The K90 Building Project

Foundation to Finish, Reimagined
Overview

Amid a housing crisis affecting major cities across the globe, the industry needs to respond by providing scalable resources and new processes. Some 70 percent of construction projects come in overtime and over budget. The industry norms of designing one-off multi-family homes and then turning over to a CM-at-Risk or General Contractor to send out to bid is cumbersome, inefficient, and no longer viable in the face of growing demand for housing.

Competitive market pricing, quality, safety, collaboration, consistent improvement -- all of these standard norms in other major industries are lacking in the current, most widely-adopted processes of building design and construction. It typically takes over 140 days to build a garden-style multi-family building and requires a large swath of skilled labor to complete it.

Katerra is working to change this, applying methods and tools such as digital technology, offsite manufacturing, and fully-integrated teams in an effort to improve construction productivity.

The K90 building project is one example of this effort. As a part of a larger multifamily development project underway in Las Vegas, Nevada, Katerra developed an R&D project to focus in on one building to ask the questions, “What can we deploy right now in order to optimize delivery of a single building as much as possible? What would it take to reduce the construction schedule by 40%, from foundation to finish in 90 days?”

The following case study details K90, Katerra’s response to building a 24-Unit Garden Style building in 90 days - from framing start to building delivery.
Today, Architecture, Engineering, and Construction (AEC) firms are building essentially the same way they did in the mid-1800s. Economies of scale simply don’t exist as most projects are designed, planned, quoted, bought out, and built as one-off, bespoke projects. This current state persists despite many projects sharing the same design components, standardized materials, labor skills, and other processes.

AEC has seen an annual productivity increase of only 1 percent since WWII, while productivity in other sectors has soared. In the United States, labor productivity in construction has declined since 1968, in contrast to rising productivity in other sectors.

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Background

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Today there is an incredible opportunity to leverage the established knowledge base from the other major global industries that have already capitalized upon their technology investment, including manufacturing, automotive, and electronics. Using a combination of process and product innovation, paired with the application of cutting-edge technology tools, the K90 project set out to optimize efficiencies and significantly decrease the time to project completion.

**Process Innovation: A Manufacturing Mindset**

K90 began with innovating the traditional processes and procedures of construction administration, including project scheduling and sequencing, labor models, and more. The team dissected every single piece of the project - big picture to nuts and bolts - to find ways to optimize the design and building process.

- Why does framing usually take 70 days?
- Why does MEPF install typically take over a month?
- What labor can be moved from the jobsite to the controlled factory environment?
- How can materials inflow and outflow on the project site be run better?

Examining these questions, and then dedicating individuals and teams to drill down into the nuances of each one, unlocked endless opportunities to optimize the construction process.

Working collectively towards the overall project timeline goal was a big mind shift for the team. It recast everyone involved as allies, rather than separate trade groups or vendors focused on only their own tasks. If a change in approach helped shorten the overall project timeline--even if it extended the time of that particular task--it was a win for the whole team.

Designing for manufactured buildings means that design must be fully finalized earlier in the process; iteration and clash detection needs to occur earlier and be finalized so that building components can be issued for manufacturing and made replicable for future projects. In this model, component design is an important discipline between architecture and manufacturing. Component designers break down 3D models into manufacturable building component pieces, defining what will ultimately deliver to the jobsite and how the building structure will be assembled.
To achieve the highest possible efficiency for K90, the team broke the project down into five main categories for “Work Breakdown Structures” - WBS, that are understandable by phase of construction:

- Framing
- Drywall
- Interior rough-in
- Finishes
- Exterior

When a manufacturing facility wants to build a complex machine - take an automobile - engineers representing different disciplines study each piece individually and iterate on their design to create a more perfect answer that is designed with actual fabrication in mind. This is how each deliverable was taken apart and pieced back together in the most optimized way possible. Then, using an integrated schedule, deliverables are viewed as a whole; instead of each piece being managed in an independent silo, components are planned with very granular details and managed like pieces of a bigger puzzle.

Katerra’s integrated factory model connects building design to the factory floor and job site. As people and materials moved through the K90 project, maintaining control of the jobsite environment was paramount; the jobsite operated as an extension of the factory, and vice versa. Constant feedback loops between teams on the factory floor and at the jobsite maintained momentum and created gains where traditional back and forth would have stalled the timeline.

“We’re proud of many of our achievements on K90, but one that stands out is the speed that we framed the building. We framed the building and got sign off from the 3rd party inspector in 26 working days. This is in large part to the Katerra Panelization process. Everything from component design, manufacturing, logistics, and field installation went smoothly which allowed us to stay productive on an aggressive schedule in the field.” -Jeff Burda, K90 Project Manager
Advanced Site and Delivery Logistics

Daily operations were set up in a precise manner, entirely different than a traditional construction site. The team started each day by managing and reporting on their Kanban Board, treating the jobsite like a manufacturing plant. This simplified the communications between the team and created real-time data and communication streams instead of using the typical assumed durations for the project. All of this was accomplished as a step toward using Parametric Scheduling and the use of Artificial Intelligence-assisted scheduling software.

One of the benefits of designing buildings for manufacturing is that the full bill of materials is known up front. Meaning teams are able to plan around every specific part for the project. At Katerra, each unique building part and product has a “KPN” - a Katerra Part Number. For the K90 project, the team used Katerra’s SAP enterprise resource planning system to plan when materials were arriving to the site. 70 percent of the materials on K90 were Katerra-made products, giving us even greater control on the delivery and staging.

Within the factory, each component was tagged with an RFID tracking number. Much like UPS or FedEx ship and track their packages, teams could identify in real-time - from factory to jobsite - the status of each building component. Instead of just knowing floor panels were coming, the team could predict their arrival down to the hour, with team members at every point to receive the delivery.

The largest contributor to non-utilized time was identified as travel. In other words, the daily hardware store runs. Travel and searching for tools and materials accounted for nearly 15 percent of labor hours on a traditional construction site. K90’s team used “Point-of-Use” (POU) delivery strategies to ensure that materials were in their specific utilization areas with an optimized work area staged with the proper tools and materials to limit the workers lost time looking for both the tools and materials that they needed for each specific job.

A daily POU delivery of critical materials was tracked on the project tracking board and an industrial engineer on the team received, audited, stored, and planned the transport of all of the materials for the building. Streamlining the delivery logistics at every touch point achieved a higher utilization of the workforce and eliminated any delays between handoffs. It also cut down on lost and damaged materials, with someone accountable to ensure everything was staged and stored onsite as efficiently and safely as possible.
Projects as Products

From site and context to personal preferences of different subcontractors, a myriad of items can guarantee that all building projects will have variability and discrepancies between the construction plan and reality. This is unavoidable; the interventions developed at Katerra and deployed through the K90 project simply work to mitigate unpredictability as much as possible. “Productizing” buildings as much as possible is a substantial piece of this effort.

Katerra buildings are designed to maximize the benefits of repeatable and predictable manufacturing, with the downstream benefit of streamlined assembly at the jobsite. By designing for manufacturing, the focus is on standardizing the highly repeatable elements of projects so every aspect of a building doesn’t need to be redesigned, every time. Working from a standardized “Kit of Parts” enables not only mass production of building components, but also better pricing control, and easier ability to 3-D model the construction assembly sequence to further improve pre-construction planning.

Building Platforms

Utilizing the methods outlined above, Katerra Building Platforms are made from manufactured assemblies and components; including wall and floor panels, casework, bathroom and kitchen kits, and more. Building Platforms are full-scale buildings optimized for manufacturing and field assembly. Using this methodology supports increased speed-to-market and early cost visibility, but also maintains a high level of building configurability to support a wide range of design expressions. Everything from roof pitch to exterior cladding systems, unit mixes, finish materials, and more can be applied to ensure each project meets pro forma needs and complements local community identities.

K90 utilized an early-stage Katerra Garden Market Rate Building Platform, a three-story walk-up multi-family building with components designed to be replicated.

Garden Market Design Configurations

- Unit library options that address regional size requirements
- A chassis library to accommodate project-specific mix needs
- An array of interior finish packages to serve a range of market tiers
- Two roof types and a multitude of exterior cladding and color options
Panelized Structural Systems

The K90 building was framed and signed off by a third party inspector in just 26 working days. MEPFP inspection occurred on the same day (26).

These accelerated timelines were made possible in large part by the Katerra panelization process. Pre-wired wall panels, integrated MEPFP shafts and floor panels all increased the level of completion offsite, streamlined onsite logistics and maximized every minute of onsite labor.

Katerra Structural Component Catalog:
- Roof Truss Assemblies
- Floor Systems
- Interior Wall Panels
- Exterior Wall Panels
- Utility Walls
- Door Framing
One of the most striking examples of this optimization of K90 building components was deployment of the Bath Kit, an innovative bathroom delivery system engineered to reduce cost and increase the speed to occupancy. Widely known to be one of the most challenging and elongated components of a building to deliver, Katerra has reimagined bathroom assembly by applying systems level thinking to optimize and simplify the process.

The bath kit includes an innovative ship cradle made from the tub/shower wall frame. Within the tub/shower are packed all other materials needed to finish the bathroom - the toilet, vanity, flooring, and all other fixtures and finishes. At K90, the bath kits were installed and finished in less than one working day, by just two people. This result represented a radically condensed schedule that removed the need for multiple sequenced trades, as well as a reduction in lost and damaged materials.
A Team of all Trades

The K90 team was intentionally formed with people from diverse professional backgrounds to bolster the key objective of disruption. From construction to aerospace to data analysis, a variety of perspectives and expertise facilitated constant collaboration and knowledge sharing between team members. The best practices and frameworks were taken from industries like aerospace, oil and gas, and manufacturing to implement a new way of building.

An industrial engineer skilled in process mapping created the site logistics plan, a chemical engineer with years in oil and gas ran data collection and product development testing on new manufactured assemblies, and a former ops consultant incorporated an operation management process to run daily production objectives. Each member of the team provided a unique value and brought a new perspective that allowed for improvements to be made across the entire supply chain.

While each team member focused on their individual scope, there was constant discussion across disciplines and tasks, with a focus on the ultimate project outcome in mind. As a result, constant brainstorming, iterating, and pivoting plans were par for the course. The K90 team quickly got comfortable being flexible, adjusting the plan, and depending on one another for honest feedback and input.

The Team

Rob Caputo | Director, Construction Operations
- Career in construction operations and estimating

Jeff Burda | Project Manager
- Background in construction engineering technologies

Tyler Pryde | Superintendent
- Background is in the construction industry

Kassi Mast | Rotation Associate
- Background in chemical engineering and field engineering

Amanda Sestrich | Manager, Operations Engineering
- Background in industrial engineering and manufacturing

Rob Fischer | Senior Operations Engineer
- 10 years experience in the defense industry working in missiles and fire control, information systems and global solutions, and aerospace

Thomas Murphy | Analyst, Business Intelligence
- Supply chain management, data analytics
Technology

Katerra’s focus on technology was center stage in the K90 project. It’s also an underpinning force behind the end-to-end service model of Katerra.

Application of technology was an integral part of K90 and making the process and product improvements possible. There is no one technology or software silver bullet; technological advances and innovations on the job site played an essential role in supporting more precise planning, stronger coordination across teams, and higher productivity at the K90 jobsite. Key examples included:

- RFID tracking building components from the factory to install real-time status updates, data feedback loops
- Katerra Apollo Construct software that integrated across the project and displayed current labor dashboards for team management
- Pre-wired wall panels fabricated in factory and placed onsite
- Building Information Model (BIM) development supporting step-by-step construction planning and early identification of potential issues
- Real-time data capture via robust video and daily drone-mapping, supporting rapid on-site adjustments and just-in-time delivery

The Katerra Apollo operating platform allows different teams to collaborate across every phase of the project. It automates tasks to accelerate workflows, improve decision-making, and return labor resources to direct toward more meaningful tasks.

As an end-to-end data platform, Apollo allows for both tracking and analysis of data throughout the building’s entire lifecycle, gathering collective data across teams. For instance, the K90 project is planned down to the individual labor hour. Laborers can scan in using QR codes on hardhats to track time, which leads to project transparency. The insights mined from data collected can then pave the way for continuous improvement.
Conclusion

The K90 project was a substantial undertaking. Made possible by an integrated team and willingness to try, fail, adjust, and improve. The project was successful in meeting its 90 day completion goal, while also providing a pivotal learning opportunity for future growth and innovation that will stretch far beyond just one building.

Many smaller individual innovations - across material tracking, schedule control, product development, labor usage, jobsite staging - all added up to play into the project’s successful delivery, ahead of schedule. Ultimately, the 90 day deadline was exceeded and the project was completed in 86 days, achieving time-saving progress through each key phase of the construction process.

Specific project phases that showed significant gains included framing, during which the framing time took less than half the time as status quo for typically stick built construction. Installation of the Mechanical, Electrical, Plumbing and Fire Protection engineering systems took less than half the time of traditional construction - and much of the labor was in factory production, instead of the field. The drywall team was able to complete installation in three days per floor, when traditionally it takes more than five days per floor.

The final task is to spread this knowledge throughout the company and see how these lessons can be applied to additional projects, both for similar and different building types. The team is currently creating process handbooks for each of the Work Breakdown Structures (framing, drywall, rough-in, finishes and exteriors) defined by the team at the beginning of the project. These will be used to identify new processes and products that are ready to scale, immediately, to all Katerra job sites. The handbooks have also helped identify problems not yet solved; pain points that can be fed back into the R&D team to help develop new solutions going forward.

90 days is just the beginning. Stay tuned for where this team will break new ground next time.

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<th>K90 Project Stats</th>
<th>Stick Built Status Quo</th>
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<tr>
<td>Framing Start to Inspection</td>
<td>26 Days</td>
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References


Thank you.