# Volumetric Modules for Mixed-Use Buildings: Logan at 51st A Case Study

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Modular construction has been a building technique since the 16th century and has since been refined into one of today's leading construction approaches. Modular construction is the process of manufacturing buildings or structures off-site. Modular construction is split into panelized systems which are two-dimensional system or volumetric system which are three-dimensional. This paper will examine the largest volumetric modular project, The Logan at 51st, in the Bay Area which is set to be complete by the end of 2020. This paper will outline the current modular construction trend; the different types of modular construction; the process that led to the selection of modular construction; the project specifics; the benefits of building using steel modules; the challenges encountered on site; the challenges faced off-site; the lessons learned; and recommendations for future modular projects. The project encountered many unique challenges due to the geographic location, the political environment of the Bay Area, and the combination of site built and off-site components. Even though there were many shortcomings of the project it proved to be a successful project and provided a lot of insightful information that can be useful for modular projects in the future.

**Key Words:** Modular Construction, Mixed Use, Steel Modules, Collaboration, Volumetric

## Introduction

The benefits of modular construction when optimized can deliver reduced build costs, overall lifetime costs, accelerated build schedules, greater certainty on build times and costs, improved quality, increased energy efficiency, and seismic performance. The benefits of modular construction on projects heavily depends on the degree of repeatability, unit size, density, and proximity to a factory. The logistic costs of transferring a pre-designed project to modular project can often outweigh the benefits, therefore it is recommended to engage with manufacturers, engineers, and contractors early in the design process. When done right the benefits can be a 50% reduction in construction time and 20% reduction in project costs according to the McKinsey report 2019.

The Logan at 51st in Oakland, California (see Figure 1) is a mixed-use project with 204 residential units, 35,000 square feet of retail and a 25,000 square foot roof top farm. The project is being developed by RAD Urban, a module developer working to transform the way buildings are built in urban cities. Being a vertically integrated company with in-house architects, engineers, builders, manufacturers and real estate developers the feedback circle was stream-lined, and they were able deliver high-quality projects with award-winning designs. RAD Urban is

currently focused on development in the Bay Area and have completed 6 projects, each new project being bigger than the previous one.

*Figure 1:* The Logan at 51st rendering
*Source:* iNew Homes

## *The modular construction industry*

The earliest documented prefabricated houses were built in Great Britain and shipped to the fishing village of Cape Anne (Massachusetts) in 1624. The Britain's decided to prefabricate houses because it was unknown was raw materials would be available for new settlers upon arrival in unfamiliar territory. (Abraham, Kennelly, Kim, Lu. 2012) In 1830 the Manning Portable Colonial Cottage was the next evolution for prefabricated homes which was created by London carpenter John Manning for his son who traveled to Australia. This design was an improvement on earlier frame and infill designs because it offered ease of construction. Fast forward to today Europe continues to lead in innovation and implementation of modular building methods. According to the National House-Building Council (NHBC) 60 percent of home builders in the United Kingdom have invested or plan to invest in the near future in manufacturing facilities. According to a McKinsey report "Modular construction could scale up to an industry that represents more than $100 billion in US and European real estate, delivering $20 billion in annual saving." (McKinsey p. 5)

The term modular construction can be used to describe many different things, each having their own level of complexity and benefits for scale (see Figure 2). The simplest being one dimensional which have elements that can easily be connected, to fully finished volumetric units. There is many debate in the industry on which method is best and most efficient but it really depends on what the modules are being used for. Currently, the range of applications of modular construction is in cellular-type buildings such as hotels, student residences, military accommodations, and social housing, where the module size is compatible with manufacturing and transportation requirements. (Lawson, Ogden, Bergin 2012)

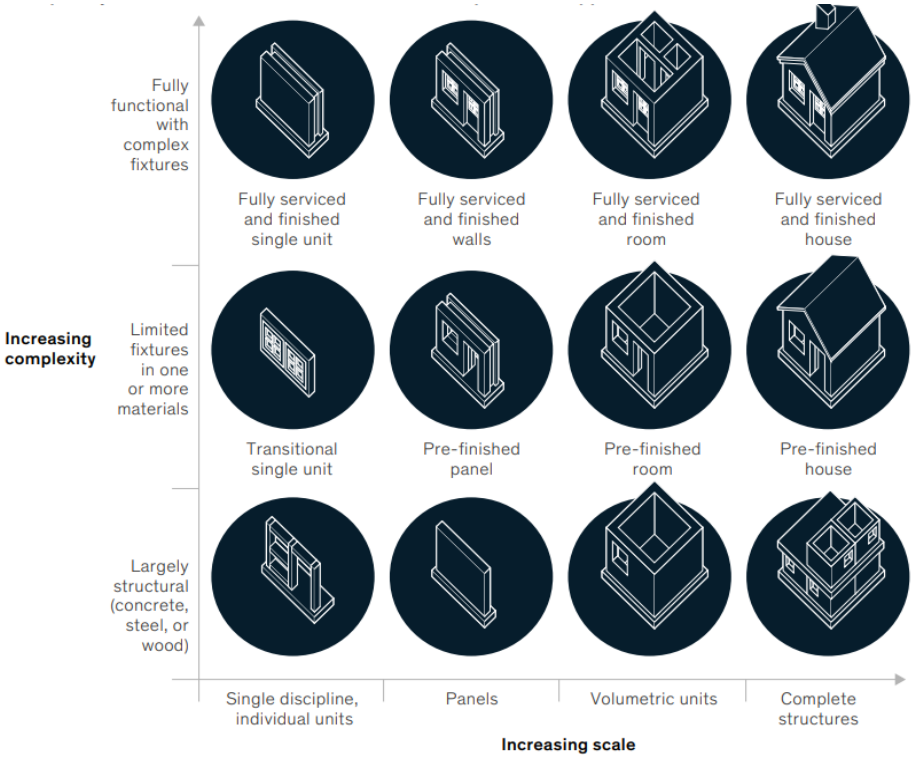


*Figure 2*: Complexity and scale of modular construction—comparison of approaches
*Source:* McKinsey 2019 p.8

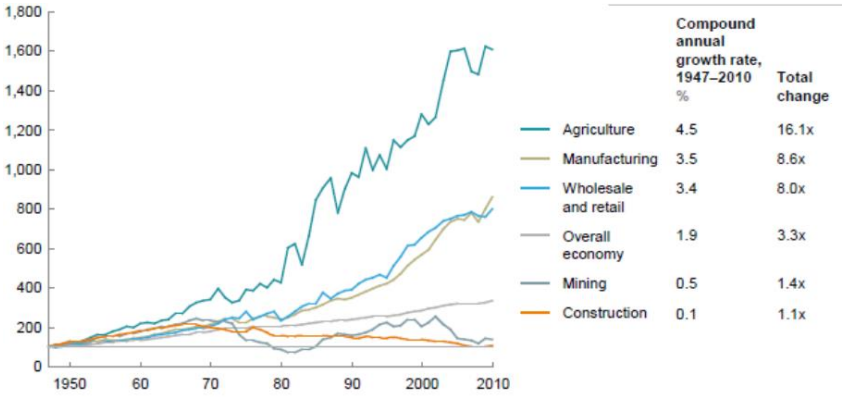


*Figure 3:* Productivity by Industry Sector
*Source:* Americanpiple.org

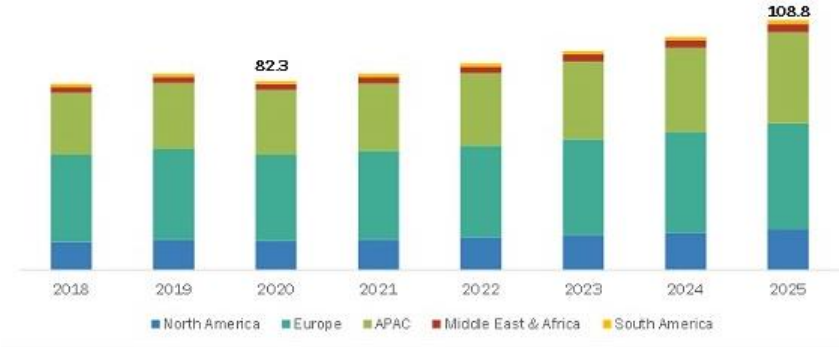


*Figure 4:* Modular Construction, by Region (USD Billions)
*Source*: Markets and Markets

The increase in demand (see figure 3.) for modular construction is mostly due to the decrease in productivity in the construction industry as shown in Figure 4. “The estimated breakdown of man-effort with respect to the completed building was 36% in manufacture, 9% in transport and installation, and 55% in construction of the rest of the building. The total effort in manufacturing and constructing the building was approximately 16 man-hours per square meter (1.5 man−hours per square foot) completed floor area, which represents an estimated productivity increase of about 80% relative to site-intensive construction.” (Lawson, Ogden, Bergin 2012)

### *Steel Modules vs. Wood module*

Wood-framed modules have been the common type of modular construction accounting for 70% in 2017, however over the past 5 year there has been a shift towards steel framed modules (Design for modular construction). This demand has been due to the increase in scale of module projects and the increase in sophistication of manufacturers. With steel framed modules, buildings are able to get taller and the manufacturing process can be dialed to have tighter tolerances because you’re not forced to work with poor lumber dimensions that is inherent when working with wood. With RAD Urban the tolerance goal was 1/32 of an inch.

## Methodology

The objectives of this case study are as follows:

- To report whether the volumetric modular development goals of the project were met.
- To highlight the challenges on-site and off-site with building modularly.
- To highlight the challenges of the tolerance gap between off-site and on-site construction.
- To highlight the benefits of using modular construction.
- To highlight the lessons learned from the project as they relate to developing modularly.
- To provide a recommendation for contractors or other developers looking at modular construction as a building option.

The methodology chosen for this project was primarily qualitative. The qualitative study was done through interviews with members from different departments within RAD Urban, other developers that have explored building modularly, and key subcontractors that were hired to work on-site. The interviews were focused around how building modularly has been beneficial and how it has affected there scope. The interviews were also focused on how the conceptual benefits and challenges translate to reality. The interviews took place when the project was close to completion; however, the interviews were with people that were involved throughout the construction of the project from conception to close to completion. The interview results were then analyzed by the researcher in order to identify and highlight the main similarities and differences. The information was then organized into goals, challenges on-site, challenges off-site, benefits and lessons learned. This information was then used to make suggestions to developers thinking about using modular construction on future development projects.

## Case Study

The Logan at 51$^{st}$ is a mixed-use development project located in Oakland, CA. The project was built on 3 separate parcels that consisted of a vacant lot, a parking lot, and an old bank that was later converted into a movie rental shop. The building is now a six-story residential and retail building with a 25,000 square foot rooftop farm and 2 story underground parking lot. The site is located in the Temescal district in Oakland which is a very sought-after community due to its thriving restaurant and entertainment scene. The supply of housing and retail has not kept up with the demand therefore over the last 5 years, rents have doubled in most cases forcing residents to move out. For many years many residents complained of the vacant lots not being used so this project was much needed. The site is built on what used to be a part of the Temescal creek which was later put into a culver and buried underground. This created a lot of problems during the construction beyond just dewatering issues.

### *Project Specifics*

The following are additional key details of the project as they relate to this case study:

- Project Hard Costs: $110 Million
- Project Timeline: 26 months
- Project Height: 74 feet
- Project Building Type: I
- Project Gross Area:  394,960 square feet
- Project Address: 5110 Telegraph Ave. Oakland CA 94609
- Modular Construction Goals:
    - Schedule acceleration: The benefits of building offsite is that the work schedules are not linear so the developer is able to stack different components of the building process that cannot happen on the tradition jobsite. For example, the manufacturing plant can start building units while the contractor is working on the foundation. In addition to stacking up different components of the building process, the modules are built indoors so the process is streamlined and not victim of weather delays. The anticipated acceleration was a 20% schedule reduction.
    - Cost savings: The benefits of streamlining the development process not only saves the developer money on the carrying costs of building a project but also hard cost savings. The anticipated savings was about 20% hard cost savings.
    - Innovation: The other goal of this project was also to test the design module (Version-4) and see how they stack up. The goal for RAD Urban from inception was to build High-rise buildings which are the next two projects in the pipeline.
    - Development certainty: With modular construction being a way to have more control over the factors that impact a project. One of the goals set out from the beginning was to solve a problem that many construction projects face, to stay within budget and on schedule.

*RAD Urban Module*

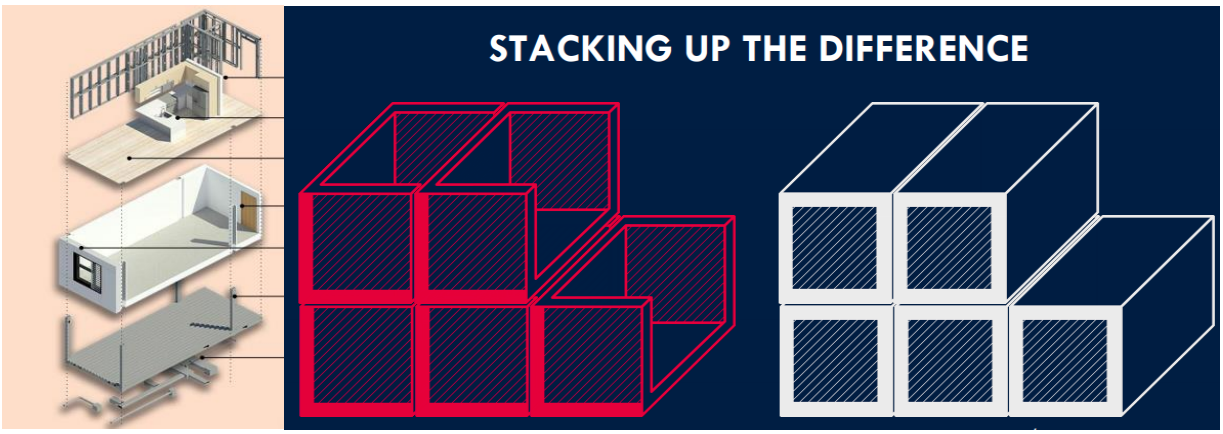


Figure 5: The RADBLOC
Source: SPUR

The RADBLOC (as shown above in Figure 5) is what allowed RAD Urban to have the competitive advantage when developing modularly. The RADBLOC

1. The four-sided module eliminates the redundancy in most traditional modular development. This reduction in redundancy also allows for taller interior space and more rentable square footage making the units more attractive for the tenant making

2. Having steel framed modules allow for more accurate production and a reduction in waste. These factors lead to cheaper production costs, more sustainability. Steel framed modules are also stronger which allow for taller stacking.

3. The RADBLOC was designed to fit on the back of the trailer like a normal trailer which reduced the transportation costs and logistic planning.

4. The steel modules allowed for more design flexibility because of the structural integrity which made developing on irregular lots possible.

## Results and Discussion

The following information was gathered through interviews with key members from multiple departments within RAD Urban and outside the firm that worked with modular projects. The goal of this study is to gather and present the information as objectively as possible. In addition to information relating to the specific project goals set out by the developer, the project also experienced unique benefits and challenges through the use of volumetric modular construction that provide valuable lessons for the future.

### *Volumetric-Modular Construction Goals*

As mentioned previously, the developer set out specific goals for the project, some of which were met, others of which were not. While the project benefitted from innovation, it did not meet the goals of schedule acceleration, cost savings, or development certainty. The reasons for these outcomes are highlighted below

1. Schedule acceleration: When it comes to achieving the schedule acceleration of 20% the project fell short drastically because even though the modular components were fabricated to a 1/32" tolerance the onsite conditions weren't. This led to massive amounts of sanding and patch work on the podium where the modular units were placed.
    a. Even though the project schedule overall was delayed, towards the end of the placing modules phase on-site a lot of the friction encountered on-site was resolved and 6-8 modules were being placed on site everyday compared to the 3 modules a day in the beginning, which was higher than the original projections.

2. Cost savings: The projected 20% cost savings from less waste and reduced redundancy was realized in the factory. However, the project suffered with faulty on-site work which resulted in a lot of change orders and ultimately led to the project running over budget.

3. Innovation: This project was supposed to prove the efficiency of the Version 4 RADBLOC module. Which proved to be successful once the on-site team was able to become more familiar with placement of the modules.

4. Development certainty: The project was supposed to be an example of how building modularly at scale can solve a lot of the uncertainty that every construction project of that size faces. Many developers have ran into cost overruns that ended up hurting the overall returns of project. Not only was the cost overruns an issue but also the time delays kill the returns for the developer. In a world where a projects success is based on the project internal rate of return (IRR) the schedule delays can ultimately cost the developer that an increase in budget.

### *On-Site Challenges*

Even though this was not RAD Urbans first project, it was the biggest one they had faced thus far. With anything new, there is always unforeseen condition that cause projects to have many challenges. So, the on-site construction took much longer and cost much more than anticipated. The challenges were as follows:

1. Limited Scope for onsite work: one of the challenges the developer encountered that was unexpected was that subcontractors refused to do work on the project when the scope was limited to one thing. When the project manager was going out to get bids for different parts of the building that would need to be built on site some subcontractors simply refused to bid the project. In the Bay Area the competition for labor is

intense and there was more demand for subcontractors then there were subcontractors available. Which meant that subcontractor could pick the jobs they would bid on and projects that did not meet their minimum threshold was ignored. This led to contracts being awarded to less than idea candidates.

2. Underground Culver: The project was built on a buried river that was still active. Which led to a lot of dewatering and required the building to be very heavy to counter the static pressure from the water pushing the project upward.

3. Union Labor: The project was located in a prime location where a lot of traffic flowed in front on (Telegraph Ave) and besides the project on (51st). This led the project to attract a lot of unwanted attention and as soon as shoring was begging to get shotcrete the labor union stepped in and forced the developer to create 2 entrances to the site one for union labor and one for non-union labor, which further complicated the already challenging site logistics plan. They also protested in front of the site harassing the non-union laborers until the developer was forced to shutdown the site.

4. Inspections: Another reason for the scheduled delivery date delay was the regulatory process of getting a project certified in a city. Since the modules are manufactured off-site in Lathrop, CA the modules are inspected and approved at the state level which technically takes precedents over local jurisdiction. However, the city ultimately signs off on the project as a whole and gives the developer a certificate of occupancy that allows for people to inhabit the building. This caused a lot of back forth between the developer and the city because if the city wanted something approved the developer would have to make adjustment to all the modules.

## *Off-Site Challenges*

When it comes to developing projects modularly some of the biggest risks are not even on-site. The logistical challenges can quickly diminish any savings both in terms of time and money that were anticipated if not taken into consideration during the design process. Some of the challenges encountered are:

1. Transportation: Since the modules are manufactured off-site the modules needed to be shipped over 60 miles to arrive on-site. This required a very detailed traffic plan to be submitted to the city of Oakland and a lot of coordination with Caltrans. Not only was it challenging to get the logistics right, but it was also challenging to get the modules delivered safely with no damage. The wind would rip the protective tarp that was placed on the modules for protection which forced the driver to pull-over and repair the rip which took over an hour.

2. Quality: When building the modules to such low tolerances everything needs to be perfect for the system to work correctly. Working with the steel modules in the factory required a lot of inspections regarding the welding quality and dimensional correctness. In addition to the structural challenges of the modules, the finishes also fell short of what was designed because of exposed connection points.

3. Factory: The factory itself had to go through assembly line changes in order to build the modules efficiently, on schedule, and ensuring the work was done safely.

4. Financing: Most real estate projects require debt to fund the project. This process requires the developer to go out and pitch their project to financial institutions in order to secure financing, most institutions have what they are willing to lend on clearly defined and since building modularly at this scale is relatively new a lot of those financial institutions were not willing to lend on the project. The interest rates that the financial institutions would lend at, depends on their opinion of the risk associated with the project. When building a project using volumetric modules the banks are hesitant to lend on projects because the project over 90% of the projects success is reliant upon a separate company's ability to deliver.

## *Volumetric-Modular Construction Benefits*

The project demonstrated that there is a lot of benefits to module construction

1. The project benefitted from having a lot of the components built in a climate-controlled warehouse. This meant that most of the unpredictable and uncontrollable aspects of normal onsite construction such as weather was avoided. This led to an increase in overall safety of the workers and decreased the number of injuries to just one minor injury.

2. The fact that modules were all the same size and everything was modeled in CAD the quantity of material needed was known and RAD Urban was able to reduce the amount of waste by 30%. This reduction in waste is a prime example of the sustainable component of the project.

3. Since the modules are designed using steel frames that are subject to higher-than-normal loads the project was able to incorporate a 25,000 square foot farm on the roof. The farm will be managed by a local farmer and add to the project sense of community and sustainability.

4. The documentation process was also streamlined because the on-site team was able to get all the documents needed for close-out from the factory.

### *Volumetric-Modular Construction Lessons Learned*

Even though the project might not have been as successful as anticipated there was a lot that one can take away from this project.

1. It is crucially important to get all major stake holders involved early on so that everyone understands what is being proposed. Setting the tone upfront in regards to tolerances and why it is important to get things built as close as possible to what is shown in the plans will save a lot of time and headache in the future.

2. The key to making the project work is to put the time required to design the project properly in the beginning and then sticking with that plan. Since modular buildings operate as a system any change to a certain component requires that the whole project be re-evaluated because any mistake gets amplified.

3. Not only does the developer need to get the internal shareholders all on the same page but he/she must also get external shareholders such as municipalities on board, so they are not surprised when they arrive on-site. This is a key part of making the project successful because they ultimately decide when you can allow tenants to move in and you can begin to earn money on your investment.

4. There needs to be more time spent upfront to making sure modules are secure during transportation of the module from the factory to the site.

5. When doing something new there needs to be an understanding between the developer and the capital partner financing the project in regards to the risks. The success of the project depends on the buy-in from all the parties involved. When doing something new the capital partner needs to understand that the solution to a problem on-site that worked on other project may not apply to a modular building.

## Conclusion and Future Research

As RAD Urbans largest modular project the Logan at 51$^{st}$ provided a lot of information in regards to system inefficiencies. As labor continues to be a problem and construction productivity continues to decrease, many urban areas throughout the country will need to adopt something new. Modular building techniques have been around for a long time but the demand for an alternative way to build has never been higher. Many developers are considering building modularly as a way to save money on labor costs and there are many modular manufacturers around the country so this may seem like a viable solution to this ever-growing problem. This case study has found that there are many benefits to building modularly if done properly and even though the site was a challenge the project was still able to live up to the expectations as the project team got more familiar with the project. The cost savings realized at the factory and the time savings initially projected will likely be realized as subcontractors, developers, municipalities, and financial institutions become more experienced with modular development. According to the

majority of people interviewed, from different sides of the business, modular development is a good alternative to traditional construction because of the systemized approach. California is currently in massive housing crisis and the modular building method is highly effective when it comes to creating something with repetitive components like an apartment complex. As more capital is invested in housing and manufacturing plants and municipalities get more exposure, the system will become more efficient from both a time and cost perspective. This case study also shows that safety and sustainability are improved using this method which will also play a bigger role in projects as the intangibles become more valuable.

As more projects get built and municipalities do more research into modular building, it may be beneficial for future researchers to look at how zoning and building codes change to better accommodate for modular development. It will also be beneficial for researchers to look at case studies in the affordable housing industry and how tax credits will accommodate for modular development. This will provide more insights as to the role modular development will play in the future because if it can be systematically accommodated at the governmental level then developers are likely to be more willing to invest in the technology upfront. As more case studies are done on projects using modular development components the better companies will understand the ins and outs of developing modularly and can better prepare for it in the beginning, which will make the project successful.

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