Affordable and Scalable Modular Multifamily Housing: A Case Study on Cost, Construction Time Savings, and Waste Reduction in California

Thibault Marzullo, Shanti Pless, Nick Cindrick, Landan Taylor
Nick Caton, Aman Patel, Isabella Hess

ABSTRACT

This case study evaluates cost, construction time, and waste metrics for a 195-unit stick-built project and for a 66-unit modular project, both based in Los Angeles, CA. We partnered with a vertically integrated real estate developer and a modular manufacturer to evaluate the impact of a 1-bedroom modular unit that is produced in a 160,000-ft^2 factory in south Los Angeles. We compare this with similar stick-built multifamily construction by the same developer in Los Angeles. This study finds that modular production reduces construction waste through precise prefabrication, concentrated workforce expertise, and streamlined logistics while cutting transportation needs, improving project efficiency, and lowering associated timelines and costs. The cost and time savings from economies of scales and standardization are being realized as production levels increase. The modular unit manufacturer has produced over 500 affordable housing units and supplied for projects up to 188 units, thereby shortening schedules, lowering per-unit costs, and supporting affordable housing goals in south Los Angeles. Modular construction methods offer a scalable, resource-efficient pathway to increase the affordable housing supply, reducing project timelines by 48% and reducing materials waste by an average of 46% while simultaneously creating local jobs and training opportunities.

Introduction

The construction industry in the U.S. is under pressure from a high demand for affordable housing. Affordable housing is defined by U.S. Department of Housing and Urban Development as housing in which the occupant is paying no more than 30% of gross income for housing costs and utilities. One approach to improving the overall efficiency of construction projects is through the production of cost-efficient modular housing. In fact, the promises of modular construction hinge on delivering affordable, rapidly deployable, and scalable housing solutions. Terner Center research shows factory-built housing can reduce hard costs by 10%–20% and construction timelines by 20%–50% under the right conditions [1, 2]. Currently, the average ground-up multifamily development project in the U.S. requires 24 months to complete the construction phase [3], while relying on labor-intensive methods that can sometimes also prove wasteful [17]. At the same time construction costs are rapidly rising, especially in California, where an affordable development costs over $600k per door on average including land cost [3], an increase of nearly 10% since last year [4]. Similar construction costs for affordable housing in California have been documented recently by the Terner Center, showing that one subsidized housing unit funded with Low Income Housing Tax Credit (LIHTC) equity in 2023 cost approximately $708,000 to develop [1]. In this paper, we will show how modular construction for a large California based affordable housing developer has evolved to offer a more efficient and economically sustainable approach to building multifamily units, starting with a repeatable and standardized design and development process and currently working to implement further standardization through a modular construction delivery process. Data from this study shows how modular construction utilizes off-site production, harnessing the benefits of factory environments that enable overall greater precision, better resource utilization, optimal timeline and labor management, and the reduction of on-site errors via labor. A factory's streamlined logistics also reduce waste and improve project timelines, greatly reducing delays and change orders. We show that by adopting industrial best practices in manufacturing and assembly, developers can achieve significant cost savings and expedite project delivery. Furthermore, there is significant legislative momentum as the California State Assembly holds multiple committee hearings on housing construction innovation, particularly on modular housing [5, 6, 7, 8].

Objectives

In this work, we use project data from a Los Angeles–based developer of affordable and workforce housing (SoLa Impact) [9]. Over the past four years, the developer has completed 24 ground-up affordable and workforce housing projects totaling approximately 1,400 units in Southern California. This experience led the project team to integrate modular construction as a strategy to increase the pace of housing delivery. The developer now utilizes volumetric modular units manufactured by Model/Z (the manufacturer) in a factory located in Watts, Los Angeles [10].

Based on data from several years of the developer's projects, the modular manufacturer designed a standardized module intended for multifamily housing applications [11]. This study compares two representative projects constructed in the same market and time period by the same developer. The first project includes 195 studio, one-, two- and three-bedroom units built on-site using stick-built construction methods, while the second uses modular construction with 66 one-bedroom units built in a factory and installed on-site. Available information includes bills of materials, project timelines, and project costs. The comparison is used to evaluate commonly cited claims regarding modular construction performance.

Modular Industrialized Construction

The modular unit presented in this study is a standardized 420 ft^2, one-bed stackable module sized to fit on a conventional heavy truck and engineered for stacking, transport, and rapid site installation, designed to meet a superset of California building codes, U.S. Department of Housing and Urban Development/Section 8 requirements, and Americans with Disabilities Act Chapter 11B standards. In the first implementation of that modular apartment unit, the construction team stacked 66 residential units and four non-residential service modules in less than 10 working days. The manufacturer uses a single unit design with an integrated mechanical-electrical-plumbing chase that houses plumbing, electrical, and service risers. The modular unit's product development followed three deliberate stages. First, the manufacturer optimized the module's structure for stacking and transport, which was a natural starting point given in-house structural engineering and metal assembly expertise. Reducing the cost and complexity of the structural frame yielded savings, as they reached a reduction of 6,000 lbs of steel. Once the structure was optimized, they harmonized floorplans, so modules fit together efficiently. Lastly, they industrialized production by defining subassemblies, standardizing components, and establishing an assembly-line process driven by takt time so each module is repeatable and predictable.

The manufacturer's factory is a roughly 160,000 ft² volumetric modular manufacturing facility. Reported early production in year one was two units per shift per day with an objective to reach a throughput of 2,000–3,000 units/year. As additional throughput and sufficient backlog is captured, greater economies of scale can occur with consistent throughput in factories improving repeatability and timelines as well as additional cost reductions through bulk ordering of products in a larger quantity and over longer time horizons. These improved economies of scale can add additional benefits already seen at a lower level of output when compared to traditional stick-built construction.

The developer's three-stage industrialization process reduces on-site scope and risk, enabling faster, more predictable builds thanks to (1) structural optimization of the module for stacking and transport, (2) floorplan standardization for efficient vertical and horizontal integration, and (3) an efficient assembly-line production process. Finally, the modular apartment unit is compliant with the Build America by America Act, as it is sourcing 100% of the steel for the chassis and approximately 67% of all materials from the U.S.

Use Cases

Modular Use Case: 66-Unit Multifamily Building

The partner developer has built a five-story, 66-unit project at 6200 Broadway shown in Figure 1. The development is financed with 70% conventional construction debt and 30% private equity from one of the developer's real estate funds. In addition, 80% of units are reserved for low-income residents (80% area median income [AMI]) and 20% for moderate-income residents (110% AMI) under the City of Los Angeles' ED-1 Ordinance. Executive Directive 1 (ED 1) is a policy enacted in the City of Los Angeles to dramatically accelerate and streamline the development of 100% affordable housing and temporary shelters. The modular units are manufactured and delivered by the modular manufacturer using their 420-ft^2 one-bedroom model. The units are transported on highways and weigh approximately 19,000 lbs. Modules are engineered as stackable, self-supporting units with a primary steel chassis sized for stacking up to five stories. Unfurnished modules are used as non-residential service modules that are empty, structural elements. On-site hookup is limited to discrete point connections per floor (e.g., water, sewage, mechanical duct/flange, and electrical/meter/feeder).

The modules are designed to exceed the California Title 24 energy efficiency code in an effort to lower the energy burden of low- to moderate-income tenants, and the design aims at maximizing factory work while minimizing on-site operations. For example, all-electric heating and cooling is used for reducing the amount of external connections, hence the one-bedroom module only requires electric, hot and cold water, and sewer connections. Fully unitized HVAC results in minimal central ducted air distributed, saving fan power. No additional connections are needed for natural gas, and the cable- and pipework is placed such that it aligns vertically from module to module. Title 24 code compliance modeling suggests a site EUI of 42.9 kBtu/ft^2/yr, 5% lower than the maximum code allowed energy use. The physical connection can be completed with low effort on the construction site, making it possible for the developer to set 66 modules in around 10 days, each module requiring less than 45 minutes to set between the moment it is lifted off the ground to the moment all connections are complete. Modules are shipped from the factory with complete continuous exterior insulation, while the external cladding is assembled on site after modules have been stacked. This approach shows how a designer can take advantage of controlled factory environments and construction processes to optimize architectural and engineering choices for the benefit of developers on construction and timeline cost.

Conventional Use Case: 195-Unit Multifamily Building

A seven-story, podium-type residential building, Crenshaw Lofts provides 195 studio, one-, two- and three-bedroom units above one level of subterranean podium parking [12]. The project leverages Transit Oriented Communities incentives to exceed standard zoning envelopes; in return, 22% of the units are deed-restricted at the extremely low-income level (30% AMI) and 9% at the low-income level (60% AMI). The shared spaces are 97,649 ft^2 including amenities such as a 10,635 ft^2 technology and entertainment center, while the remaining 118,482 ft^2 are wood-framed apartment units. Construction began following the Metro K-Line opening; completion is scheduled for the first quarter of 2026. The construction uses a traditional design method with five wood-framed stories above a concrete podium and is built to comply with local building codes.

Figure 1. One-bedroom modular units ready for shipping (top) and during site assembly (bottom). These units are a successful example of modular industrialized construction. *Credit*: Model/Z

Methodology

Data

We use data from primary sources in this work. For processes controlled by the partner developer and factory, we used mechanical drawings and technical specifications from the volumetric modular factory. This data is very granular and includes precise quantities from bills of materials, mechanical drawings, material stock dimensions, high-level waste take-off quantities from production and construction sites and precise construction timeline data. For processes executed by contractors, we used data supplied by the general contractor, often high-level aggregated data, such as total purchased volume of concrete and paint, total mass of steel, total length and type of lumber stock, and total surface of purchased gypsum board. On costs, the general contractor supplied a breakdown of labor and material costs billed by all subcontractors, their usage in the construction phases, and accurate project timetables for all phases. The developer self-reported the total project development costs with a breakdown of hard, soft, and land acquisition costs. We verified that these data were realistic by comparing to typically reported data for the U.S. construction market and found the conventional case to be within 10% of average market rates, as shown in the Results section.

Study Boundaries

The system boundary for comparative metrics is defined as modules A1 through A5 (product and construction stages, cradle-to-construction-completion) and are detailed in Table 1 below.

Table 1. Modules used in defining the life cycle assessment boundaries

Phase	Description
A1	Raw material supply
A2	Transport to manufacturer
A3	Manufacturing
A4	Transport to site
A5	Construction/installation

Modules A1 to A3 cover raw-material supply, transport to manufacturer, and manufacturing. This boundary is typically called “cradle-to-gate.” Module A4 covers transport to site, while A5 covers on-site installation. In the conventional test case, we can make an accurate account of life cycle costs in phases A4-A5, which are the phases completed by the developer, while we made a best assumption for phases A1-A3 based on published literature and the overall quantities obtained from project data. For the modular project, however, the developer was in control of phases A2-A5 for most of the product supply chains because the volumetric modular units are produced in-house, by the Watts factory. Therefore, data availability is more granular and provides better confidence.

Baseline

To establish baselines for costs and timelines of conventional construction processes, we used the RAND Research 2025 report on “The High Cost of Multifamily Housing in California,” which collected data from nearly 100 projects to compare detailed costs and timelines across Colorado, Texas, and California [13]. This report provides an extensive and up-to-date dataset on affordable housing development in California. We contrasted it with findings from the Terner Center 2024 report on the impact of prevailing wages on Low-Income Housing Tax Credit projects that establish a higher per-door baseline of $708k in 2023 [1], and we used the California Cost of Construction Index (CCCI) as an accurate indicator of inflation during recent years [14].

Results

Timeline

We document construction timelines in Figures 2 and 3 as recorded by the general contractor and by the project developer. The developer has estimated that the project could take 11.7 months to complete the construction period from start-to-finish. However, in this comparison, we found that the modular project took about 519 days, or 48% less time compared to the conventional project (994 days), and 15% less time than the average affordable housing project in California (610 days) [1, 2]. This is largely due to the fact that in this project, the modules were fabricated almost 250 days in advance and stored off-site before the construction began, but in future projects they could be fabricated just in time for the superstructure construction phase. If the modules were manufactured just in time, then the project would have indeed taken 12 months for construction. Furthermore, the total construction time for the conventional case excludes the time needed to pour and dry the concrete parking and podium (73 days).

The developer notes that in the future, they expect modular construction times to improve further thanks to lessons learned from this project, for example in the areas of procurement and crane staging. In particular, the panelized roof saw important delays in delivery.

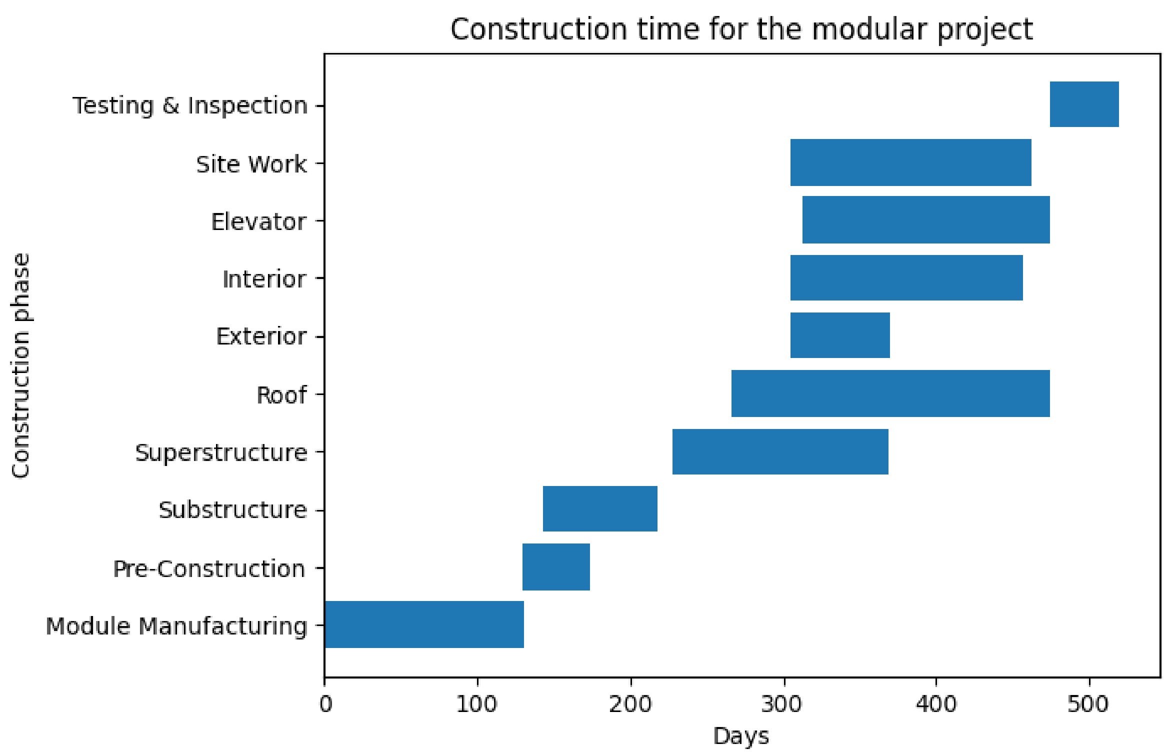

Figure 2: Construction time, in days, for all construction phases of the modular project.

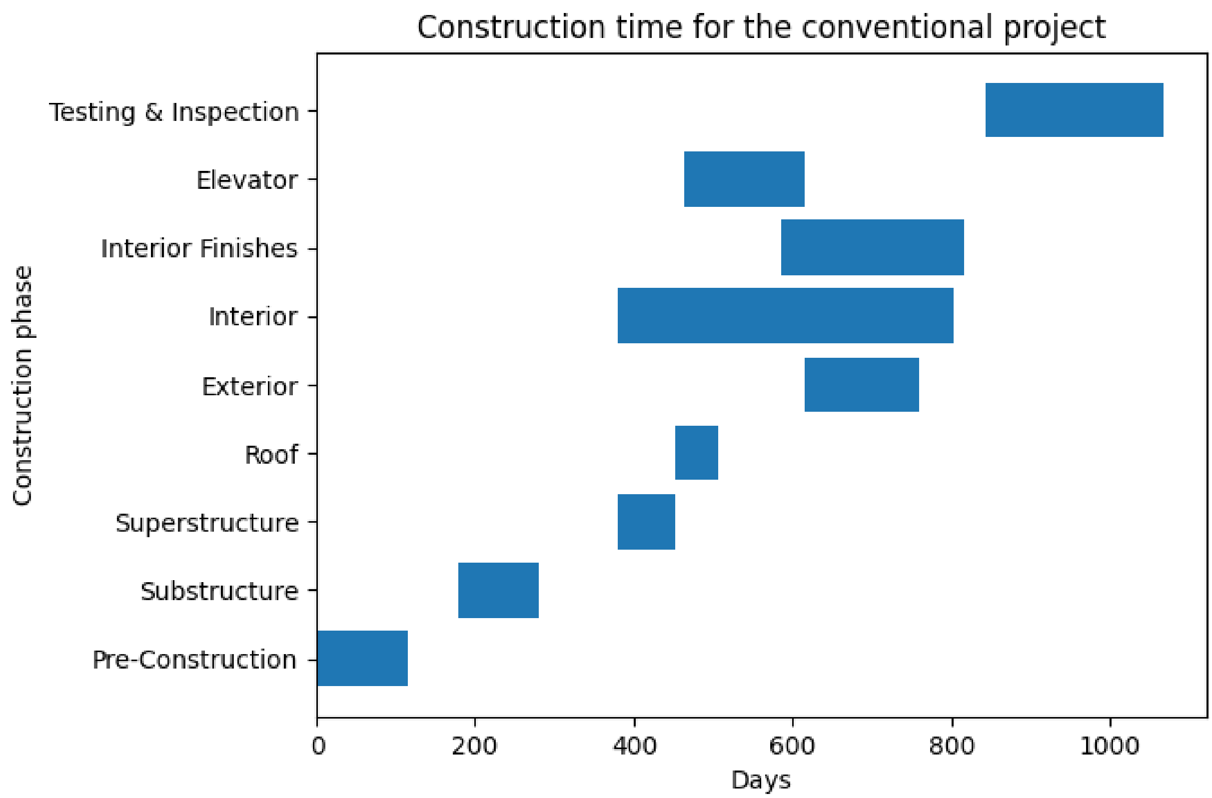

Figure 3: Construction time, in days, for all construction phases of the conventional project

Cost

Costs for the conventional project included hard costs, such as material and labor, and soft costs, such as architectural and engineering services, permitting and impact fees, legal services, and project financing. We have subtracted land costs from the total development cost to account for differences in land costs and focus specifically on construction costs. Likewise, we have subtracted the construction cost for the parking garage from the conventional project for a fair comparison of the costs. The building features studios and one-, two- and three-bedroom apartments; however, the average unit floor area was 637 ft^2 and the average studio and one-bedroom floor area was 552 ft^2. On a per-unit basis the total development cost for the conventional project is \$432,485 per unit, or \$678/ft^2, while the one-bedroom modular project's total development cost was about \$344,331 per 420-ft^2 unit, or about \$818/ft^2. In our baseline [3], once adjusted for inflation using the California Cost of Construction Index (CCCI) [3], the average cost for developing affordable housing in Los Angeles is \$608,000 per unit, or \$973/ft^2. These costs are reported by the developer and consistent with publicly available data on these construction projects.

The reported conventional construction costs for this developer's site built non-modular apartments are about 30% below industry average, both the costs per door and per square foot. We compared the cost reported on the modular project to the baseline and the conventional project in Table 3 below. Percentages are all expressed relative to the industry average construction cost.

Table 3. Comparison of costs reported by the developer for the conventional and modular cases to the baseline average costs reported in the literature

	RAND Baseline	Developer-Conventional	Developer-Modular
Per unit	$608,000	$432,485 (-29%)	$344,331 **(--44%)**
Per square foot	$973	$678 (-31%)	$818 **(-16%)**

In this case study, the developer's first modular project has lower costs than the local industry average, but it is more expensive than the same developer's other conventional projects. It is important to note that the Terner Center for Housing Innovation reports higher average costs [2] in the California market, reaching as much as $770,000 per unit, but the data represents state-wide average, while the baseline we use is specific to Los Angeles.

In Figure 4 we show that for the conventional project, about 62% of the reported hard cost is dedicated to labor, and 38% dedicated to materials. In the modular case, this ratio is 47% to 53%, respectively. Finally, in the industry-wide baseline, this ratio is 60% for labor and 40% for material costs on average for affordable housing projects built in Los Angeles.

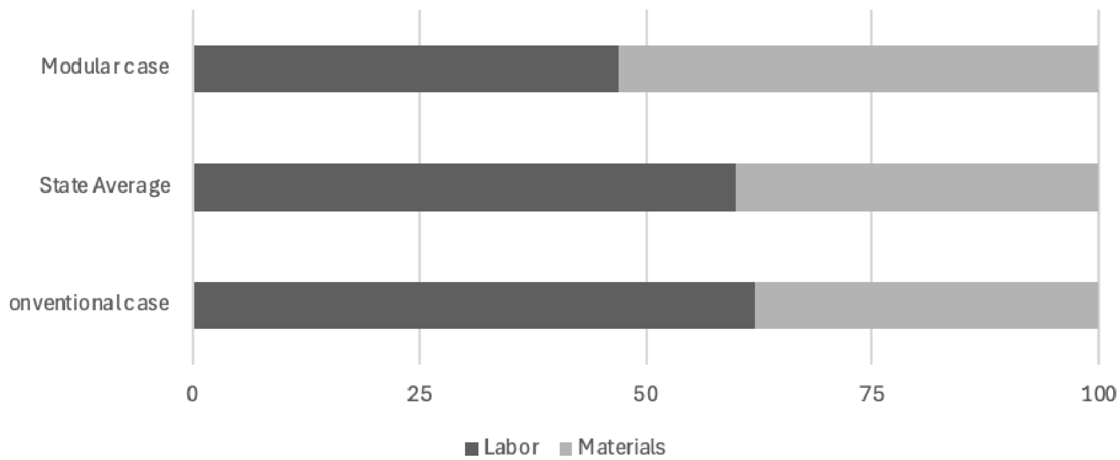

Figure 4. Proportion of hard costs attributed to labor and materials in the modular, baseline, and conventional cases

Materials

Notable differences are seen in material usage, as reported in Table 4: The shift from wood-framed to metal-framed means that we see a higher proportion of recyclable and locally sourced materials like steel in the modular case, while we see a reduced amount of lumber. We also see that the modular case uses a lower amount of gypsum board, a material with high wastage rates and commonly found in large quantities in construction waste [15]. On a per-unit basis, differences in concrete usage can be explained by the presence of a podium and a parking garage in the conventional project, which uses as much as three times more concrete than the modular project.

Table 4. Material usage comparison showing the change in material types and quantities

	Project totals - t		Per unit - t	
Material	**Modular**	**Conventional**	**Modular**	**Conventional**
Concrete	1983.8	18168.0*	30.1	93.2
Steel	138.8	71.7	2.1	0.4
Gypsum and Cement Boards	79.7	1028.3	1.2	5.3
Metal—Other	151.7	6.4	2.3	0.0
Glass/Glazing	5.0	-	0.1	-
Polymers	79.4	39.4	1.2	0.2
SureBoard	34.7	-	0.5	-
Lumber	0.2	211.8	0.0	1.1
Interior Insulation	50.3	-	0.8	-
Waste Generated	218.3	1940.0	3.30	9.9

** including podium and parking garage*

Waste

We reviewed waste take-off quantities billed to the conventional construction project. We assumed that all 40-yard containers are filled to the maximum capacity of 5 tons. When compared to the total mass of materials billed to the project, the overall waste rate is 11.5%, which is consistent with typical construction waste. In the literature, we find that worst case scenarios waste 30% of construction material, while best-in-class practices could bring this down to 5% [16]. Similarly, we reviewed waste take-off quantities for the Model/Z project and estimate that between 3.7% and 8.7% of material was disposed of, in relation to mass. Of that waste, about 20% is sorted on-site, while 80% represents mixed waste, expressed as a fraction of volume. This represents a waste reduction of around 24% to 67%, or an average of 46%, compared to the conventional construction project.

Discussion

This case study finds that the developer has delivered both the conventional and modular projects at a lower cost than the industry average. However, when built by the same developer, the modular project has a cost about 20% higher than the conventional one on a per-square-foot basis. We think that this is due, in part, to inefficiencies of ramping up the modular learning curves for the construction of their first modular project. In fact, while the developer has extensive experience with conventional projects, this was their very first modular project with Model/Z. The developer’s long-term goals for modular affordable units are to deliver each unit at a total development cost (TDC) of $250,000. With their initial attempt coming in at a TDC of $344,331 per unit, continued development, design, and production and manufacturing efficiencies will need to be accelerated. If they are ultimately successful in achieving this modular TDC goal, they would have reached a cost about 13% lower than conventional on a per-square-foot basis. The developer is already planning a second modular project and wants to apply lessons learned from their first modular project to reach 10% savings per door

(~$335,000/door TDC) when compared to the modular project presented in this study. Continued improvements and results documentation is warranted to verify that learning by scaling can indeed result in continued TDC compression in modular over time.

Construction timelines show a meaningful improvement, with the modular project completing 15% faster than the state baseline and 48% faster than the conventional project. Findings from this case study indicate that modular construction can substantially reduce affordable housing construction timelines. The developer's first modular project was completed in approximately 11.7 months versus the 24+ month timeline typically associated with comparable conventional projects. The expectation is that some additional cost advantages of modular construction will emerge through future cost reductions through scaling production in addition to the time savings already realized. Construction timeline savings alone create meaningful economic benefits through reduced carrying costs, lower interest expense, faster lease-up, earlier revenue generation, and reduced project risk, key for future cost compression goals for more affordable housing.

This study reviewed material usage for two use cases, and it underlines a shift in material proportions and types due in part to the high level of industrialization in the manufacturing processes undergone at the Model/Z factory, and in part to faster construction timelines. In fact, we can see a better proportion of recyclable and locally sourced materials in the bill-of-materials, such as steel sourced in the U.S., and a reduction in landfillable materials such as gypsum board and lumber. These materials typically suffer from high wastage rates, whereas the components used in the fabrication of volumetric modules are optimized to provide low wastage rates, for example by designing certain dimensions to better fit stock sizes. Overall, the modular case produced at least 24% less waste, and at a maximum of 67%, compared to the conventional case.

Conclusion

This paper reviewed data from a Los Angeles-based affordable housing developer to compare one conventional construction project to a volumetric modular project and to national and state baselines. The results show an increase in total development cost (20%), a strong improvement (15%-48%) in construction timelines, and a reduction in generated waste (24%–67%) in the modular case compared to a conventionally built project. It is also important to note that the developer's conventional construction projects benefit from more than 7 years of experience delivering 1,400 units across 24 projects in Los Angeles. Those projects reflect a highly optimized development and construction process that has been refined over many cycles. By comparison, the developer's first modular project served as a learning and validation project for their modular production system. Their first modular project generated critical operational data that has already informed improvements in design standardization, logistics, inspection processes, and installation sequencing. The difference between the approximately $340,000 per unit cost observed at their first modular project and the developer's long-term target of approximately $250,000 per unit should therefore be viewed as the difference between a first-generation demonstration project and a scaled production platform over the next set of projects. The study also suggests a shift in material and waste composition that places modular construction as a means of improving efficiency in the industry going forward.

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AI Disclosure

No AI tools were used in the preparation of this manuscript, nor in the associated research activities.