

Utilizing Prefabrication in Lean Construction: A Reasoned Decision or an Educated Guess?

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This research poses three primary questions: 1) How do construction firms and industry professionals decide on which assemblies to prefabricate? 2) When deciding to prefabricate certain assemblies and components, do industry professionals perform a detailed analysis to compare the traditional means and methods vs. prefabrication in respect to duration of schedule and/or cost savings? and 3) Are the anticipated cost savings or the schedule gains tracked to determine the realized benefits at the completion of the project? To answer these three primary questions in depth, interviews were conducted with 10 construction industry professionals who are familiar with prefabrication and Lean Construction.

Key Words: Prefabrication, Prefabricated Assembly, Lean Construction, Cost Savings

Introduction

Prefabrication is not new it has been around for a number of years, but it is currently seeing resurgence as a feature of Lean Construction. Lean construction is a growing movement in the construction industry. What is Lean construction? The question sounds simple enough, so in theory it should have a simple answer. One of the struggles with the movement is that there is neither a consistent definition of Lean construction nor a consensus on how to best utilize and implement it (Hild, 2010). Most people would somehow mention that one of the goals of Lean construction is to eliminate waste. Gregory Howell, in his 1999 paper, *What is Lean Construction*, states, "Lean construction results from the application of a new form of production management to construction." Howell goes on to say, "Essential features of lean construction include a clear set of objectives for the delivery process, aimed at maximizing performance for the customer at the project level... and the application of production control throughout the life of the product from design to delivery." The Lean approach focuses on how value is generated as a whole, rather than the management of activities as individuals; activities are considered and managed as pieces of the greater whole (Howell & Ballard, 1998). Some of the tools implemented in Lean construction are Last Planner, increased visualization, daily huddle meetings, First Run studies, the 5s process, quality control and prefabrication (Salem, 2005). Lean construction principles and processes can be implemented on any type of project, as well as on any size of project or construction market sector, whether it be commercial, institutional, residential, or healthcare (Reiser, 2005). The earlier in the construction project's process a Lean approach is decided upon and implemented, the more effective its approach can be and the more value it can add to the project (Hild, 2010).

One aspect of Lean construction is the utilization of prefabricated materials. Prefabrication is defined as transferring the stages of construction projects from the field to an offsite production facility (Tatum, 1986). By utilizing prefabricated assemblies, modules, and components, which are assembled in a production facility and then integrated into a construction project, industry professionals can lower costs and reduce project time while delivering a product of higher quality. "The strong increases in productivity offered by using prefabrication and modularization fit squarely into the Lean building model. The difficult economic conditions in the construction industry have increased the appeal of Lean methods and practices" (Bernstein, 2011).

According to Bernstein, the most important factor in deciding whether to use prefabrication or modularization is jobsite accessibility; this was followed closely by the number of stories of the structure. Accessibility is important to facilitate delivery of the prefabricated assemblies. If transportation and delivery are problems, additional costs can be incurred in order to "get the goods to market." The number of stories in a structure is a way to gauge the repetitiveness of the building. For example, if the project involves a nine-story, four-hundred patient bed tower; general building knowledge dictates that those patient rooms will be repetitive and thus a strong candidate for prefabrication.

The aim of this research is to investigate the decision-making process related to prefabrication on Lean construction projects. Questions will include: 1) How do construction firms and industry professionals decide on which assemblies to prefabricate; 2) When deciding to prefabricate certain assemblies and components, do industry professionals perform a detailed analysis to compare the traditional means and methods vs. prefabrication in respect to duration of schedule and/or cost savings; and 3) Are the anticipated cost savings or the schedule gains tracked to determine the realized benefits at the completion of the project?

A primary issue related to this research and the use of prefabrication is the issue of cost. The interviewees were asked numerous questions about cost savings and how anticipated cost savings figured into their decision on whether or not to attempt prefabrication. As the researchers soon found out the issue of cost savings was somewhat complex and if the interviewees claim cost savings for prefabrication it was probably related to one of the following: Cost savings as related to time; Cost savings related to direct (sticks & bricks) cost; or Cost savings related to impact costs.

In regards to cost savings as a function of time, prefabrication is thought to reduce the overall job duration because prefabricated components can be assembled as soon as the project is awarded. And the installation time is significantly reduced compared to components that are completely field fabricated and assembled. Time is money on a construction project in the sense that every day a contractor is mobilized at the jobsite, the “meter is ticking” on the jobsite overhead and administrative costs, which include things like trailer rental, field laborer’s salaries, equipment rental, etc. This can be a significant portion of the overall project cost and by reducing the overall job duration you can reduce these costs. In a survey, 66% of user respondents confirmed that prefabrication processes have had a positive impact on project schedules. Thirty-five percent of respondents denoted that prefabrication can reduce the project schedule by four weeks or more (Bernstein, 2011). “Additional time may be spent in the design phase on complex projects to coordinate the use of prefabrication and modularization. However, the time saved onsite typically reduces the overall project schedule” (Bernstein, 2011).

An important factor to note is that almost half of survey respondents that are current users of prefabrication find that the combined purchase price and installation cost for prefabricated components is lower than the typical traditional purchase, assembly, and installation of material on the jobsite (Bernstein, 2011). Savings to the project budget attributed to prefabrication are not solely due to schedule improvements but can also be attributed to material and installation costs. A reduction in the project schedule, as well as in the actual cost of the procurement and installation of materials, creates significant savings when compared to the cost of traditional construction. (Bernstein, 2011).

Lastly, some commentators have attributed the cost savings related to prefabrication and its ability to limit change orders and other such impact costs. “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” (Bernstein, 2011). Project budgets on traditional construction projects are notorious for incurring cost increases due to change orders during the construction process. Even in situations when prefabrication appears to be more expensive, the avoidance of unexpected costs during the construction process is considered to be valuable, especially in situations in which budgets are inflexible. This certainty provided by prefabrication increases in value when it is combined with the guaranteed, high-quality workmanship (Bernstein, 2011).

Methodology

The researchers sought to explore the decision making process of individuals who employed prefabrication and frankly were unsure of what might be learned. An early decision was made to target individuals with significant experience in prefabrication and perform interviews to uncover answers to our research questions. All of the interviews were with primary sources who had been involved in the implementation and management of prefabrication. Primary data is described by Dr. Naoum as, “Data observed or collected directly from first-hand experience.” Our ten primary sources we interviewed included; architects, contractors, and specialty contractors. Most of the professional experience of the ten primary sources was concentrated in the Southeast United States.



Figure 1: Interviewee Demographics

From the interviews, an analysis was completed to draw conclusions regarding the current use of prefabrication in construction, current trends within the construction industry regarding prefabrication in construction, and where prefabrication in construction may be heading in the future. The interviews allowed for the collection of data from multiple points of view in the construction industry. While this research study is not claiming to be a complete survey of the population of construction professionals, it will allow preliminary conclusions which could be a stepping stone for future research. The questions posed in the interviews were open ended, allowing for a myriad of answers and perspectives about the implementation of prefabricated assemblies in commercial construction, as well as serve as a “jumping off point” for conversations about prefabrication as an aspect of Lean construction.

Interviews

This data and research revolve around three questions: 1) How construction firms, and industry professionals, decide on which assemblies to prefabricate? 2) When deciding to prefabricate certain assemblies and components, do industry professionals perform a detailed analysis to compare the traditional means and methods vs. prefabrication in respect to duration of schedule and/or cost savings? and 3) Are the anticipated cost savings or the schedule gains tracked to determine the realized benefits at the completion of the project? Ten interviews were conducted for this study, either in person or via the telephone. The interviews provided a myriad of results. Below I have provided excerpts from those interviews.

James Decker

James Decker a project manager with a large general contractor had this to say on the subject of prefabrication in construction. There was not a cost or time savings realized by the implementation of prefabricated assemblies on his project. “In this project, we are prefabricating patient rooms, in twelve double-units, which total twenty four patient rooms. Each unit consists of two exam rooms, built back-to-back. They literally build the unit down to the finishes in a prefabrication shop about forty-five minutes down the road,” (J. Decker, phone interview, June 25, 2012). “Our electrician had to basically make one connection in the field; all the switches and cover plates had already been installed. The plumber’s only field work was sleeving a riser through the slab, and then make a connection under the millwork to the sink (J. Decker, phone interview, June 25, 2012). Speaking further about the prefabrication, “We prefabricated twelve units, consisting of twenty-four exam rooms, out of the fifty-four exam rooms in the project. Six of those exam rooms which were not prefabricated were along an exterior wall, and did not have mirroring unit opposite them. This left forty-eight possible exams which could have been prefabricated, and we chose to prefabricate only half, due to cost” (J. Decker, phone interview, June 25, 2012). When asked if it was more expensive to prefabricate those twenty four units than it would have been to use traditional means and methods to stick-build, James said, “Yes, it was.” “This was initially set up as a hard bid project. Although the job was designed to facilitate the prefabrication and the modular construction, that was not in the bid documents. So it did not make it into the base scope, and was an afterthought. And in that scenario, you lose any competitive advantage of allowing the prefabrication to happen. So what we had to do was go back to our subs that originally bid the job, and work through some various pricing scenarios. Do we take a credit back from our field plumber for twenty-four versus forty-eight, and how does that compare against our modular subcontractor’s cost to build twenty-four versus forty-eight. Which is why we ended up with twenty-four because with forty-eight, the dollars weren’t working out? The cost was too much, and the credits we were getting from our field subs could not offset it.

Todd Humphries

An interview with Todd Humphries yielded a different response. In essence, they do not know if there is a savings

from utilizing prefabrication. Todd Humphries is an estimator for a large commercial general contractor whose prefabrication has been limited to the mechanical, electrical, and plumbing trades. “It is probably ninety percent gut feeling and being familiar with how buildings are built, when deciding what assemblies to prefabricate” (T.Humphries, phone interview, June 21, 2012). When asked about the decision to prefabricate certain assemblies, and the cost analysis in that decision-making process, Todd responded by saying, “We depend on the input from our subcontractors to tell us what makes sense and what does not make sense to prefabricate.... There is some analysis which goes into making the decision of which assemblies to prefabricate, however it does not involve putting a hard pencil to paper.... When asked about the savings created by utilizing prefabrication, Todd responded by saying, “We don’t know what kinds of savings prefabrication is yielding, since we have not done an in depth analysis or tracked the time and cost” (T. Humphries, phone interview, June 21, 2012).

Shane Garner

Shane Garner is the prefabrication plant manager for a large commercial plumbing contractor in Alabama. His firm has been prefabricating plumbing components since 2008, when they realized the impact of the potential savings it could bring. In 2009, they decided to build a prefabrication shop of their own. The company works mainly in northern and central Alabama, with annual revenues of approximately eight to ten million dollars a year, focusing mainly on commercial, institutional, education, and healthcare projects. “We try and prefabricate as much as possible on every project we do” (S. Garner, phone interview, June 12, 2012). Utilizing building information modeling software to detail their work has enabled the company to prefabricate assemblies to precise measurements, ensuring the successful installation in the field. “We hope to save twenty percent across the board in both the financial cost and the time it takes to complete the work on a project by prefabricating our plumbing assemblies” (S. Garner, phone interview, June 12, 2012). “In the past, we have done a poor job tracking our costs to see if we are realizing any savings. We are now implementing a tracking system to measure our savings in both time and money” (S. Garner, phone interview, June 12, 2012). It seems that as of now, the company does not know if the push to prefabricate has yielded any savings whatsoever.

Eric Rothrock

An interview with the director of preconstruction sees prefabrication as a tool, not necessarily to provide cost savings, but to make a project more constructible. Eric Rothrock is has been in the construction industry for two decades and has been utilizing prefabricated assemblies since 2009. As an executive with a medium-sized general contractor that works in the commercial, healthcare, and multi-family markets, they have utilized prefabricated assemblies on several projects. “We are currently panelizing the wood framing members of the walls as opposed to using the traditional means and methods of stick building. It has become a necessity in some of the urban jobsites where there is no room for a laydown area” (E. Rothrock, phone interview, June 21, 2012). “We also utilize prefabricated penthouse mechanical rooms” (E. Rothrock, phone interview, June 21, 2012). Going further and discussing some of the costs involved, he stated, “In the case of stick framing versus panelized wood framed walls, it is typically cheaper to build with traditional means and methods, especially if the project schedule and the amount of space on the jobsite are conducive, and the cost difference is usually between two and five percent of the contract amount for the wood framing. In talking about the cost analysis of prefabrication, he stated, “We look at each situation, and based on our experience, we make decisions about what to prefabricate, however there is not a hard estimate type of financial analysis done, but more of a few quick numbers worked out on the back of a napkin” (E. Rothrock, phone interview, June 21, 2012). “After buyout, we do not track the financial costs or savings to compare back to estimates. We have a contract for a price with the sub, and the amount agreed on in the contract is all that we are concerned with” (E. Rothrock, phone interview, June 21, 2012).

Ashley Colburn

In an interview with Ashley Colburn, on June 11, 2012, the head of a Lean initiative for a large general contractor in the commercial, educational, institutional, and healthcare markets, he stated that the largest benefit to prefabrication was the reduced duration of activities, which led to a shortened schedule. For a project in which they prefabricated mechanical soffits, it was the hope of the company to save time and cost, as well as increase quality; however, time (the schedule) was the most important factor. The decision to prefabricate assemblies was based upon some sort of analysis but can be described as “quick, rough estimates” instead of in-depth cost breakdown. Ashley stated that on

this project, the company did not create any cost savings or incur additional costs; however, quality was improved, and they experienced what was considered to be a substantial time savings. However, during the process, there was not a tracking protocol to see what cost savings actually occurred.

Callie Smith

During an interview on June 21, 2012, with Callie Smith, a project manager with a large construction manager who works in the institutional, higher education, and technology markets, she revealed their company has been using Lean principles since 2006 and prefabrication since 2009. Using building information modeling and reverse pull planning has helped establish prefabrication as a viable tool. The company bases the decision to prefabricate assemblies on input from the trades and past lessons learned. While no formal tracking system is in place, there is a general feeling of generating savings, especially in regard to the schedule, which relates to financial cost savings for the overall project. She noted there was also a feeling of increased quality, and in projects like data centers, which have large complex mechanical electrical and plumbing systems, prefabrication is necessary in order to meet such “tight” schedules.

Chris Giattina

In an interview with architect Chris Giattina, who is also a principle of a prefabrication company, we gained another perspective. When deciding to move in the direction of prefabrication, Chris stated, “We have been interested in prefabrication as a component of providing a better project for the last six years (2006)” (C. Giattina, phone interview, June 22, 2012) and have been prefabricating since 2010. He goes further to discuss which Lean principles they have incorporated, “We tried what we thought would work, and then made adjustments from there” (C. Giattina, phone interview, June 22, 2012). When asked about how they decide on which prefabricated assemblies to incorporate into the project’s design, Chris responded by saying, “We try to come up with solutions for our clients, if you don’t know what are the strengths and weaknesses of prefabrication, then designing for that is very difficult” (C. Giattina, phone interview, June 22, 2012). The architect says the he does not perform an analysis of either cost or time to compare the traditional stick-built components with the cost of the prefabricated modules when designing. When questioned on what kind of savings with respect to time or money can be realized by utilizing prefabricated assemblies on projects, he replied, “You’re starting off with the wrong idea; it is not cheaper to make them. There is more planning, more overhead, what there is less of is time. Assuming that what you are working on has a critical mass, what you are able to do is shave off time from the schedule” (C. Giattina, phone interview, June 22, 2012), meaning that time is his number one goal in prefabrication. However, does not have a tracking system in place to measure the savings created or costs incurred in respect to time. However, Chris states that he does try to design for the implementation of prefabricated assemblies in his projects and says that, “It takes an architect who is knowledgeable about this process, who knows what is possible and what can be done” (C. Giattina, phone interview, June 22, 2012).

Douglas Lee

Douglas Lee, is the head of preconstruction for a large general contractor, and works in several different markets but has expertise and experience in healthcare. The company started implementing prefabricated assemblies in their projects in 2009 and had used everything from bathroom pods, in-wall plumbing rough-in, overhead MEP racks, mechanical units, and med gas systems. “On a hospital project in Texas, all of the med gas was prefabricated. In a warehouse, all of the walls were framed and the med gas and electrical rough in could be completed in the patient room head walls. We are currently looking at a prefabricated modular wall panel assembly for the exterior. This was considered for use on a project in Kentucky, but was not utilized because it was deemed cost prohibitive” (D. Lee, phone interview, June 15, 2012). He goes on to state, “On a future project, we are looking at an insulated concrete panel for the exterior, which will be cast in a plant, and then delivered to the jobsite for installation, in an attempt to modularize the skin so as to have the building dried in faster. On an upcoming project, the owner has challenged us to frame the walls, and installing the EIFS and metal wall panels on the ground, and then lifting the wall panels into place with a crane” (D. Lee, phone interview, June 15, 2012). When deciding to prefabricate assemblies to be incorporated into construction, the preconstruction department performs cost and schedule analysis as part of the decision-making process. The numbers they come up with usually show a ten to twenty percent savings by utilizing prefabricated assemblies, according to the analysis. However, no tracking system is in place to see if those savings

are realized on the project. He goes on to state, “One issue we have encountered with prefabrication is that we had a hard time getting the value out of the trades to make prefabrication economical. There is definite value in the schedule savings, however, for example with the pods for the restrooms in the patient tower bedrooms, the issue we were running into is that the subcontractors are prefabricating enough in their own shops and facilities that a lot of the efficiencies are already being made in their work product, that we are not getting the dollars back that justify multi-trade prefabricated assemblies” (D. Lee, phone interview, June 15, 2012). “On an IPD project in Kentucky, we were able to trim about ten percent off the cost and put work into place twenty five percent faster. The plumber on that project did not deliver a piece of material to the jobsite that was under fifty feet in length, it had all of the pieces already done, and all of his underground came to the site prefabricated” (D. Lee, phone interview, June 15, 2012). “Prefabrication allows for a standardization of quality, and an increase in speed, which results a significant savings in the schedule” (D. Lee, phone interview, June 15, 2012). “One of the barriers to implementing prefabricated assemblies on a non-IPD project is bringing the subcontractors on board. The pushback from the trades happens because they are being forced to give up some of their scope of work, and it cuts into their fee” (D. Lee, phone interview, June 15, 2012). “In a conventional contractual agreement, it is tough to get the subcontractors on board with a multi-trade prefabricated assembly” (D. Lee, phone interview, June 15, 2012).

David Craft

David Craft, a vice president for a medium-sized general contractor, had some interesting things to say about prefabrication and Lean construction. The company has been emphasizing Lean principles since 2010 after seeing the potential savings with respect to both cost and time, as well as the standardization of quality. As of the time of the interview, the company has used prefabricated assemblies for two different applications, penthouse mechanical modules and prison cells, utilizing building information modeling and the last planner scheduling system to help make the implementation of prefabricated assemblies successful. When asked about how the company makes decisions on which prefabricated assemblies to utilize on projects, he stated they make decisions after estimating the potential savings in a rough estimate and then following up with an intensive study comparing the prefabrication with traditional means and methods, based on the possibilities of prefabrication due to the repetitiveness of the modules in the design of the building. “On the prison, a thirty month schedule was trimmed down to a twenty four month schedule, and an estimated cost savings of 1.5 to 2 million was accomplished on a 70 million job. That does not include the additional overhead required for the six months trimmed off the schedule, so a cost savings estimate of 8 to 10 million dollars was incurred” (D. Craft, phone interview, June 11, 2012). He went on to say a savings in both time and money were realized. He further elaborated that the decision to utilize prefab on the prisons was made at the DD stage 50% drawings. Estimates were created comparing traditional stick-built methods with prefabricated prison cells complete with all finishes. The increase in quality was described as very significant. The lower level cells were constructed of two cell modules that set on a concrete slab, and the second level cells sat directly on top of those prefabricated cells, utilizing the top of the lower cells as the floor for the second level cells.

Fernando Gallardo

I had the opportunity to spend several hours interviewing Fernando Gallardo, a project manager for a national electrical contractor that is heavily involved in the utilization of prefabricated assemblies. When asked about the historical cost data for prefabrication, he replied, “Our prefabrication is still in the infancy stage. To say that we have historical data is going to be not necessarily reflective of our situation for many years and numerous projects. We are fairly new to prefabrication on a large scale. The actuals that we have recorded, in terms of our production, as a result of prefabrication, and the prefabrication itself does not necessarily have that historical data component yet” (F. Gallardo, personal interview, June 22, 2012). When asked how long the company has been prefabricating to this extent, he responded, “It’s been a couple of years or a year and a half that we have been prefabricating to this extent. We are shifting thirty to forty percent of our labor hours offsite to prefabrication” (F. Gallardo, personal interview, June 22, 2012). Speaking about the location of the prefabrication shops, he said, “For the eastern part of the country, we have a prefabrication plant in Richmond, Virginia which has warehousing capabilities, the prefabrication shop, offices for the detailing that goes into the prefabrication process in terms of generating drawings that are sent to the production floor. There is another prefabrication plant in Dallas, Texas as well. This includes overhead racks for conduit, electrical rooms where we can prefabricate as much of the electrical room that can be assembled in a kit type of form, to the entire electrical room itself with studs and sheetrock if it is possible to transport for that particular project” (F. Gallardo, personal interview, June 22, 2012). Talking about the percentage

of scope that is prefabricated, he stated, “Currently, we are targeting around forty percent of our scope of work for prefabrication” (F. Gallardo, personal interview, June 22, 2012). Complexity is a big criterion when deciding what to prefabricate. Especially in the underground work, for instance if there are several ninety degree turns that stub into a series of elbows which stub into the switchgear, the complexity involved in that scenario dictates that it is more cost effective if we build a stand, attach the sweeps to it, and then have a means to transport it with a forklift and set it in place.

On cost analysis for deciding what to prefabricate, he stated, “We are trying to do as much cost modeling as we can, but a lot of time you have to make an assessment based on experience and judgment. We are doing this because we think it will help us and we think it will work, however we don’t know for sure” (F. Gallardo, personal interview, June 22, 2012). Explaining how the process works, he says, “Everything that is installed is detailed, whether it is prefabricated or not” (F. Gallardo, personal interview, June 22, 2012). “Once the project’s design is completed by the engineers, the Revit model is handed over to the detailers. The detailer sharpens the focus of the model making it much more precise. He coordinates with other trades; he establishes the runs and the precise locations of other components so that they will not be in conflict with components from other trades. All of this information is added to the model. The prefabrication department then makes decisions about how to prefabricate. They basically designate to build a conduit rack, which fits into an actual rack on wheels, that is able to be moved around the floor, and depending on the size of that rolling rack which can be wheeled around the floor, they designate what size to build the rack. For instance, if that rack is too heavy of a product, it cannot be easily lifted into place. So you go from detailing to spooling, and spooling in essence is taking the detail drawings and generating production drawings, it is basically something that you generate to give to the factory floor, which has all the necessary information. After the rack is prefabricated, it is labeled, packaged with any necessary hangers or supports, and shipped to the field” (F. Gallardo, personal interview, June 22, 2012).

On calculating the cost or savings, he stated, “To do a proper analysis of the cost, all the additional engineering and detailing that goes into process needs to be included in the cost for prefabrication. There is a lot of additional engineering and detailing that goes on in addition to the labor and the materials at the prefabrication shop” (F. Gallardo, personal interview, June 22, 2012). “We also want to maximize our shipping costs, we don’t want to send just a half a truckload to the site, so we have to generate the prefab drawings, we have to make sure the detailing is done, we have to make sure the right assemblies are prefabricated in the order they are needed in the field, and then we ship it to the jobsite (F. Gallardo, personal interview, June 22, 2012).

When discussing how to design, he said, “We would prefer to have the ability to choose what to prefabricate, not have the designers dictate it to us” (F. Gallardo, personal interview, June 22, 2012). When discussing the savings, he stated, “We are prefabricating approximately forty percent of our work, and seeing a savings of five to ten percent” (F. Gallardo, personal interview, June 22, 2012). “We are still new to this, and sometimes we find that it was more expensive to prefabricate than assembly” (F. Gallardo, personal interview, June 22, 2012).

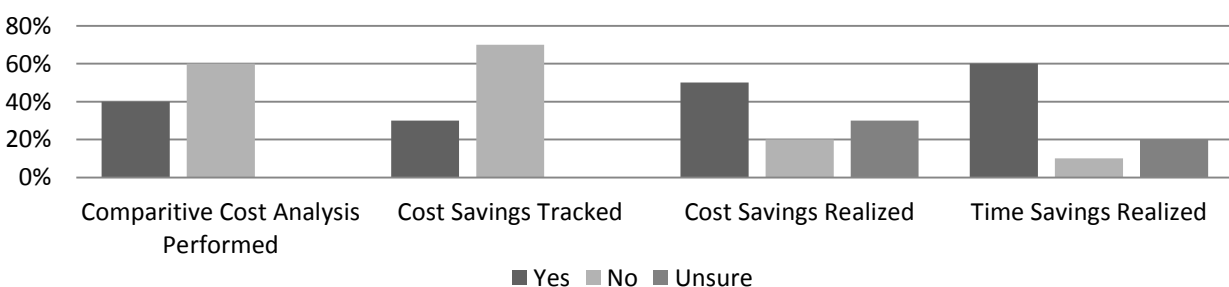


Figure 2: Summary of Interview Responses

Conclusion

This research revolved around three questions: 1) How construction firms, and industry professionals, decide on which assemblies to prefabricate? 2) When deciding to prefabricate certain assemblies and components, do industry

professionals perform a detailed analysis to compare the traditional means and methods vs. prefabrication in respect to duration of schedule and/or cost savings? and 3) Are the anticipated cost savings or the schedule gains tracked to determine the realized benefits at the completion of the project? The answers to the above questions were relatively consistent amongst the interviewees and in general demonstrated that in its current forms prefabrication is a relatively new strategy for most construction professionals and its resurgence is related to Lean construction. It was also clear that they lack the historical costs and schedule data to make strategic decisions about prefabrication and are relying on their best guesses when making their decisions on what to prefabricate. A more striking issue that became apparent to the researchers is that in this early stage of prefabrication industry professionals are not capturing their cost and schedule data which would allow them to make informed decisions in the future. The cost data is complex. Costs for shop fabrication, delivery and design all need to be included in order to do a full accounting. The majority believe the intrinsic value of prefabricated assemblies is the value created by the reduction of activity durations, which in turn shortens the overall project schedule and the indirect cost associated with time.

During this research the authors became aware of a few issues ancillary to our primary research questions. First is that the decision to utilize prefabricated assemblies commonly takes place either in the construction phase or very late in the preconstruction phase, instead of early on in the design and planning phases. Some of the construction professionals interviewed like the idea of being able to make the decisions about what to prefabricate instead of having it included in the design. This allows them to make decisions about what scope they consider to be most economically advantageous. Having the installer make decisions on prefabrication works well if the prefabricated assembly only involves their work; however, multi-trade prefabricated assemblies need to be designed and planned for in order to create the most value for the project. If a multi-trade prefabricated assembly is not included in the contract documents, the general contractor or construction manager is pricing the prefabricated assemblies as change orders. In this scenario pricing received from trades especially for credits, is not likely to be more competitive than if it was included in their base scope. This could explain the lack of cost savings claimed by the interviewees.

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