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Industrialized Construction for affordable, low-rise housing using Cross Laminated Timber with Modular Bathrooms and Kitchens.

Part One: An Introduction to Industrialized Construction for Housing

In this multi-part series, we will take a look at some of our work developing an Industrialized kit-of-parts for market rate and affordable housing in Northwest Arkansas. In this installment we provide some background and context for the systems used.

Background

Industrialized Construction (IC) is an umbrella term used for a set of practices that have been developed for manufacturing but are now, increasingly, being applied to construction. This includes the application of LEAN principles which emphasize efficiency in procurement and process over mass production. Prefabrication, which involves building components in a controlled plant environment and then transporting them in large sections, is another important IC practice. Modular construction, which standardizes components as products with options that can be specified to meet market needs, is yet another.

The current drive to incorporate IC in the construction sector is now fairly well established and goes back over a decade. There are several primary factors driving adoption, including:

- Cost escalation and volatility in the construction market
- Labor scarcity, particularly in skilled trades
- High market demand for housing, healthcare and infrastructure construction
- Demonstrated success of manufacturing methods in controlling costs and improving quality, particularly since the introduction of the Toyota Production System and other LEAN methodologies to the United States
- Availability of affordable digital tools and equipment, lowering the barrier to entry for advanced fabrication and manufacturing within the construction sector

IC products come in several common formats. **Volumetric** refers to a complete spatial enclosure that is delivered on site more or less finished and then installed over a foundation or floor system or stacked on top of another module. **Panels** are another common type of IC product and can include floor, wall and roof panels that come in a multitude of materials, formats and uses. **Rack and Skid systems** supply mechanical, electrical, plumbing equipment and distribution elements combining structural supports, building

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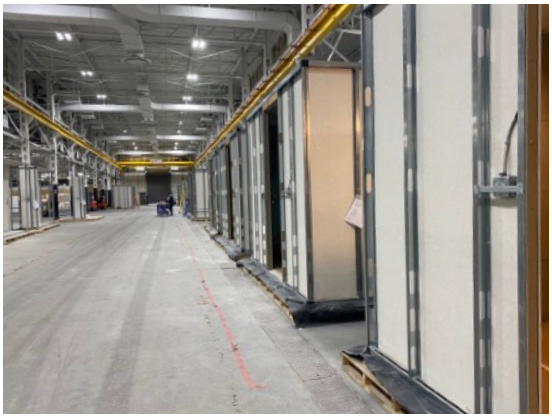
elements and connections from multiple trades into a single package, greatly reducing on-site labor, costs and duration.

Successful implementation of IC programs has been largely focused on the healthcare, mission critical and, to some extent, housing/ hospitality market segments. In many cases, a critical factor is the diversity of systems used. Successful efforts commonly use multiple systems in combination rather than a single product or modality. The higher the proportion of IC content, the greater likelihood of project success.

The final design of these systems and their interplay should be determined by owner requirements. Owners typically seek out IC systems due to constraints encountered in delivering either **cost, quality** or **speed**. The importance placed by the owner on one or more of these features should determine which systems are selected and how they are designed and deployed. A customer looking to increase speed to revenue will likely have a different mix of IC products used than one trying to manage a complex build out in a remote location. Often, the set of goals is a combination of weighted criteria, which places a high importance on problem definition and careful study of product selection, design and field coordination.



Top: Volumetric bathrooms and kitchens on production line
Below: Volumetric dwelling units being installed on site.

Industrialized Construction Programs

In our experience, the most successful adopters of Industrialized Construction are long term owner/ operators of facilities with a project pipeline that requires them to think strategically about construction sourcing. These organizations are in the best position to field the prototyping and set-up cost needed at the outset of an IC program. These programs perform the following functions on behalf of the owner:

- Initial product selection, design and prototyping
- Negotiation of direct to vendor purchasing agreements
- Management of design, project and construction teams using the product
- Tracking quality assurance and product performance
- Execution of an ongoing continuous improvement program

One of the important concepts that IC takes from manufacturing is continuous improvement, sometimes called kaizen. The basic tenet of kaizen is that incremental improvements to the production system yield exponential results over time. This is what unlocks the added value of manufacturing in terms of cost, quality and speed. Implicit in this idea, however, is the certainty that the cost of the initial units will be the most

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expensive by far, since all of the tooling and process engineering must be absorbed in order to manufacture of the first unit off the line.

The sensitivity of these early phase activities in manufacturing is one of the reasons LEAN places a heavy emphasis on extensive market research during initial product development. Given the cost of setting up a new product, its important for owners to carefully consider the ultimate customers needs, market size and cost targets. Availability of product and suppliers within range of the market are other important criteria to consider in this phase. Owners will also need to consider the different modes of IC products and the final selection may involve multiple products in combination. A program roadmap is sometimes developed to gradually phase in the IC program, with milestone targets and off-ramps to manage risk.

Above: Mockup review at manufacturing facility

Program managers will often start by helping owners identify a Minimum Viable Product (MVP) for the IC component and a pilot project for the initial roll-out. Pilot projects provide a proof of concept test for owners considering larger investments in IC and manage program risk. Problem definition, success criteria and pain thresholds for the pilot should be established early on during this phase, prior to any work on unit designs.

In most cases, owners will need to tailor the specific design of IC products to most effectively service the needs of the user and facilities teams. There is usually no “off-the-shelf” solution that will be completely responsive to the owners specific needs and so typically, the initial phase of the IC program involves converting a more or less pre existing chassis design to an owner-specific final design.

One of the less known benefits of this prototyping process for owners is the availability of functional, full-scale mockups during this phase. This gives facilities and user group teams the best opportunity to fine tune product design decisions. Because this is usually done within the actual manufacturing facility, owner teams can gain unique insight into the available options and capability of the vendor. These insights are often invaluable and can provide a competitive edge for the owner.

Another important benefit during this phase is the potential to realize cost benefits due to the Original Equipment Manufacturer (OEM) relationships plants have with suppliers. These allow manufacturers to source materials directly from factory to factory at reduced prices from what is typically available to owners through conventional distribution.

NEXT: An IC Program for Housing