Prefabrication and Modularization:
Increasing Productivity in the Construction Industry
Prefabrication and modularization are construction processes that the industry has used for centuries. So why in 2011 is McGraw-Hill Construction conducting forward-thinking market research on what many consider to be old, well-established methods used on construction projects? Well, to paraphrase the song, everything old about prefab and modular is new again. This reemergence of prefab and modular as a “new” trend is tied to the rise of BIM and green building, critical new trends identified by McGraw-Hill Construction and other industry leaders. The emergence of building information modeling (BIM) is influencing design and construction processes and how project teams collaborate. In the Business Value of BIM SmartMarket Report (2009), we found that a key benefit of BIM is enabling the increased use of prefabrication and modularization, which in turn improves worksite productivity and overall project ROI. Contractors were especially excited, with 77% believing that BIM would allow them to use prefabrication on larger, more complex projects in the future. The phenomenal growth in green building has also had an undeniable impact on the construction industry. Just last year, in Green Outlook 2011 we estimated that up to 35% of new nonresidential construction is green, representing a $54 billion market opportunity that will grow to $120 billion or more by 2015. Last year, in the Green BIM SmartMarket Report (2010), we looked at the convergence of the BIM and green trends and found that construction professionals who use BIM on green projects are more likely to do model-driven prefabrication than non-green BIM practitioners. These green BIM practitioners saw model-driven prefab as a way to design and construct greener buildings and have a greener site. Now, in this SmartMarket Report, we take a new look at prefabrication and modularization and their impact on a major initiative within our industry—improving productivity. Through an Internet survey of hundreds of AEC professionals, we gathered data on the impact of prefabrication and modularization on key industry productivity metrics including project schedules, costs, safety, quality, eliminating waste and creating green buildings. Some of the most significant productivity findings from prefabrication and modularization users include the following:

- 66% report that project schedules are decreased—35% by four weeks or more.
- 65% report that project budgets are decreased—41% by 6% or more
- 77% report that construction site waste is decreased—44% by 5% or more.

We would like to thank our premier partners including NIST, the Modular Building Institute, Island Companies, and SYNTHEON; and our other corporate & association partners for supporting this study.

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Prefabrication and modularization are processes that have been used by generations of construction professionals. Over the past century, these processes have developed a stigma of "cheapness" and "poor quality." However, through modern technology, that image has changed. Now it's a key component of the drive to improve construction industry productivity.

**Adoption and Usage**
Prefabrication and modular building processes are not new activities—63% of those that are using these processes have been doing so for five years or more. Given that prefabrication/modular construction has been around for many years, it is not unexpected that 85% of industry players today are using these processes on some projects—including 90% of engineers, 84% of contractors and 76% of architects.

By 2013, nearly all players (98%) expect to be doing some prefabrication/modularization on some projects. Among users, usage today is fairly low. Only about a third of users (37%) have been using it at a high or very high level (more than 50% of projects). Over the next two years, usage on projects is expected to moderately grow, with high or very high usage reaching 45% by 2013. Among all players surveyed, the highest level of current and future usage is among fabricators, mechanical contractors and design-builders.

Among all players, the primary reason they are not using prefabrication and modularization on some or all of their projects is that the architect did not design it into their projects. Owner resistance was the primary reason given by architect users (39%) and non-users (54%) for not including prefabrication and modularization into their designs.

**Building Sectors and Areas of Usage**
Adopters are using prefabrication/modular building processes on a wide variety of commercial building projects. In particular, respondents today are using it on healthcare facilities (49%), college buildings and dormitories (42%) and manufacturing buildings (42%). These respondents see the most future opportunity in healthcare facilities (14%), hotels and motels (11%), commercial warehouses (11%) and other building types (10%) that included data centers, prisons, power plants and oil refineries. These opportunities do vary by player type.
Within a building, prefabrication and modular construction are used in a variety of areas but most often in the building superstructure (27%), mechanical, electrical and plumbing (MEP) systems (21%) and exterior walls (20%).

When deciding whether or not to use prefabrication or modularization, the most important factor is the job site accessibility (58%) followed closely by the number of building stories (53%) and the type of building exterior (52%).

**Usage Drivers**
The most important driver to current usage of prefabrication and modularization is its ability to improve productivity (82%). This is particularly important to contractors (92%). All players also see these processes as making them more competitive in the marketplace (75%).

**Productivity Improvements—Primary Future Driver**
Architects, engineers and contractors are also very closely aligned in the belief that the primary drivers to future usage will be the improvements that prefabrication and modularization can provide to elements of productivity including project schedule, cost, safety and quality.

**Improved Project Schedules**
A key metric of productivity is the project schedule. 66% of user respondents indicated that prefabrication/modularization processes have a positive impact on project schedules, with 35% of those respondents indicating that it can reduce the project schedule by four weeks or more.

**Reduced Cost and Budgets**
Another key productivity metric is project cost as measured by the project budget. 65% of user respondents indicated that the use of prefabrication/modularization had a positive impact on project budgets, with 41% indicating that it reduced project budgets by 6% or more.

**Site Safety**
More respondents (34%) believe that prefabrication and modularization can improve site safety versus those who think the practices reduce safety (10%). Most users believe that these processes are safety neutral (56%).

**Green Building and Waste Reduction**
Green was not a major driver to prefabrication and modularization adoption. However, when asked about elements of green, including site waste and amount of materials used, a different story emerges. 76% of respondents indicated that prefabrication/modular construction reduces site waste—with 44% indicating that it reduced site waste by 5% or more. In addition, 62% of respondents believe that these processes reduce the amount of materials used—with 27% indicating prefabrication/modularization reduced materials used by 5% or more.
From the start, Texas Health Resources (THR) approached the Texas Health Harris Methodist Alliance Hospital project with the goal of improving the process for constructing hospitals moving forward, for THR and for the industry as a whole. The two main opportunities the project team has found were in using integrated project delivery and in maximizing use of prefabrication, including seeking prefabrication best practices in Europe.

Creating a Learning Opportunity

According to Denton Wilson, the director for facilities development at THR, the development team was charged with using this project as a test case for future work: “One of the tasks that THR put to this team was to get outside the box. Go out and find other things in other industries that would benefit our process.”

In a previous project, Wilson had begun to experiment with the use of BIM tools and an integrated design process. He took the opportunity to fully embrace these approaches in the Alliance project because of the benefits he had observed: “If you align the people together that actually build things as units and cohesive parts and pieces, it just opened up the world to do that. All the metrics [demonstrated] more value, quicker [work], fewer change orders.”

Thus the Alliance project began with a full commitment to an integrated design process and use of BIM.

The team at the Beck Group, the construction manager, shared THR’s goals. Dominick Calabrese, the director of healthcare services at the Beck Group, affirms that the opportunity to improve the construction process was the main benefit sought rather than immediate cost or schedule savings: “I don’t think we’ll see a huge savings [on this project], but what Beck is interested in, what our subcontractors and THR mainly are interested in, is what can we learn? How can we learn to do prefabrication on this project so that we’ll improve the industry and how we deliver [future projects]?”

He clarifies that the cost and schedule gains of using prefabrication on a small 188,000-square-foot hospital like this one can be minor, but the experience that they gain on it will pay off on larger projects.

Integrated Project Delivery, BIM and Prefabrication

For Wilson, using prefabrication in an integrated design process has an impact on the process itself; he argues that it encourages “the design philosophy of how to do the right thing from the beginning.” The need for accurate, buildable specifications early in the process reinforces the collaborative nature of the process between the designers, the fabricators and the builders.

Wilson affirms that an open, collaborative design approach, especially one using BIM technology, can also increase the use of prefabrication. “When you have a technology-based, strong project team who are BIM modeling, you are going to test prefabrication.”

Calabrese also finds this connection. He states, “Because IPD allows [the project team] to come together early in the design process, we are able to use the collaboration, our BIM technologies and other 3D modeling technologies to work with the architect, the owner and the major trades
to identify what can be prefabbad.” He cautions that “if you go through the traditional process and design everything first without considering prefab, you are just creating a whole lot of rework [if you ultimately want to implement prefabrication].”

Jeff Ratcliff, project manager with the Beck Group, points out the particular value added by working in BIM. “If it wasn’t for BIM, we would not get the level of prefabrication we are doing. We are coordinating so much in such detail, [and BIM allows us] to really maximize the prefabrication and go into the detail that we need to.”

BUILDING TEAMS

The greatest challenge associated with IPD is building the team’s sense of trust and cooperation, but that is also its greatest opportunity. Calabrese argues that one challenge for any new team is to get everyone, especially the subcontractors, to adopt what he dubs “the IPD mindset,” a recognition that it is the productivity savings for the project as a whole rather than for their own individual piece that matters.

“When Jeff and I were interviewing subcontractors for this project,” reports Calabrese, “we would talk about prefabrication. Invariably, everyone we talked to [said], ‘No, I don’t want to do prefab. I can do it faster in field,’ or ‘Yes I do prefab, so I don’t need to do anything differently.’” However, each contractor was only regarding their own individual trades, “looking at what is best for them as far as manpower and productivity, but not what is best for the project.” He explains that working in a factory setting may not save any of the individual contractors anything, but “that is better and more productive for the overall project than it may be for one singular entity.” He reports that once the subcontractors adopted this mind-set, “that is when they really got excited about the project.”

The adoption of the IPD mindset was particularly critical for the success of their most unusual use of prefabrication: the creation of multitrade racks for the hospital corridors.

CROSSING THE LINE

According to Wilson, team members were regularly surveyed to find out how well the process was working. One question asks whether the team is working with true trust and respect, while another asks, “Are the parties on the team actually crossing the line?” For Wilson, that ability to participate beyond the traditional boundary of their specialty is a good measure of the success of this project. However, the process of collaborating and seeking better approaches takes longer than simply doing what has worked in the past. Wilson believes that the process change led to a different product: 50% implementation drawings are weaker than a normal set of construction documents because in this kind of IPD project, “you are not building the drawings, you are building shops.” The entire process is fundamentally changed because it is geared toward implementation as a whole rather than just completing a set of documents, focusing on the end result rather than on the individual steps to achieve that result.

Multitrade Prefabrication

The most promising and challenging application of prefabrication on this project is the multitrade prefabrication of the racks in the hospital corridors. Since that approach is not common in the United States, the team went to the United Kingdom to learn how it could best be applied. Scott Brady, the president of DynaTen, the mechanical/plumbing subcontractor, describes a typical process in the U.K. for creating these racks: — “mechanical contractors hire [independent prefabrication firms] to
The hospital will feature multi-trade prefabricated racks in the corridors, an approach that is still new in the U.S.

**SAFETY**
According to Brady, the workers will be able to do at least 90% of their work with the racks at waist level rather than working from ladders in a multi-story building.

**QUALITY**
Working in a controlled environment also typically yields better, more consistent results than those produced by workers on ladders.

Of course there are challenges associated with this process as well, especially when it comes to installing the fully loaded racks. “These racks weigh in excess of 2,000 pounds and they are 20 feet long, seven feet wide,” states Brady, “but we’ve developed methods for lifting them, and we have made special lifts to get them in place.”

**Other Prefabrication Opportunities**
The multitrade racks were the most innovative use of prefabrication, but not the only example of this approach. The patient rooms will also have prefabricated bathroom modules and headwalls. Wilson states that “those two components are a win on every facility we will ever do” because of the efficiency and quality of the construction.

He mentions the ability to conduct sound attenuation studies of the headwalls at the factory as a factor that contributes directly to patient satisfaction. “Who wants to hear the patient next door? Now we get to do all those studies in a warehouse ... and we get to do multiple scenarios to [measure the benefits].”

Finally, there will likely be few deviations from the schedule. Wilson notes that dependability—knowing exactly when the project will be completed—is a major benefit of prefabrication.