INTRODUCTION

BACKGROUND

With a $1.6T productivity gap\(^1\) in the construction industry, exploring alternative means and methods is crucial to drive efficiency and solving some of our greatest challenges, including the shortage in skilled labor. Modular construction is a method of building that entails prefabricating modules or pods that are placed together to construct the final building.

Modular construction is not a new method; the first recorded modular building was designed in Great Britain\(^2\) and constructed in Australia in 1838. In the US, Sears Roebuck Company designed kit homes that were quite popular. These modular kits redefined the housing market from 1908 to 1940 by making home buying available via catalog order. On a larger scale, hotels have commonly been constructed using a modular method due to the repeatable nature of the typical building design, and the typically compact size of the rooms. Recently, modular construction has gained momentum across many building types and sizes due to the increasing need to reach market equilibrium. Industry leaders like hospitality giant Marriott\(^3\) are embracing modern modular construction, and residential markets are also seeing growing interest with the likes of Plant Prefab, which Amazon reportedly invested in last October\(^4\).
KEY INSIGHTS

One of the most immediate and clear benefits of modular construction is increased efficiency over traditional approaches. Time is money, so balancing labor costs can result in significant project savings. Today’s construction industry faces massive labor shortages, so utilizing our workforce more efficiently is incredibly beneficial to jobsite operations and eventually the bottom line for our clients.

Modular construction is typically more cost effective than traditional building – schedule efficiency alone can result in a cost saving of 20-30%). Faster deliveries enables building tenants to move in faster, which offers owners access to the potential revenue stream of an occupied building sooner.

There is robust opportunity for contractors of all sizes to learn, test, and implement a method new to many industry players.
HITT sees modular construction as an opportunity to transform how we build across asset classes, however, experience with modular construction to date has focused on the multi-family market. At the outset of this project, a small team was formed to manage the goals and scope. The project’s research goals were multi-faceted:

1. Report how modular construction may address industry inefficiencies, focusing on labor shortage and rising material costs
2. Explore the difference between a build-in-place method and the traditional prefabricated method, which involves transporting the modules from a permanent factory
3. Minimize post-setting construction activities on-site to reduce labor requirements
In typical modular construction, pods are prefabricated in a factory and transported to the jobsite for installation. HITT utilized a build-on-site method, erecting a make-shift temporary factory on site where the two modules were produced. By fabricating on-site rather than in a factory elsewhere, we were able to create pods larger than currently available on the market, as they didn’t need to be transported by trucks. This enabled fast-tracking during the stacking phase, since the final modules could be fastened together.

The on-site factory requires significant space, which will present challenges when building in densely populated areas. We are currently investigating solutions to this obstacle.

To meet the goal of minimizing on-site labor, the module was designed in partnership with Gensler to be a final product, complete with envelope installation, fully finished interior, and plumbing. In theory, the field team would be able to set the two modules together for a finished building product, minimizing post-setting tasks as compared to more typical prefabricated approaches.

Because the envelope was installed on the pod during prefabrication and obscured the connection points, the modules would have to be blindly set and connected, creating a new challenge. As a solution, HITT developed a custom connector (patent pending) during the design phase utilizing 3D-printed prototypes.

The connector was used as to fasten onto the crane during the lift, as well as being the attachment mechanism that keeps the modules securely connected. When designing the connector, many concepts were considered, including cables and rods. The project team collaborated with the structural engineer, ARUP, to test theories and ultimately determine the connector design.
While the test project’s primary goals were logistics and testing focused and time and money were secondary data points, we still found that the method fell close to the budget (within a 5% variance). However, the actualized cost per module is not scaled to an entire building since the test project carried all input costs. While the materials did not prove to be more cost-effective than traditional materials, the labor operations presented interesting findings.

“In my experience leading the field operations for the test project, I drew a lot of similarities to typical core and shell construction. It was similar in sequencing and process of course for materials, but being able to rotate subcontractors in and out was seamless. Each was working on one module at a time, instead of multiple trades crossing over each other, as tends to happen on a traditional jobsite,” says Bobby Hatala, HITT’s Assistant Superintendent overseeing the site operations. Maximizing our subcontractors reduced the gaps in the schedule, ensuring the most efficient labor usage both of the HITT project team and our subcontractors.

The completed final product fulfilled the design intent and met the vision for the process. The installation day ran smoothly as a result of the prefabrication; there were no unforeseen circumstances in the field. The custom connector design used to seamlessly secure the two modules was placed flawlessly. “It was unbelievable on stack day. We were all holding our breath to watch the connector be put in place,” says Bobby Hatala.

The on-site prefabrication method resulted in several key takeaways:

1. Shipping time was eliminated through the build-in-place approach, saving time in the schedule

2. Skin construction was fast-tracked as it was installed during prefabrication of the modules

3. Material cost was steady – we leveraged our buying power for materials

4. Labor operations were streamlined by eliminating schedule gaps between activities

5. Post-setting activities were minimized by fastening the finished modules to one another on stack day using the specialized connector
CONCLUSION

As with any research and development project, there are opportunities to improve the process and tools. One key consideration is the envelope – the selected materials were expensive, and we plan to choose different materials next time to decrease costs as well as installation time during the fabrication phase.

One notable challenge encountered by the project team during fabrication delayed the project by one month – when the first module was framed, it was clearly too tall. We had to decrease the modules’ height by roughly one foot, causing further delays, but ensuring we explored viable solutions. On the next phase of this project test, the heights of each modules will be further decreased, which will reduce our structural material costs and minimize input costs per module.

The second phase is in planning and HITT looks forward to further investigating fully prefabricated modules. As this method of building becomes more mainstream, it is important that we have the knowledge and research to best serve our clients. Although we did not find our test to have lower material costs than traditional methods, we do see modular construction as an industry opportunity to accelerate schedule and minimize labor, thereby addressing major industry inefficiencies.

SOURCES
2. EarthTechling, “A ‘Mod’ History – Modular Construction Makes a Mark” (July 2014)
4. Los Angeles Times, “Amazon wants Alexa in every home – so now it’s getting into the home-building business” (October 2018)
Co|Lab serves as HITT Contracting’s designated space for the research and testing of emerging materials, approaches, and technology that will rapidly transform the construction and real estate industries. This important work will rely heavily on collaboration amongst our industry and community partners, investing resources to mock up, test, and share our experiences broadly to improve the way we build.

**MATERIALS**

**EXPLORING INVENTIVE ELEMENTS**

Sourcing the right materials means understanding and trusting your options. Co|Lab provides a platform to bring the AEC community together to test innovative materials that benefit our stakeholders.

**APPROACHES**

**DEVELOPING EFFICIENT SOLUTIONS**

In an ever-changing landscape, we must constantly evaluate new means and methods that can drive productivity in the way we develop and deliver our built environment.

**TECHNOLOGY**

**HARNESSING THE POWER OF INNOVATION**

Leveraging technology requires a willingness to try new things. Co|Lab aims to test and showcase innovative solutions to equip decision makers with the knowledge needed to drive efficiencies.
Construction shapes the world we live in, driving economic growth, producing jobs, and creating the built environment around us. As building professionals, we must take responsibility for innovating and improving our industry.”

- Kim Roy, HITT CEO