass Timber

Enthusiasm around mass timber stems from the strength and stability of some mass timber products, which allow developers to push the perceived boundaries around building height and other characteristics for wood construction. Recent successful projects include a combination of the following mass timber products to achieve structural and design goals in balance with cost and sustainability concerns.<sup>39</sup>

### **Cross-Laminated Timber (CLT)<sup>40</sup>**

CLT is comprised of three, five or seven layers of dimension lumber that are oriented at right angles to one another then glued to create structural panels. Because it is cross laminated, CLT offers two-way span capabilities. CLT products are well suited to floors, walls and roofs. CLT Panels can be manufactured in custom dimensions. CLT products are recognized under the IBC, though currently structural use of CLT may require additional approvals under the IBC's alternative methods provisions. CLT is approved for use on structures under six stories in approximately 30 states.

### **Nail-Laminated Timber (NLT or Nail Lam)**

NLT is created from individual dimension lumber members (2x4, 2x6, or 2x8) stacked on edge and fastened with nails or screws. NLT has been used for over one hundred years for floors, decks and roofs. It can be used for a variety of aesthetics as well as for wood structural panels. NLT has also been used to create elevator and stair shafts in mid-rise buildings. NLT can be created through on-site carpentry or through prefabrication. When prefabricated, panels are typically produced in sizes up to ten feet wide and sixty feet long.

### **Glue-Laminated Timber (Glulam)**

Glulam is composed of individual dimension lumber selected and positioned based on performance characteristics then bonded together with adhesive. The grain of glulam runs parallel to length of the member. Glulam offers excellent strength and stiffness making it well suited for beams and columns. It can also be used for panels with curvature or unique geometry.

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<sup>38</sup> See <https://www.thefifthstate.com.au/innovation/residential-2/australias-largest-residential-timber-building-is-an-affordable-housing-project/>. For profiles of additional mass timber buildings, see Think Wood project gallery at <https://www.thinkwood.com/project-gallery>.

<sup>39</sup> For an excellent overview, see Mass Timber in North America at <https://continuingeducation.bnppmedia.com/courses/think-wood/mass-timber-in-north-america/>.

<sup>40</sup> For more information on CLT, see the US CLT handbook, available on the Think Wood website, <https://www.thinkwood.com/products-and-systems/clt-handbook>.

### **Dowel-Laminated Timber (DLT)<sup>41</sup>**

DLT is the first all wood mass timber panel. It is similar to NLT, however, DLT uses wood dowels to join laminations instead of nails or screws, which makes it easier and safer to mill and route. DLT allows for significant architectural flexibility and is well-suited for horizontal spans. Because its grains run in one direction, it is best suited for flooring and roofing applications.

### **Structural Composite Lumber (SCL)**

SCL is created by layering dried and graded wood veneers, strands or flakes with adhesive into blocks of material, which are resawn into specified sizes. SCL includes laminated veneer lumber and laminated strand lumber, which can be manufactured as panels up to eight feet wide and in varying thickness.

### **Wood-Concrete Composite**

For high rise construction, hybrid wood-concrete approaches are available. Most of the material types described above can be coated in concrete to create a composite.

## **iii. Advantages of Mass Timber**

Mass timber components are already in use in many construction projects, but given changing codes around the use of mass timber products and their component role in many project, the full extent of any cost savings is unclear. However, mass timber offers a host of structural, aesthetic and environmental benefits that may also offer direct and indirect cost savings, particularly as these products become more commonplace and efficiencies of scale are achieved.

### *1. Strength and Weight*

Mass timber can produce strong and lightweight structural components. The lower weight can mean smaller foundation requirements and lower forces for seismic resistance since the seismic force is proportional to the weight of the building. These flexibilities can reduce costs and complexity of construction.

### *2. Construction Efficiencies*

Principals involved in mass timber projects consistently report efficiencies in mass timber construction of 30 to 40 percent faster than comparable concrete construction, thanks in large part to prefabricated components.<sup>42</sup> For example, in the T3 building (Appendix 2b), the wood

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<sup>41</sup> For more information on DLT, see DLT Profile Handbook + Design Guide at <https://structurecraft.com/blog/dlt-design-guide>.

<sup>42</sup> Think Wood, "Mass Timber Conference Recap: The Economics of Mass Timber," June 27, 2018, Mass Timber Conference 2018, <https://www.thinkwood.com/news/mass-timber-conference-recap-the-economics-of-mass-timber>.

structure took only 9 days per 30,000 square foot floor to erect.<sup>43</sup> One expert, Bernhard Gafner of Fast + Epp, estimates that the panelized nature of mass timber results in up to 90 percent less construction traffic and 75 percent fewer workers on-site. These factors may make mass timber, like other panelized approaches, a good option for urban infill sites.<sup>44</sup>

### *3. Design Efficiencies*

In projects where the warm aesthetic of an exposed wood interior is desirable, mass timber products like CLT and glulam can serve as both structural elements and finished interior surfaces. This can generate efficiencies during construction and save costs.

### *4. Sustainability*

Proponents of mass timber also note its sustainability advantages over steel or concrete. In addition to wood being a renewable resource, a Life Cycle Assessment of CLT and other mass timber products' carbon footprint also shows a lower carbon impact than concrete or steel.<sup>45</sup> Mass timber products such as CLT can create airtight envelopes that are well suited for efficient approaches like Passive House. Wood construction can also be insulating and reduce cooling costs.

## **iv. Regulatory Landscape**

As noted above, under the current IBC, heavy timber construction is currently limited to a height of 85 feet.<sup>46</sup> The IBC would permit taller wood structures if the architect demonstrates that the design meets the prescribed code and performs as well or better than a similar concrete or steel structure. The IBC serves as a model code for most jurisdictions, which may have additional requirements.

The International Code Council (ICC), which develops and administers the IBC, formed a committee to explore tall timber construction and propose changes to the 2021 IBC. The committee focused on concerns around the combustibility of wood and conducted testing. Based on its work, the committee made a number of proposals for the IBC, including the introduction of three new construction types that connect mass timber construction to allowable building heights of up to 270 feet.<sup>47</sup> According to reports of unofficial voting results, the proposals were approved in December 2018, but won't take effect until 2021 and it may take several years for

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<sup>43</sup> Think Wood. 2017, "Mass Timber in North America," <https://www.thinkwood.com/our-ceus/mass-timber-north-america>.

<sup>44</sup> Ibid.

<sup>45</sup> Azadeh Fallahi, "Innovation in Hybrid Mass Timber High-Rise Construction: A Case Study of UBC's Brock Commons Project," *University of British Columbia* (2017), <https://research.thinkwood.com/en/list?q=innovation+in+hybrid&p=1&ps=20>.

<sup>46</sup> Michael Kilkelly, "Support for Tall Timber Reaches New Heights in the Building Code."

<sup>47</sup> For an explanation of the proposals see Mass Timber Code Coalition, "Understanding the Mass Timber Code Proposals," <https://www.awc.org/pdf/tmt/MTCC-Guide-Print-20180919.pdf>.

jurisdictions to adopt these changes.<sup>48</sup> Nonetheless, this will be an important step forward for making mass timber a viable option.

State legislation in Washington and Oregon has already laid the groundwork for increased use of mass timber. In Washington, legislation was recently passed requiring the State Building Council to adopt rules for the use of mass timber in both residential and commercial construction.<sup>49</sup> In Oregon, following an advisory council's close examination of the technical and scientific facts of using mass timber as an alternate method, an addendum to the state building code will allow timber buildings above six stories without special consideration.<sup>50</sup> Similar approaches could offer a slightly expedited path to tall timber construction in other jurisdictions before the 2021 IBC is effective and adopted by local jurisdictions.

#### **v. Cost and the Way Forward**

Proponents of mass timber tout quicker construction times, aesthetics, and sustainability as benefits. Mass timber may offer competitive pricing, particularly when taking these benefits into account, but to date there has not been significant uptake in multifamily. Increased use in office buildings and other commercial uses together with changes in the regulatory landscape could help mass timber increase scale and drive down prices. Given the favorable regulatory environment, acute housing need and proximity to both natural resources and the mass timber infrastructure that has emerged in British Columbia and the Pacific Northwest, we anticipate that markets in this region will see the most rapid initial growth in mass timber. Kattera's recent announcement of a planned CLT plant in Spokane, Washington should further support this growth.

### **C. Integrated Project Delivery**

In addition to exploring materials and construction methods that may create efficiencies, owners, architects, contractors and other stakeholders are seeking ways to make the design and construction process more efficient. Many of the manufacturers engaged in offsite construction pursue vertical integration of design, engineering and project management. Efficiencies can be realized in site-built or hybrid projects as well. One such approach is Integrated Project Delivery (IPD). IPD harnesses highly effective collaboration among the owner, the prime designer, and the prime contractor from early design to delivery to increase efficiency and value to the owner and

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<sup>48</sup> Nadine M. Post, "Tall Timber Model Code Proposals Closer to Adoption," Engineering News-Record, December 20, 2018, <https://www.enr.com/articles/46120-tall-timber-model-code-proposals-closer-to-adoption>.

<sup>49</sup> ESB 5450, Sess. Of 2018 (Was. 2018), <http://lawfilesexternal.wa.gov/biennium/2017-18/Pdf/Bill%20Reports/Senate/5450.E%20SBR%20FBR%2018.pdf>.

<sup>50</sup> State of Oregon Building Codes Division, *Statewide Alternate Method No. 18-01 Tall Wood Buildings – Background* (Oregon, 2018), <https://www.oregon.gov/bcd/codes-stand/Documents/sam-18-01-tallwoodbldgs.pdf>.

reduce waste.<sup>51</sup> IPD can be implemented philosophically, where parties agree to a higher level of collaboration, but don't have contractual requirements for collaboration, or can be implemented as the delivery method, meaning that the parties have contractual obligations for collaboration using a multi-party contract.<sup>52</sup>

In the contractual approach to IPD, parties to a multi-party contract include the owner, its architect and its contractor. Other members of the project team that are deemed critical to the project may also be brought into the multi-party agreement. Under the agreement, risk allocation and compensation are tied to team success rather than individual performance. IPD contracts are typically open-book, cost-plus without a guaranteed maximum price and often include liability waivers that reduce litigation risk. This rebalancing of risk and reward can encourage innovation and increased productivity. Another advantage of IPD is that it facilitates early involvement of all participants, which can help produce better designs with fewer costly late-stage design changes. At Akron Children's Hospital, a single mechanical system location change early in the design process generated savings of approximately \$1 million.<sup>53</sup> IPD teams report savings of 10-12% and projects frequently delivered ahead of schedule.<sup>54</sup>

Collaboration and integration can be further enhanced using technology, such as Building Information Modeling (BIM), to help improve communication and decision making. When coupled with these technologies, IPD implementation can also help identify and maximize opportunities for environmental sustainability. Contractors, like Suffolk Construction, as well as modular firms are using technology beyond BIM to drive towards a more integrated project delivery system.<sup>55</sup>

While improving collaboration to achieve the most efficient project seems like a common sense approach, there are cultural and programmatic obstacles to implementing IPD. Successful implementation of IPD requires that parties shift their internal and external thinking and behaviors about how they partner with other parties and manage risk to focus on the collective outcome rather than their own firm's risks and rewards. There is significant writing around best practices and principles for IPD both as a philosophy and a delivery system, much of which focuses on aligning motivation, risk tolerance and culture among the participants. For instance, IPD is best supported by a qualification-based selection or alternatively a best value fee proposal. Policies that require sealed proposals and low bid selection processes don't facilitate the collaboration

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<sup>51</sup> *Integrated Project Delivery: A Guide* (Washington DC: The American Institute for Architects, 2007), [http://info.aia.org/siteobjects/files/ipd\\_guide\\_2007.pdf](http://info.aia.org/siteobjects/files/ipd_guide_2007.pdf).

<sup>52</sup> *Integrated Project Delivery For Public and Private Owners* (National Association for State Facilities Administrators et. al., 2010), [https://www.agc.org/sites/default/files/Files/Programs%20%26%20Industry%20Relations/IPD%20for%20Public%20and%20Private%20Owners\\_1.pdf](https://www.agc.org/sites/default/files/Files/Programs%20%26%20Industry%20Relations/IPD%20for%20Public%20and%20Private%20Owners_1.pdf), [https://www.agc.org/sites/default/files/Files/Programs%20%26%20Industry%20Relations/IPD%20for%20Public%20and%20Private%20Owners\\_1.pdf](https://www.agc.org/sites/default/files/Files/Programs%20%26%20Industry%20Relations/IPD%20for%20Public%20and%20Private%20Owners_1.pdf), accessed December 2018.

<sup>53</sup> Josh Gregerson, "Integrated project delivery saves time, cuts costs, shares rewards," BuiltWorlds, March 23, 2017, <https://builtworlds.com/news/integrated-project-delivery-save-time-cut-costs-and-share-savings/>.

<sup>54</sup> Ibid.

<sup>55</sup> "Suffolk to Manage Cancer Center Project Using Integrated Project Delivery," Medical Construction & Design Magazine, January 17, 2012, <https://mcdmag.com/2012/01/project-is-one-of-first-healthcare-projects-in-the-country-to-utilize-innovative-ipd-process/#.XBhWvc9KjBJ>.



needed for an IPD process. Similarly, public programs that dictate types of construction contracts (e.g. guaranteed maximum price) used may also create impediments to an integrated delivery.

## IV. Policy Recommendations

OSC, mass timber and collaborative delivery processes like IPD offer opportunities to not only reduce costs, but also to deliver critically needed affordable rental housing more quickly than traditional site-built construction. Federal, state and local policymakers can support innovation and adoption of these technologies by making policy changes that acknowledge how these approaches differ from site-built construction. Below, we describe steps that policymakers can take to accelerate the uptake and efficiency of these approaches in order to increase the rate at which we fill our affordable rental housing shortage across the country.

### A. Zoning and entitlements

Developers utilizing hybrid and volumetric modular approaches in many jurisdictions have reported significant delays as projects move through the zoning and entitlements process. These delays, most often caused by lack of familiarity with modern off-site construction and preconceived notions of modular homes, erode some of the time and cost savings of off-site construction. In California, recently passed law SB 35 provides that the more than 95% of cities or counties that have not met their Regional Housing Needs Assessments will be subject to streamlining requirements for proposed developments that include affordable housing. In affected jurisdictions, projects that meet legal requirements have by-right approval, which helps curtail efforts to block development as long as the project is properly zoned, thus accelerating production. Policymakers should consider whether an analogous provision explicitly including modular construction is needed to help ensure that modular projects will not face further delays.

### B. Codes and Inspection

#### *State and Local Inspection of Modular Units Should be Combined or Streamlined*

As discussed above, codes for modular housing are developed at the federal level and typically enforced by the states, but significant authority may also rest at the local level. Inspectors visit the factory and may also inspect on-site when units are delivered. Local code still governs site preparation, foundation and any on-site work to connect manufactured components, meaning that a local inspector and a state inspector are often on-site. Where modules are delivered mostly complete, local inspectors may not have the ability to inspect certain elements already enclosed in panels or units constructed offsite. Further, there is often limited or no opportunity for modifications to the units once they have arrived onsite. In some jurisdictions, local inspectors frequently make requests for modification to enhance accessibility or other features. This could be addressed through both education and regulations. Manufacturers and developers seeking to use OSC products should invest time educating officials in their markets on the products to be used and addressing local concerns. This investment of time should help expedite current and future projects. Jurisdictions could also support the use of OSC by promulgating state or local regulations that permit the local inspector to rely on the state inspection or by allowing the state and locality to contract with a single inspector who will inspect for both state and local requirements. Jurisdictions could further agree on a single set of plans and drawings for review

and approval. A single set of documents and/or a single inspector could potentially save both public and private resources and expedite the delivery of rental housing.

*Adopt the IBC 2021 revisions and approve mass timber as an alternate method*

Mass timber and tall timber projects offer a promising alternative to steel and concrete construction that could help move quickly meet housing needs with sustainable buildings. Assuming that the proposed revisions to the IBC are formally adopted, they are not scheduled to become effective until 2021. States and localities should seek to adopt the IBC as soon as they become effective. In the interim, local codes and other requirements should be reviewed to identify whether there are other easily addressed impediments to the use of mass timber. Where states have authority to evaluate alternate methods, as in Oregon, states should undertake that process in order to more quickly, but safely, facilitate the scalable use of mass timber for higher density projects.

## C. Labor and Economic Development

*Implement Labor and Wage Requirements in the context of OSC*

Off-site construction often reduces the amount of labor required on-site, which can contribute to cost savings and decrease in delivery time, however, this shift in labor from the site to a factory can create tension with local hiring requirements. Policymakers should consider how to encourage local hiring for on-site work and should also consider policies that recognize that OSC methods employ a different mix of workers that may include fewer unionized trades and may have fewer opportunities for local hires in the property's jurisdiction.

*Build manufacturing capacity and infrastructure with policy and financial support*

As discussed above, factory capacity for modular, hybrid and component construction is currently a challenge in many regions. Policymakers at state housing finance agencies and other state and local agencies that award funds in support of affordable housing can help create a stable pipeline with policies that acknowledge or even create preferences for some amount of production using these approaches. As a result of the stable demand for these innovative approaches, manufacturers will be able to invest more in expanded manufacturing capacity and may more quickly reach a scale that will help realize further savings in materials costs. State and local government can also consider economic development tools including bonds, tax incentives and other tools to spur investment in facilities and job creation.

## D. Financing

State and local policymakers can also promote efficient and innovative production of affordable housing through their allocation and administration of housing finance programs. Below, we outline some possible approaches.

*Address upfront funding challenges for modular housing*

OSC manufacturers often require deposits of up to fifty percent of the cost of building modules in order to reserve space in the production schedule. Even well-capitalized manufacturers need these deposits to meet reasonable expenses, but lenders have been hesitant to advance funds for factory-built units or components where their ability to inspect is different and their interest in the materials and units as collateral for the loan would be more challenging to perfect than in site-built construction. State and local funders should take the lead in addressing these issues through remote inspection procedures and an analysis of how construction lenders can safely advance these funds. Manufacturers can offer detailed and real time ability to track materials and units through the process, offering a clear view of progress and the location of collateral. State and local funders can also help lead the way in creating an industry standard for underwriting and securing construction loans for modular units.

For modules that incorporate advanced building operations and management tools (e.g. Blokable) that will support reduced operating and maintenance costs and for those products and modules constructed of more durable materials with longer lifecycles, state and local funders should explore the extent to which their underwriting assumptions can recognize these opportunities for savings and efficiencies. State and local funders should lead the way in this work not only to make OSC transactions more viable, but also to lead the private sector to safe and sound underwriting practices that support more affordable construction and operations approaches.

Finally, states and localities should consider whether they have other flexible sources of funding that could be provided to the developer to help meet these costs outside of a traditional construction lending structure.

#### *Accept selection methods that support integrated project delivery*

Integrated project delivery (IPD) can offer cost savings and accelerate the delivery of rental homes. In order to engage design professionals, general contractors, manufacturers of modules or components and other stakeholders in a collaborative delivery system, developers must be able to carry out a selection process that values collaboration. State and local policymakers can support this by amending requirements for sealed bid or lowest bid selection processes on government supported projects where owners will execute an IPD. The opportunity for efficiency and a higher quality completed project could outweigh any cost savings created by lowest bid policies, particularly given the inefficiencies of lowest bid contracts. Policymakers should also consider piloting contract types that would support integrated project management, such as contracts without a guaranteed maximum price.

## **V. Conclusion**

The critical shortage of homes affordable to low- and moderate-income people demands new approaches that will help rapidly increase the housing supply. Off-site construction of units and components and more integrated design and construction processes are promising strategies that could help speed the rate at which affordable homes are preserved and created, even in high cost markets with tight labor pools. However, challenges to reaching scale and realizing the full benefits of these approaches remain. Manufacturers, developers and other stakeholders can help drive towards these efficiencies by 1) continuing to invest in the use of OSC and integrated processes, and 2) proactively educating policymakers at the state and local levels and

encouraging them to support exploration of these strategies by providing flexibility and incentives for innovative approaches, particularly in the development of affordable rental housing. The role of state and local government in approving and providing financial support for affordable rental housing creates an excellent opportunity for policymakers to pilot regulatory flexibility and incentivize innovation, particularly with experienced, mission-driven developers.

## Appendices

1. Profiles of strategies and providers (*as of April 2019*)\*
  - a. Factory\_OS
  - b. Guerdon
  - c. RAD Urban
  - d. Prescient
  - e. Katterra
  - f. Sustainable Living Innovations
  - g. Blokable
2. Manufacturer Comparisons
  - a. Feature/Benefit Comparison
  - b. Cost and Time Savings Comparison
3. Mass Timber
  - a. Project Profiles
  - b. Directory of manufacturers

*\*Information in Appendix 1 was found on vendor websites, provided by vendor representatives or included in articles found in the bibliography. Vendors were provided an opportunity for feedback in April 2019*



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# Factory\_OS

1245 Nimitz Ave., Building 680 Vallejo, CA 94592

[www.factoryos.com](http://www.factoryos.com)

## CONTACT

**Larry Pace, COO**

[lpace@cannongroup.com](mailto:lpace@cannongroup.com)

415.546.5500

## CONTACT

**Rachel Villicana**

[rvillicana@factoryos.com](mailto:rvillicana@factoryos.com)

707.246.3782

## ABOUT:

**YEAR FOUNDED:** 2017

**FACTORY LOCATION:** Vallejo, CA

**SERVICE AREA:** Northern California

**FACTORY LABOR:** Carpenters' Union

**ON-SITE LABOR:** Local contractors

**ANNUAL PROD. CAPACITY:** 2,000 - 3,000 units (anticipated)

**CAPITALIZATION:** Privately held firm with several investors

## MODULES:

**TYPOLOGY:** Volumetric

**CONSTRUCTION TYPE:** Type V; Type III Mod.

**BUILDING DIMENSIONS:** 60-500 units (max. 5 stories)

## PROJECTS:

**HOLLIDAY DEVELOPMENT:** 110 market-rate units in West Oakland, CA; 105 market-rate units in Emeryville, CA (in development).

## CANNON CONSTRUCTORS -

**MOFFETT FIELD:** 300 workforce units in Mountain View, CA

**SF MAYOR'S OFFICE:** 300-400 market-rate, affordable, and PSH units in San Francisco, CA (in development).

**DESCRIPTION:** Factory\_OS manufactures modular multifamily buildings in a factory in Vallejo, California. Completed residential units are shipped and assembled on-site. Their factory contains an "Innovation Lab," a UC Berkeley Turner Center for Housing Innovation initiative to bring together a wide range of industry stakeholders to advance ideas that modernize industrialized building techniques.

**EXPERIENCE:** Factory\_OS is in its second year of operation with plans to construct 1,000 - 1,500 apartment units this year. Their staff has deep expertise in multifamily affordable housing and they have strong connections with the San Francisco mayor's office. Their current projects are seeing cost savings of 20% and time savings of 40%. They hope to go even further, reducing costs by 30% and construction time by 50%.

**DESIGN:** Standardized design-to-value, despecification of structural designs. Modules consist of 1,000 square foot "volumes" with wood frames that can be stacked up to 5 stories tall (over a 2 story Type 1 podium). Each volume contains two 300-500 square foot units, which range from studios to 3 bedrooms.

**PROCESS:** Vertically integrated architecture, engineering, design, and manufacturing with contracted on-site assembly crews. They use Autodesk software and engineering support to digitize their modules with lean manufacturing. All finishes and appliances are installed before shipment. On-site work is performed with local labor and includes preparing foundation, stacking and "stitching" modules, connecting the utilities to the pre-installed wiring and piping, and roofing and landscaping.



## SAVINGS OVER SITE-BUILT

Advertised

**20%**

cost savings

**40%**

time savings

## STATISTICS

Advertised

**8**

homes built per day (factory)

**10**

homes stacked per day (on-site)

# Guerdon

5556 Federal Way Boise, Idaho 83716

[www.guerdonmodularbuildings.com](http://www.guerdonmodularbuildings.com)

## CONTACT

[information@guerdon.com](mailto:information@guerdon.com)

(208) 345-5100

## ABOUT:

**YEAR FOUNDED:** 2001

**FACTORY LOCATIONS:** Boise, ID

**SERVICE AREA:** Western US

**FACTORY LABOR:** Non-union

**ON-SITE LABOR:** Guerdon specialist on-site to advise Gen. Contractor

**ANNUAL PROD, CAPACITY:** 1,200 modules per year; Approx. 4-6 months work currently pipeline.

**CAPITALIZATION:** Portland-based Riverlake Partners made majority equity investment in 2014

## MODULES:

**TYPOLOGY:** Volumetric

**CONSTRUCTION TYPE:** Type III

**BUILDING DIMENSIONS:** Up to five stories; Modules can be built up to 72L x 22W but transit costs may increase with larger units.

## PROJECTS:

**UNION FLATS:** 328 unit TOD apartment community with live-work lofts and community art gallery on ground floor in Union City, CA.

**COLISEUM CONNECTIONS:** 110-unit affordable housing transit village in Oakland, CA. Completed in April 2019

**LA VEREDA (SAN LEANDRO SENIOR APTS):** 85 unit TOD project developed by BRIDGE Housing for seniors at 30-50% AMI; Mix of 1- and 2-bedroom units.

**DESCRIPTION:** Guerdon is a manufacturer of large-scale, commercial modular construction projects located in Boise, Idaho. They offer fixed-price contracts with owners and oversee the project from design to installation. They are able to provide architecture and design services as necessary or work with owners' architects.

**EXPERIENCE:** Guerdon has over a decade of experience in multifamily modular construction and significant staff expertise in multifamily design, engineering, and building codes. They have worked with a wide range of developers, general contractors, subcontractors, and lenders including BRIDGE Housing.

**DESIGN:** Guerdon does not use a catalog of existing designs like other modular producers but works with clients' architects and engineers to build each modular construction project to the exact material, finish schedules, and design approved or provided by the owner. Guerdon uses only Systems-Build IBS/IRC code products and many projects receive LEED Platinum Certifications. Modules can be built up to 72L x 22W but transit costs may increase with larger units.

## ADVERTISED SAVINGS AND STATISTICS

**30-40%**  
time savings  
(over site-built)

**12**  
units stacked per day  
(on-site)

**PROCESS:** Guerdon works with owners and architects to design projects and uses local and regional suppliers to source materials in bulk at a discounted rate. They store materials and manufacture modules at their 20 acre factory location and ship them to the project site using a temporary shrink-wrap weatherization method. They provide a minimum of one on-site factory-trained technician to oversee the installation by the General Contractor and other subcontractors.

**COST COMPARISON:** In 2018, Guerdon provided a cost estimate for a mixed-use project in San Mateo, CA. Areas of cost savings using modular include carpentry, plumbing and electrical. Areas of cost increases using modular include foundation, insulation and waterproofing. **Estimates were made at the design drawings stage, meaning savings are not maximized and should not be seen as fully representative.**

	Modular	Stick-Built
Total sq. ft.	117,125	112,265
\$/gross sq. ft.	\$323.43	\$326.97

# RAD Urban

2101 Webster Street, Suite 1801 Oakland, CA 94612

[www.radurban.com](http://www.radurban.com)

## CONTACT

[info@radurban.com](mailto:info@radurban.com)  
510.398.0888

## ABOUT:

**YEAR FOUNDED:** 2013

**FACTORY LOCATIONS:** Lathrop, CA

**SERVICE AREA:** Seattle to San Diego

**FACTORY LABOR:** Carpenters Union

**ON-SITE LABOR:** RAD Urban is  
General Contractor on-site

**ANNUAL PROD, CAPACITY:** 500 units  
in first year; 1,000-1,500 units in  
future years

**CAPITALIZATION:** Investors include  
New York-based Innovatus Capital  
Partners

## MODULES:

**TPOLOGY:** Hybrid

**CONSTRUCTION TYPE INDICATED:**

Type I, Type II

**BUILDING DIMENSIONS:** 40-200+  
units; Up to 40 stories

## PROJECTS:

**2201 DWIGHT:** 77 units, 5 story (50  
feet tall) student apartments in  
Berkley, CA; includes rooftop  
farm; construction type IIB over IA

**5110 TELEGRAPH (in construction):** 204  
units, 6 story (74 feet tall) mkt. rate  
apartments w/ 17 ELI units in Oakland,  
CA; includes rooftop farm and 35k sq.  
ft. of retail; construction type IA.

**4700 Telegraph:** 48 unit, 5 story (57  
feet fall) apartment building in  
Oakland, CA. Began leasing in 2019

**DESCRIPTION:** RAD Urban manufactures modular multifamily homes in a factory in Stockton, California. Modules have 4 sides (compared to complete modules with six sides) and are made of steel (rather than wood in other modular manufacturers). Modules are shipped to site and can be stacked up to 40 stories tall.

**EXPERIENCE:** RAD Urban has built two student housing projects in Berkeley, CA and is currently working its third mid-rise project in Oakland, CA's Temescal neighborhood. RAD Urban has plans to build two high-rise projects in Oakland, which will be the country's tallest prefab high rise apartment complex. They also have one project in the pipeline for a third-party affordable housing developer.

**DESIGN:** Standardized four-sided boxes (volumetric, but not complete) that can be configured into units with up to four bedrooms. The floor of one unit also serves as the ceiling of the unit beneath it, which reduces needed material and allows for a greater number of stories in a given height restriction. Modules have temporary waterproofing system, which allows for all year shipping and installation. Partnership with Top Leaf Farms brings rooftop garden to most buildings. While RAD Urban has produced 3-5 story buildings, it is seeking a pipeline of 12+ story buildings to maximize the benefits of their design and materials.

## SAVINGS OVER SITE BUILT

Advertised

**30%**  
material savings

**20%**  
cost savings

**30%**  
time savings

**PROCESS:** RAD Urban has a vertically integrated architecture, engineering, design, and manufacturing structure with contracted on-site assembly crews. All finishes and appliances are installed before shipment. On-site work is performed with local labor and includes preparing foundation, stacking and "stitching" modules, connecting the utilities to the pre-installed wiring and piping, and roofing and landscaping.

## STATISTICS

Advertised

**8**  
units constructed per day  
(factory)

**8**  
units stacked per day  
(on-site)



# Prescient

14401 W 65th Way, Unit B Arvada, CO 80004  
[www.prescientco.com](http://www.prescientco.com)

## ABOUT:

**YEAR FOUNDED:** 2012

**FACTORY LOCATIONS:** Arvada, CO;  
Mebane, NC

**SERVICE AREA:** Continental US

**FACTORY LABOR:** Non-union

**ON-SITE LABOR:** Trained and  
certified installers across country  
(unskilled; union and non-union)

**ANNUAL PROD, CAPACITY:** 10 million  
square feet across two plants.

**CAPITALIZATION:** Raised \$190  
million to date

## MODULES:

**TYPOLOGY:** Panelized

**CONSTRUCTION TYPE:** Type IB, IIA, IIB

**BUILDING DIMENSIONS:** 3-17 stories

## PROJECTS:

**UNIVERSITY STATION:** 60-unit, six  
story TOD senior affordable housing  
in Denver financed w/ 9% LIHTC.

**RENAISSANCE DOWNTOWN LOFTS:**  
101 units PSH in Denver for CO  
Coalition for the Homeless financed  
with 4% and 9% LIHTC.

## ALEXAN UPTOWN:

12 story (8 stories of Prescient  
structure over 4 stories of concrete)  
apartment building in Denver, CO;  
Completed in 2017.

## CONTACT

### Bill Huberty

VP, Business Development  
[whuberty@prescientco.com](mailto:whuberty@prescientco.com)  
415.816.8950

## CONTACT

### Erin Hamilton

Director, Architectural Design  
[ehamilton@prescientco.com](mailto:ehamilton@prescientco.com)  
303.214.9742

**DESCRIPTION:** Prescient uses software and advanced manufacturing techniques to speed up and increase precision of multi-unit construction projects. They utilize light-gauge recycled steel to manufacture factory-made posts, panels, trusses, and metal floor decks. All components contain unique QR codes that allow for precise and efficient assembly and streamlined replacement in the case of damage.

**EXPERIENCE:** Prescient has completed a total of 39 assignments (6 million SF of construction) with another 10 assignments currently under construction. They have worked in 15 states and have new assignments in California and the Northeast. Prescient has completed projects financed with Low Income Housing Tax Credits and HOME funds.

**DESIGN:** Rather than create a model after the Schematic or Conceptual phase of design, Prescient can start with a simple massing and target unit mix. Prescient can then create a working REVIT model for all stakeholders to utilize, including MEP subs, the architect, and the GC. While Prescient's scope is confined to the metal superstructure, the design and engineering work upfront facilitates all other stakeholders on the job site. Each floor uses an identical post and beam design with less than a quarter inch of compression over 10 stories. Prescient can also prefab and install metal stairs as well as single piece balconies designed to eliminate the risk of water intrusion-related failures. The Prescient superstructure can be "uninstalled" with a torque wrench and then re-purposed or recycled.

## ADVERTISED SAVINGS AND STATISTICS

**20%**  
cost savings over concrete

**40%**  
time savings over concrete

**60-80k**  
SF per month installed on-site

**PROCESS:** Prescient works with developers' architects and engineers to model structures using a patented grid-based system that drives efficient and expedited layout, design, and system coordination. They manufacture and ship light-gauge steel components that include both super structure framing and non-structural infill wall framing. Components are loaded onto pallets in sequence with assembly and delivered in a precise timeline to eliminate the need for staging area. On-site, 2-3 Prescient experts oversee a crew of about 35 people that install the lightweight and easy-to-assemble materials using screws and a torque wrench. Drywall and windows on the lower floors can be completed simultaneously with upper floor assembly due to minimal compression system and stairs can be easily installed and used throughout construction, eliminating the need for temporary stairs.

**COST COMPARISON:** Prescient provided a rough order of magnitude estimate for Project S at the design drawings stage, **meaning savings are not maximized and should not be seen as fully representative.** Additional savings may be realized if the structural benefits of a metal superstructure are incorporated in the design process. Metal superstructure may also reduce insurance costs.

Prescient	Stick-Built
\$535.26	\$526.79
per net rentable sq. ft.	per net rentable sq. ft.

# Katerra

2494 Sand Hill Rd., Bldg. 7, Suite 100  
Menlo Park, CA 94025  
[www.katerra.com](http://www.katerra.com)

## CONTACT

### Justin VanLeuvan

Sales Director, Multifamily  
[Justin.VanLeuvan@katerra.com](mailto:Justin.VanLeuvan@katerra.com)  
678.687.2167

## CONTACT

### Pete Kobelt

Sales Director, CLT/Mass Timber  
[Pete.Kobelt@Katerra.com](mailto:Pete.Kobelt@Katerra.com)  
406.314.5086

## ABOUT:

**YEAR FOUNDED:** 2015

**FACTORY LOCATIONS:** Phoenix, AZ; Spokane, WA (CLT only); Tracy, CA (opening April 2019); San Marcos, CA (opening late 2019)

**SERVICE AREA:** Continental US and Canada

**FACTORY LABOR:** Non-union

**ON-SITE LABOR:** Katerra as GC with local subcontractors

**ANNUAL PROD, CAPACITY:** 20,000 apartments per year

**CAPITALIZATION:** Valued at \$3 billion after recent \$1.3 billion capital raise

## MODULES:

**TPOLOGY:** Panelized

**CONSTRUCTION TYPE:** All

**BUILDING DIMENSIONS:** Dependent on construction type

## PROJECTS:

**UNION FLATS (in construction):** 357 units and 30k sq. ft. retail space in 4- and 5-story wood frame buildings in Carson, CA; Katerra is providing construction management and materials

**PARALLEL:** 368 market-rate apartments in wrapped wood frame building in Anaheim, CA; Katerra provided construction management and materials

**DESCRIPTION:** Katerra is striving to become a vertically integrated technology company that offers end-to-end design, procurement, manufacturing, shipping, and construction services for multifamily apartment, hospitality, and commercial buildings. Katerra's approach is to market buildings as products. Developers will select from a fixed number of designs constructed using panels. Katerra will then handle design and construction end-to-end. They have been acquiring and affiliating with architecture and general contracting firms domestically and suppliers both domestic and international. By aggregating material demand across multiple projects and using robotics and technology in their manufacturing plants, Katerra projects that it can lower pricing and drastically reduce construction time. In pursuit of this goal, Katerra is primarily seeking to work with national developers with 400-500 million unit pipelines to lower pricing.

**EXPERIENCE:** Currently valued at \$3 billion, Katerra was founded three years ago and has just completed a \$1.3 billion capital raise through which they have acquired a pre-cast concrete manufacturer in India, a tall-timber focused architecture firm, and several other architecture, design, and construction firms around the country. They currently operate a factory in Phoenix, AZ and plan to open seven additional factories across the country in the next two years, including a mass timber factory in Spokane, WA scheduled to open in early 2019. They are currently working on their first "end-to-end" project in Las Vegas.

**DESIGN:** Katerra uses one of its firms as the architect of record. It is moving toward a small catalogue of standard designs using panelized construction that will be able to be customized for site and project specifications, though significant modifications can reduce efficiencies. Katerra also has an interior design team that uses its supply chain to construct fully designed finishes and white label appliances to deliver fully completed projects.

**PROCESS:** Katerra's architects and engineers work with developers to design projects. Panels are constructed in a factory and can include mechanical, electrical and plumbing components, all of which are flat-packed and shipped to the job site. On-site, Katerra serves as the General Contractor and leverages the subcontractor relationships of its acquired GC firms to have the building assembled and inspected. All components include unique QR codes for streamlined replacement in case of damage.

**COST COMPARISON:** Katerra is seeking to achieve significant decreases in construction time and cost as they reach scale. Current savings vary significantly by project.



# Sustainable Living Innovations

710 Second Ave., Suite 1400 Seattle, WA 98104

[www.sustainablelivinginnovations.com](http://www.sustainablelivinginnovations.com)

## CONTACT

**Rick Osterhout**

Executive Vice President  
rosterhout@collinswoerman.com  
206.713.1102

## ABOUT:

**YEAR FOUNDED:** 2008

**SERVICE AREA:** Currently West Coast;  
Expanding to East Coast in 2021

**LABOR:** SLI controls supply chain, contracting w/ third party vendors for components and building assembly; and a GC for site work/ foundations/utilities/unit finishes & utility connections

**ANNUAL PROD. CAPACITY:** Currently at 15% capacity w/ four projects (1,000 units) in pipeline

**CAPITALIZATION:** Completed one private capital raise; second raise slated for year-end 2019

## MODULES:

**TYPOLOGY:** Panelized

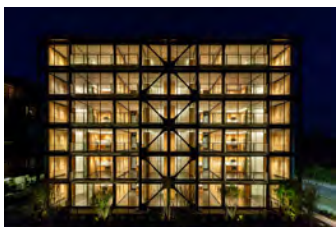
**CONSTRUCTION TYPE:** Type I, Type II

**BUILDING DIMENSIONS:**  
100-400+ units; 10-40 stories

## PROJECTS:

**303 BATTERY (in development):**  
112 units (27 affordable), 14 stories in Seattle, WA

**47+7:** 24 unit, 6 story award-winning apt. building in Seattle, WA; completed in April 2015; pictured below



**DESCRIPTION:** Sustainable Living Innovations (SLI) builds mid-rise and high-rise apartment projects from a catalogue of factory-made components (structural steel pieces, wall and floor panels, etc.) sourced from key vendors in the US and Canada. Component parts are trucked to the project site and assembled to create a finished building up to 40 stories developed as turnkey products. SLI focuses on "gateway" urban markets.

**EXPERIENCE:** SLI's proprietary building technology has been in product development for over 10 years, with 122 patents issued or pending in 11 countries. SLI's first commercial development utilizing version 2.0 technology was completed in 2015. SLI utilizes a software-based continuous improvement platform similar to aircraft and automobile manufacturing. Currently, SLI has four multifamily projects in development utilizing version 5.0 technology.

**DESIGN:** SLI designs buildings in-house, with unit types ranging from studio (338 SF) to three bedroom (1246 SF). All units are clear span and column free with 100% usable square footage. Units have floor-to-ceiling glass slider window walls, ranging from 13 feet to 47 feet wide. Every unit has balconies or decks.

## COMPARED TO SITE BUILT

Advertised

**10%**

cost savings

Advertised

**70%**

reduced energy use

**50%**

time savings

**33-50%**

reduced water use

**PROCESS:** SLI and its affiliates contract with institutional and private asset owners to purchase completed buildings either on a pre-sale or fee-for-service basis. Projects are delivered turnkey either at certificate of occupancy or stabilization. Approximately 85% of the building is manufactured or assembled off-site under the control and direction of SLI and its affiliates. The structural steel fabricator erects the building including setting wall and floor panels. A General Contractor is retained to perform field work; make plumbing/electrical connections and install cabinets, lighting, appliances and finishes.

**COST COMPARISON:** SLI declined to provide a hard construction cost estimate on Project S as it doesn't conform to their model but furnished an estimate based on the 112-unit, 15 story building.

## PROJECTED CONSTRUCTION COSTS

**\$310/sq. ft.**

112 unit, 15 story turnkey development

# Blokable

1136 Poplar Pl S, Seattle, WA, 98144

[www.blokable.com](http://www.blokable.com)

## Contact

**Aaron Holm**

Co-CEO

[aaron@blokable.com](mailto:aaron@blokable.com)

## ABOUT:

**YEAR FOUNDED:** 2016

**FACTORY LOCATIONS:** Vancouver, WA

**SERVICE AREA:** WA, ID, OR, CA

**FACTORY LABOR:** Non-union; Earn prevailing wage

**ON-SITE LABOR:** Partner GC firms working for Blokable

**ANNUAL PROD, CAPACITY:** TBD - Newly operationalized; Pipeline full for WA factory in 2019; Additional plants coming in 2020

**CAPITALIZATION:** Investors include: Vulcan Capital, Kapor Capital, Revolution Ventures, Building Ventures, Urban.US and Jason Calacanis

## MODULES:

**TPOLOGY:** Volumetric

**CONSTRUCTION TYPE:** Type III

**BUILDING DIMENSIONS:** Designed for 1-3 story communities; Mix of studio, 1-, 2-, and 3 BR units

## PROJECTS:

### EDMOND LUTHERAN:

70 unit, 3 story apt. building for residents making up to 50% AMI in partnership with Compass Housing Alliance

### NAPA VALLEY:

20 unit, 3 story garden style apt. building in partnership with nonprofit partner. Expected development time of 10 months from site acquisition to project completion

**DESCRIPTION:** Blokable is seeking to deliver both a product and real estate development as a service in order to unlock the efficiencies of technological and financial system advances. Units "Blocs" are volumetric modular housing components assembled in the manufacturing facility and designed to be stacked, combined, and connected. Blokable intends to use its vertically integrated approach to foster equity and prosperity in communities.

**EXPERIENCE:** Blokable has spent the past two and half years refining its designs and process. They are currently working on their first round of projects, including projects with Compass Housing in Edmonds, WA, with Valley Cities in Auburn, WA and in with SAAEVI Development in Richmond, CA. Blokable will soon have two production lines active in its Vancouver, Washington facility.

**DESIGN:** Blokable is building a library of designs for studio, 1, 2, and 3 bedroom "Blocs." A proprietary structural steel frame and shear-wall system allows wide open spaces, as well as attached decks, railings, stairs and architectural features. All Blocs come equipped with BlokSense home hardware pre-installed in a hardwired built-in system. BlokSense equips residents community and property managers optimized tool to monitor performance and safety features of their homes and communities in real time, including temperature, power usage, humidity, and air quality, as well as smoke, carbon monoxide, and water leak alarms. A wired network of intelligent sensors gather and report data to the BlokSense Insights Dashboard, where customers can monitor and manage the home in real time. This instant access to current and historical data can minimize maintenance, repair, insurance and other management and operations costs. Blokable is also exploring implications of a longer life cycle and real time maintenance information for reserves and other financing costs.

### Advertised Costs Per Door

**\$200,000 - \$350,000**

avg. across typical mix of studio, 1-, 2-, 3 BRs and common spaces (excludes land costs)

**PROCESS:** Similar to other manufacturers, Blokable seeks to achieve the greatest efficiencies through full vertical integration, managing projects from planning & design through production, site work, installation, and ongoing monitoring and support. This approach means that Blokable must be engaged at the design stage. Blocs are manufactured in a facility in Vancouver, WA and connected onsite. Blokable works with preferred partner architects, contractors and assembly crews that are trained on the Blokable system to assemble the property. Blokable is distinct in that it is a self-performing developer with two approaches for development: 1) For for-profit markets, Blokable will partner with land owners and investors to develop the property; 2) For not-for-profit development, Blokable will offer fee-based development and deliver the project to a nonprofit service provider for ownership and operations. This model is intended to create greater transparency in the development process and maximize cost savings and resulting affordability.

Offsite Construction Manufacturer Feature Comparison								
Manufacturer		Factory OS	Blokable	Guerdon	RAD Urban	Prescient	Katerra	Sustainable Living
Manufacturer Location		Vallejo, CA	Vancouver, WA	Boise, ID	Vallejo, CA	Arvada, CO	Phoenix, AZ	Seattle, WA
Panelized or Volumetric		Full Volumetric	Full Volumetric	Full Volumetric	Hybrid Volumetric	Panels/ Components	Panelized	Panelized
Design	Fully customizable design	●		●	●	●		
	Steel frame		●		●	●		●
	Wood frame	●		●			●	
	Suitable for high rise				●	●		●
	Maximizes height ratio				●	●		●
Construction	Self-performing/ manufacturer engages general contractor		●		●		●	●
	Opportunity to dual track construction (factory and on-site)	●	●	●	●			●
	Less waste in construction process	●	●	●	●	●	●	●
Costs	Labor cost savings at factory	●	●	●			●	
	Union agreements at factory and/or prevailing wage	●	●		●			
	Flat pack for ease of transit					●	●	
	Factory proximate to BRIDGE markets	●	●		●		●	●
	Building performance monitoring		●					

## Offsite Construction Manufacturer Cost and Time Comparison

***Savings presented are as advertised or reported in interviews. "As observed" costs are for different sample projects and should not be compared to one another. Observed cost/sqft were derived from estimates based on design drawings when savings are not maximized and should not be seen as fully representative.***

Manufacturer		Factory OS	Blokable	Guerdon	RAD Urban	Prescient	Katerra	Sustainable Living
Manufacturer Location		Vallejo, CA	Seattle, WA	Boise, ID	Vallejo, CA	Arvada, CO	Phoenix, AZ	Seattle, WA
Panelized or Volumetric		Full Volumetric	Full Volumetric	Full Volumetric	Hybrid Volumetric	Panels/ Components	Panelized	Panelized
Cost	Cost Savings Advertised	20%			20%	20%		10%
	Cost/ sqft Advertised							\$310 turnkey
	Cost/sqft Observed			\$323.43/G SF (-\$3.54) <sup>1</sup>		\$535.26/NR SF (+\$8.47) <sup>2</sup>		
	Cost/Door excluding land <sup>3</sup>		\$200K-350K					
Time	Time Savings Advertised	40%		30-40%	30%	40%	20%	50%
Other	Other Features or Savings		- Net zero ready  -Real time monitoring system supports lower operating and maint. costs			Steel components recyclable Additional savings may be realized in insurance premiums and other design elements.	Varies with project; add'l efficiencies anticipate as they scale.	- 70% reduced energy  - 33-50% reduced water

<sup>1</sup> Estimated modular option as 4,860 square feet larger than stick built option meaning that while \$GSF was lower, the gross costs exceed stick built estimates.

<sup>2</sup> Based on Project S

<sup>3</sup> Average across mix of unit types( studio, 1, 2, 3 BR)

# Mass Timber

NOTE: This profile does not feature a specific manufacturer but rather discusses the use of mass timber in residential and commercial construction broadly. For a list of manufacturers, see the back of this page. For additional resources, see [www.thinkwood.com](http://www.thinkwood.com).

## DESCRIPTION:

Mass timber refers to buildings constructed of engineered or manufactured wood products that exceed current height restrictions for wood in the Int'l Building Code. It includes any product currently permitted for use in Type IV construction, including those listed below.

## TYPES:

**Cross-Laminated Timber (CLT):** 3, 5, or 7 layers of dimension lumber; typically used for floors, walls, and roofs

**Nail-Laminated Timber (NLT):**

Individual dimension lumber members (2x4, 2x6, or 2x8) stacked on edge and fastened with nails or screws; typically used for floors, decks, and roofs but also used for elevator and stair shafts

**Glue Laminated Timber (Glulam):**

Created by layering dried and graded wood veneers, strands or flakes with laminated veneer lumber and laminated strand lumber; manufactured into panels up to 8 ft. wide and in varying thickness

**Dowel-Laminated Timber (DLT):**

Similar to NLT but uses wood dowels to join laminations instead of nails or screws, making it easier and safer to mill and route; best suited for floors and roofs

**Wood-Concrete Composite:** Hybrid wood-concrete approaches are available for high-rise construction; most material types described above can be coated in concrete to create a composite

## BENEFITS:

**Strength:** Stronger and more stable than other wood products, which allows for greater building height

**Sustainability:** Renewable, non-combustible resource with lower carbon impact than concrete or steel

**Efficiency:** Light weight and panelized nature results in significant construction cost and time savings.

**Aesthetic:** Products can serve as both structural element and interior surface, creating warmth aesthetic

## CARBON 12:

**Portland, OR**

**MANUFACTURER:** Structurlam

**DESCRIPTION:** Carbon 12 is an 8 story, 14-unit condo building with a solar-ready roof, an underground mechanical parking system, and ground-floor retail space. It has a steel brace frame core, surrounded by a timber and CLT structure. It is the tallest mass timber and CLT building in the US.

## PDX FLATIRON:

**Portland, OR**

**MANUFACTURER:** Structurlam

**DESCRIPTION:** PDX Flatiron is a 6 story, 28k square foot commercial building with four floors of office space above first floor retail space and basement level parking. The building has CLT floors supported by glulam beams, topped with reinforced concrete.

## T3:

**Minneapolis, MN**

**MANUFACTURER:** StructureCraft

**DESCRIPTION:** T3 is a 7 story, 234k square foot office building with ground floor retail, six floors of office space and a rooftop patio. The top six floors have glulam supports and joists and NLT ceilings. The 180k square foot timber structure was installed in only 9.5 weeks. StructureCraft and the developer are now replicating the building in Atlanta.

## FRAMEWORK:

**Portland, OR**

**MANUFACTURER:** StructureCraft

**DESCRIPTION:** Framework is a planned 12 story apt. building that has received local subsidy to include 60 affordable units. CLT panels up to 40' long form the floor system, resting on Glulam beams and columns. The project is currently on hold due to financing challenges with a former manufacturer.

# Manufacturers:

## DESCRIPTION:

## EXPERIENCE:

### Structurlam

Penticton, BC

[www.structurlam.com](http://www.structurlam.com)

Structurlam manufactures CLT, glulam, and GLT for commercial and residential buildings in Vancouver, Calgary, Washington, Oregon, and California.

Structurlam has been operating with mass timber products since the 1990s and opened North America's first CLT plant in 2011. They manufactured the world's tallest wood structure in Vancouver (18 stories) and the US's tallest wood structure in Oregon (12 stories).

### Katerra

Menlo Park, CA

[www.katerra.com](http://www.katerra.com)

Katerra is developing a catalogue of CLT and glulam products for residential and commercial projects. They are building a new mass timber manufacturing facility in Spokane, WA that is scheduled to begin production in early 2019.

In 2018, Katerra acquired Michael Green Architecture, a Vancouver-based architecture firm that specializes in CLT and designed two of North America's largest CLT structures.

### StructureCraft

Abbotsford, BC

[www.structurecraft.com](http://www.structurecraft.com)

StructureCraft manufactures or sources a range of mass timber products including DLT, CLT, NLT, and Glulam as well as steel components such as connections, cables, and castings.

StructureCraft manufactured or sourced products for T3, the largest mass timber building in the U.S., and are now fabricating for Framework, which will be the country's tallest mass timber building.

### D.R. Johnson

Riddle, OR

[www.oregonclt.com](http://www.oregonclt.com)

DR Johnson is a family-owned manufacturer of CLT and glulam panels for residential and commercial buildings on the West Coast.

DR Johnson is the first company in the US to receive APA certification to manufacture structural CLT panels. They were the former manufacturer for the 12-story Framework building in Portland that is currently on hold due to financing challenges.

### SmartLam

W. Columbia Falls, MT

[www.smartlam.com](http://www.smartlam.com)

Smartlam is a certified manufacturer of CLT products for commercial and residential buildings. In addition to their products, they offer design, engineering, and consulting services.

SmartLam is the first CLT manufacturer in the United States. They are APA PRG-320 certified to produce architectural grade CLT products and they are the first US CLT manufacturer to earn a Sustainable Forestry Initiative (SFI) certification.

### International Beams (IB)

Sarasota, FL

[www.internationalbeams.com](http://www.internationalbeams.com)

IB is a manufacturer of pre-fabricated I-joist beams that recently completed the East Coast's first CLT manufacturing facility in Dothan, AL. The facility will also manufacture glulam.

IB's CLT facility opened in April 2018. While new to the CLT business, IB was founded in 1995 and holds 42% of the solid sawn I-joist manufacture capacity in North America. They have additional factories in Quebec and Ontario.