Use of Industrialized Construction Strategies Among Associated General Contractors of America

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Industrialized construction (IC) strategies are techniques used on a construction project that allows for significant time and schedule savings. The goal of this study is to analyze trends among general contractors and their experience with these strategies. Associated General Contractors of America (AGC) firms were asked various survey questions including size of firm, experience with several types of IC strategies, and their willingness to use similar strategies in the future. By answering questions about their percentage of use of prefabrication, automation, and BIM for various contract types, delivery methods, and payment methods, trends relating to the use of IC emerge. These questions allow connections to be made between the type of work being done, revenue of firms actively using IC strategies, and how much success they have seen after implementation. The success of certain firms’ use of IC strategies can be applied to similar projects and firms to ensure the reliability and lowered risk of adopting strategies like building information modeling (BIM), prefabrication, and automation. The purpose of this paper is to analyze those trends and show construction industry professionals the potential that IC strategies have on a given project.

Key Words: Industrialized Construction, Prefabrication, Automation, BIM, AGC

Introduction

Industrialized construction is the application of manufacturing processes and production methods in construction. By modernizing construction, contractors and owners are able to reduce cost and control schedules with little to no negative impact on quality and safety. Industrialized construction strategies may include productization, offsite work, and other manufacturing-type production methods.

The three main areas of industrialized construction emphasized in this paper are building information modeling (BIM), prefabrication, and automation. BIM utilizes an intelligent digital model that shows data pertaining to all trades and disciplines in the construction process. Use of BIM allows for individuals to detect clashes across trades, collaborate in real-time, and make better decisions for design and execution. Prefabrication involves designing, fabricating, and assembling building elements at a location other than their final, permanent installation location. This process can drastically cut down installation for certain items with repetition or long cure times. Automation uses tools and processes that utilize automated workflows to build structures. Typically, automation is used to minimize the risk of human error. This can be done using automated drones or robotics throughout the entire construction process. These three examples of industrialized construction strategies allow for significant cost and schedule savings by supplying more information and repeatability while lowering risk.
The purpose of this paper is to explore the willingness of varying sizes of AGC firms to adopt industrialized construction strategies, the benefit of these strategies at varying levels of construction, and existing knowledge and experience of AGC firms across the nation.

**Figure 1. Industrialized Construction components (Marks, 2021)**

**Literature Review**

Due to the lack of adequate respondents, valuable information can be gathered through previous surveys, case studies, and journals regarding the use of industrialized construction strategies.

According to a previous, similar survey, IC strategies are involved most in “non-volumetric pre-assembly” and “modular” systems, with “component manufacture and sub-assembly” following closely behind. In addition, the strategies were adopted most in commercial and institutional buildings with industrial buildings further behind (Razkenari). These findings are as expected when comparing to the annual revenue of respondents. Most respondents landed in the $100 million to $1 billion range. A unique trend that can be found in this survey is that of the working experience of firms using IC strategies. Very new and very experienced firms were the highest population of respondents, and a connection can be made that young and new firms are being created with the vision of technological advancement while experienced firms are adopting IC strategies more due to their past projects and successes.

Research shows that some of the main benefits of the adoption of IC strategies include improved quality, increased health and safety, reduction of construction costs, time, and labor, and environmental benefits. The main challenges include lack of demonstrative practicability and scalability, reluctance to change, low accuracy of models or systems, technical issues, and lack of information interoperability (Qi). In other words, without definitive proof that firms of all sizes and focuses can succeed when using IC strategies, there will still be reluctance to adopt them. IC strategies may lead to significant benefits on a project, but they require tools, information, and some level of collaboration to effectively introduce.
A study on the importance of BIM in 2014 showed that using a digital information system allowed for a more transparent supply-chain and enabled communication across the entire project duration. In the field, enterprise resource planning (ERP) and supply-chain management (SCM) are two examples of complex strategies to adopt on a project, but the basis of BIM makes their implementation more fluid (Čuš-Babič). Industrialized construction strategies are something that show increased strength from the ground up, meaning that BIM and other technology and process enablers encourage and allow for the use of other tools in the prefabrication continuum. Construction is an ever-changing industry even within one project, so having a strong basis of information makes it much easier and efficient in adopting IC strategies.

Methodology

The data collected in this paper was acquired through a survey of Associated General Contractors of America (AGC). Targeted participants included AGC firms of any size (i.e. revenue, number of employees, projects accepted). The survey was sent to AGC chapter engagement department heads and select chapters around the country. The survey was created in conjunction with subject matter experts, Paul Redden and Lonny Simonian. The main purpose of the survey was to collect information about AGC firms’ knowledge of industrialized construction strategies, their use of them in the past, and their willingness to use them in the future. Analysis would then lead to the finding of trends of IC use in the construction industry.

The survey included a short introduction including the purpose of the survey. Questions that included topics about industrialized construction, building information modeling (BIM), prefabrication, and automation also included a definition to ensure respondents had unanimous understandings of the given topics.

The first 3 questions of the survey were general background questions including name of the respondent’s firm, location of primary work, and the previous year’s earned gross revenue. Questions 4 through 6 aimed to understand the type of work, delivery method, and contract payment types the respondent engaged in. Each of these questions asked the respondent to estimate the percentage of each type, method, and payment type they engaged in. Question 7 was meant to understand how much experience the respondent had with industrialized construction strategies in the past. Questions 8 through 12 asked the respondents to estimate their percentage of each type of work (building, highway, heavy, and municipal) in comparison to their use of BIM, prefabrication, and automation. It was ensured that each term included a specific definition to keep respondents’ understanding of the terms the same. Question 13 asked respondents to estimate the percentage of their use of IC strategies in several construction areas including framing, electrical, plumbing, HVAC, concrete, and multi-trade. Question 14 asked respondents to estimate their cost and schedule savings as a percentage of their original bid value and schedule. The last few questions asked their willingness to use IC strategies in the future, willingness to enroll in a course hosted by California Polytechnic State University, and additional contact information for additional case studies.

Results

With a lack of responses of the given survey, accurate and true analysis cannot be done. However, comparing two or more of these survey questions against each other provides valuable insight on the use of IC strategies and what kind of firms adopt them. Due to the nature of industrialized construction and its implementation of unique tools and processes, certain expectation can be made regarding the size of firms that engage in these strategies. It is expected that larger firms will have more experience and willingness to adopt IC strategies and smaller firms would have a harder time finding applicable uses. It is also expected that areas of work including HVAC, plumbing, electrical,
and concrete will have more opportunities to apply these strategies because of their replicability. While IC can be implemented on any project of any size, it is often found on projects with high levels of repetition or ability to compile large amounts of information. Due to this, it can be predicted that highway construction projects or those with unit price contracts would involve more prefabrication and modular possibilities while commercial and large industrial building projects would involve more possibilities for automation, BIM, and prefabrication of components.

**Figure 2: Question 4 regarding the percentage of each project type used.**

Another prediction that can be made is involving the cost and schedule savings associated with the adoption of industrialized construction strategies. It would be expected that larger scale projects with higher levels of repetition would result in a significantly higher level of cost and schedule savings than small scale projects. Therefore, highway and unit price projects would be much easier to estimate when it comes to cost and schedule.

Because process and technology enablers are the foundation of industrialized construction, it would be safe to assume that firms with no experience with BIM have little to no experience with other industrialized construction strategies, while firms with a lot of experience with BIM have more experience with other industrialized construction strategies. The heavy emphasis on the importance of BIM also makes it safe to assume that the few cases where firms have experience with industrialized construction but not BIM, have a lower success rate. These projects are likely to see less cost and schedule savings than the projects that incorporate BIM effectively.

**Figure 3: Question 14 regarding cost and schedule savings.**

The previous assumptions and expectations can be directly related to the willingness of firms as well. Firms with more experience with IC strategies would most likely be more willing to incorporate them
again in the future, while firms with no experience would likely be much more hesitant to adopt the strategies. This connection to willingness depends on factors like BIM usage, success, and cost and time savings, however. Similarly, firms that engage in more unit price and highway construction projects are likely to be more willing to adopt prefabrication or modular strategies while commercial projects are more willing to adopt component prefabrication and BIM.

**Conclusion**

The construction industry has been hesitant to accept change in the past due to added risk of the unknown, cost sinks, and experience. Industrialized construction strategies are a way to significantly reduce cost and schedule of a project but are more easily incorporated by large firms and large projects where repetition is seen. While small firms and projects can utilize IC strategies, the options available are more limited than that of large general contractors. Until the benefits of IC strategies are proven to be reliable, the construction industry will likely keep refusing to adopt them.

**Future Research**

This paper includes preliminary research on the topic of industrialized construction, and the application of survey results would make more trends in the use of IC apparent. Interviews with industry professionals would also contribute to the ability to find trends through more detailed case studies. Comparative case studies would directly show the cost and schedule savings thanks to IC strategies among projects of similar type, contract, and delivery method.

Industrialized construction strategies are an important factor in the future of the construction industry. Further research into case studies including benefits and barriers of these adopted strategies may make it easier to convince industry professionals to use these strategies. The construction industry cannot effectively grow without the adoption of new technological advancements like BIM, prefabrication, and automation on the jobsite.
References


## Appendix

### Industrialized Construction Survey for AGC Firms

The purpose of this survey is to analyze the adoption of and willingness to use industrialized construction strategies by different sizes of AGC firms. Please estimate answers to the best of your knowledge.

* Required

#### 1. Name of your firm

Please state the name of your firm.

#### 2. Primary work location

- [ ] US West
- [ ] US Central
- [ ] US East
- [ ] US South
- [ ] Other

#### 3. Gross revenue

What was your firm's earned gross revenue last year?

- [ ] < $1,000,000
- [ ] $1,000,000 - $5,000,000
- [ ] $5,000,000 - $25,000,000
- [ ] $25,000,000 - $100,000,000
- [ ] $100,000,000+ - $500,000,000
- [ ] > $500,000,000

#### 4. Project types

What percentage of last year's gross revenue for each project type did your firm perform?

- Building
- Highway
- Heavy
- Municipal

#### 5. Project delivery methods

In terms of contracts awarded to you last year, what percentage of each project delivery method did your firm perform?

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<tr>
<th>Method</th>
<th>0-20%</th>
<th>20-40%</th>
<th>40-60%</th>
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<td>Integrated Project Delivery</td>
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#### 6. Payment types

In terms of contracts awarded to you last year, what percentage of each payment type did your firm perform?

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<th>Payment Type</th>
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<td>Lump Sum</td>
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<td>Unit Price</td>
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How familiar is your firm with industrialized construction? *

Industrialized construction is the application of manufacturing processes and production methods (e.g., Factory Physics, Operations Science) in construction. Visit http://www.autodesk.com/Autodesk-Industry-Notes/Power-Industrialized-Construction-2019 for more information.

What percentage of your firm's man-hours worked last year was modeled in BIM? *

Building information modeling (BIM) is the process of creating and managing information for a built asset. Based on an intelligent model and enabled by a cloud platform, BIM integrates structured multi-disciplinary data to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operations.

Of the projects that implement BIM last year, what percentage of models was done internally (by your own firm)? *

Prefabrication is the planning, design, fabrication and assembly of building elements at a location other than their final installed location to support the rapid and efficient construction of a permanent structure (e.g., using concrete forms poured off-site and transported on-site to reduce time to construct formwork and wait for concrete to cure).

What percentage of your firm's man-hours worked last year used prefabrication? *

Some Experience
Use Whenever Possible

What percentage of your firm's prefabrication was done internally (done on-site or in your firm's own shop)? *

10. What percentage of your firm's man-hours worked last year used automation? *

The term construction automation captures the processes, tools and equipment that use automated workflows to build buildings and infrastructure (e.g., programmable robots to survey sites or using robotics in concrete works to minimize human error).

What percentage of each area of construction did your firm use industrialized construction strategies last year? (CM, Prefab, Automation, etc.) *

11. What percentage of your firm's prefabrication was done internally (done on-site or in your firm's own shop)? *
In your estimate of projects that used industrialized construction strategies last year, what percentage did your firm save in cost and schedule (based on original bid value and schedule)?

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<td>Schedule</td>
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Rate your firm's willingness to use industrialized construction in the future.

1. Not Willing
2. 
3. 
4. 
5. Very Willing

Rate your firm's willingness to attend a course for education and certification in modern production concepts hosted by California Polytechnic State University. Visit [https://projecteducation.org/industrialized-construction](https://projecteducation.org/industrialized-construction) for more information.

1. Not Willing
2. 
3. 
4. 
5. Very Willing

Please provide contact information for the use of any case studies regarding projects where industrialized construction strategies were a success.