

# Use of Industrialized Construction Within Mechanical Contractors Association of America

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It is a constant battle in the construction industry to improve productivity and efficiency while keeping the cost and schedule as low as possible. This can be made possible through the use of industrialized construction strategies such as, prefabrication, building information modeling (BIM), and automation. In this study, the main purpose of this survey was to collect information about MCAA firms' knowledge of industrialized construction strategies, their use of them in the past, and their willingness to use them in the future. It also aims to explore the use of industrialized construction and its viability as a path for mechanical contractors to create more work and grow construction businesses. This study also investigates and the different strategies used within industrialized construction and defines the benefits of their use. A survey was created and sent out to companies within Mechanical Contractors of America (MCAA). From the survey results, it can be concluded that there was a mix of those who used it as much as possible and those who have never heard of it, however, of the companies that have used these strategies, there was significant savings in cost and schedule on their projects.

**Key Words:** Industrialized Construction, BIM, Automation, Prefabrication, MCAA

## Introduction

Currently in the construction industry, mechanical contractors are faced with many obstacles to win work and in turn create profits. One of the obstacles that they face is the migration towards pushing work offsite. This "industrialization" of their work is a great opportunity to grow their business, but the shortage of skilled labor and dated processes, contracts, and project structures is an issue that must be addressed. Strategies of industrialized construction can be used to help mitigate the issues that mechanical contractors are facing. Industrialized construction is the application of manufacturing processes and production methods in construction to improve productivity and efficiency of a construction project. The processes of industrialized construction commonly involve prefabrication, automation, modularization, building information modeling (BIM), and more (The Power, 2020). By

implementing these strategies, contractors and owners are able to reduce cost and control schedules with little to no negative effects on the quality and safety of their work.

The objective of this research is to explore the use of industrialized construction and its viability as a path for mechanical contractors to create more work and grow their businesses. To achieve this, information about MCAA companies' knowledge of industrialized construction strategies, their use of them in the past, and their willingness to use them in the future is needed.

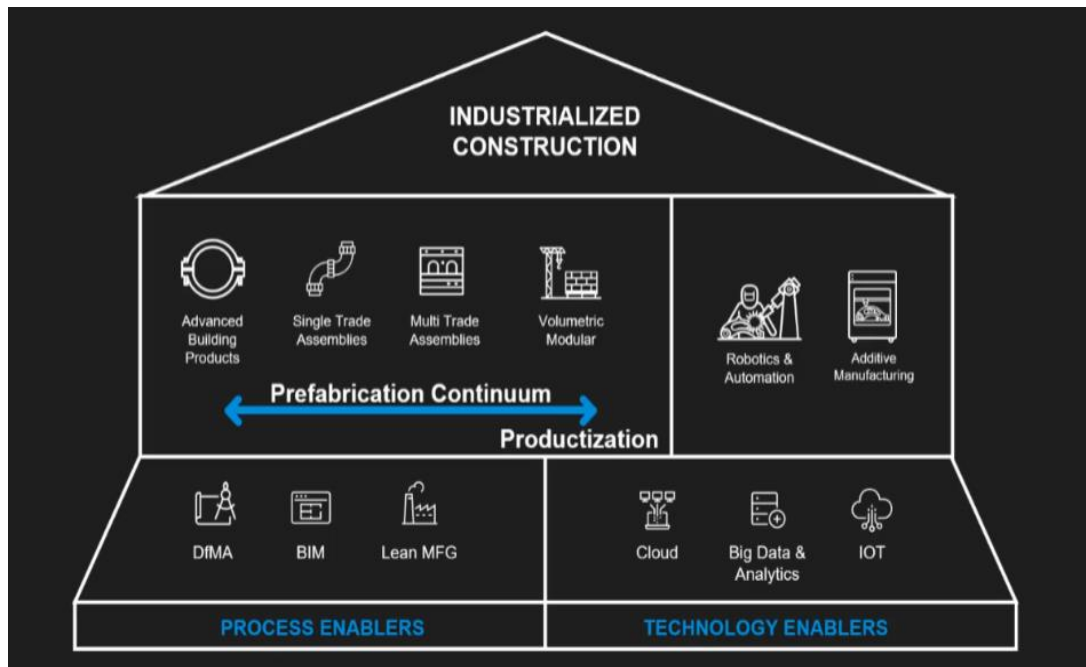


Figure 1. Industrialized construction components (Marks, 2021)

### *Prefabrication*

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). When prefabrication was implemented, there were multiple benefits that came along with it. The process of prefabrication allowed for better quality products because the components were being constructed in a controlled environment. By constructing the building elements in a controlled environment, the manufacturers have more control over quality and are able to produce top quality work in a very repeatable manner (Prefabricated). Another benefit of constructing in a controlled environment is producing less waste. In the factory and workshop, there is more control over excess materials and how they are recycled and repurposed for other processes. Since the material is stored indoors, there is less loss of materials due to damage caused by weather conditions. Not only does the material's safety increase, the safety of the workers is also increased when prefabricating components in a factory or workshop setting. Instead of constructing components on site where dangers like heights, bad weather conditions, and other risks that come with working on site. Also, the amount of labor needed with prefabrication is less than what would be needed for constructing the same components on the jobsite without prefabrication (Razkenari). With the

collection of all the benefits of prefabrication, the result is saving time and shortening the construction schedule.

### *Building Information Modeling*

Building Information Modeling (BIM) is the use of computer software to create and manage three-dimensional models a building that is to be constructed. It allows all parties of the construction team including, contractors, manufacturers, architects, engineers, and others to design and construct a structure or building as an intricate three-dimensional model (Design, 2022). Mechanical professionals use these intelligent three-dimensional models to help them efficiently design, document, and create building mechanical systems. BIM gives mechanical professionals the ability to optimize the design of the building systems, improve accuracy, and mitigate clashes within their own systems as well as plumbing or electrical systems. The advantages that BIM can bring to a construction project will result in saving time on the schedule later down the road because all aspects of the structure or building will be planned out in detail before construction even begins (BIM for MEP, 2021).

### *Automation*

Automation in construction captures the processes, tools, and equipment that use automated workflows to build buildings and infrastructure. It is taking work that previously would be done by manual labor and moving it to a manufacturing setting where tools will automate the process. An example of this would be the use of robots or automated tools to cut out the correct sizes of timber for framed walls of a house (Davis).

## **Literature Review**

Creating the survey was the most difficult and time-consuming part of this project and is where the literature review and research was needed the most. It was needed to come up with the correct question to ask to ensure that the data collected was useful and ticked all the boxes for the objectives of the survey. Industrialized construction is not a topic that is very popular or is commonly talked about, so it was important to gather as much information about the different strategies used and how a construction company would go about implementing these strategies.

The most relevant and useful sources of information for industrialized construction are the Autodesk website and the Project Production Institute (PPI) website. From the Autodesk website, all the information and models of industrialized construction without the numbers are available and easily found. The modules included the definitions of each strategy, its uses within the industry, and its benefits. The Autodesk website is more than a sufficient starting point for an individual that is looking to understand the basics of industrialized construction. The PPI website gave a more in depth look into the topic with the science and hard numbers that deal with industrialized construction. When the numbers from PPI and design models from Autodesk are integrated together, they become a very powerful source. The three strategies mentioned earlier make up a big portion of the questions being asked in the survey, so having a good foundation of knowledge for these topics is essential.

There are a few other literature sources that were used to fill in the gaps of background knowledge found on the Autodesk website and to also add more detail industrialized construction. These sources are *Industrialized Construction: Emerging Methods and Technologies* by Mohamad Razkenari and A

*Systematic Review of Emerging Technologies in Industrialized Construction* by Bing Qi. These two sources gave an in-depth explanation of industrialized construction and its implementation into the construction industry.

## **Methodology**

The methodology of research strategies used for this project fits in with quantitative research. The approach to data collection that was chosen for the project was fieldwork research where descriptive surveys were used. The use of a survey was chosen because it is very efficient for collecting data in a short period of time.

The data collected in this paper was collected through a survey of Mechanical Contractors Association of America (MCAA). The first step was to come up with questions and create the survey that would be sent out to the MCAA members. With the help of subject matter experts, Paul Redden and Lonny Simonian, the survey was quickly created and specifically tailored for our target audience. The targeted audience for the survey included all MCAA firms of any size (i.e. project sizes, number of employees, earned revenue). The survey was sent out by email to select members within MCAA specifically in California, but also to a few throughout the nation. The main purpose of the survey was to collect information about MCAA firms' knowledge of industrialized construction strategies, their use of them in the past, and their willingness to use them in the future. The survey included a short introduction including the purpose of the survey. Questions that included topics pertaining to industrialized construction, BIM, prefabrication, and automation contained a definition. This is to ensure that the audience can respond to all the questions with equal basic knowledge of all terms used in the questions.

The first six questions of the survey were to get general information about the companies themselves. Questions one through three asked for information including the name of the firm, location of primary work, and earned gross revenue in the previous year. Question four asked what percentage of the previous year's gross revenue was performed for each of the project types listed. Question five and six asked about the type of delivery types and payment types for their projects.

The rest of the questions were aimed to get information about industrialized construction and its use within the companies. Question seven asked respondents to rank their familiarity of industrialized construction from "never heard" to "use whenever possible". Question eight through question twelve asked in terms of man-hours, how much of the company's work used certain industrialized construction strategies over the last year and how much of that work was done internally. The three strategies of industrialized construction referenced in these questions were Building Information Modeling (BIM), prefabrication, and automation. Question thirteen asked the percentage that the firm use industrialized construction strategies in the areas of piping, HVAC systems, plumbing, mechanical systems, and sheet metal. Question fourteen asked respondents to estimate their savings, from implementing industrialized construction strategies, in cost and schedule based on their original bid value. Question fifteen asks the respondents to rank their willingness to use industrialized construction strategies from "not interested" to "very interested". Question sixteen asked firms to rank their interest in attending a course hosted by California Polytechnic State University involving modern production concepts. Question seventeen asked firms to provide any additional information for the use of case studies where industrialized construction strategies were successful.

## **Results**

To get the points of view of mechanical companies in different areas, the expectation for the survey was to reach multiple MCAA companies all over the nation. However, only nine companies responded to the survey so the data collected is only preliminary. Question two shows that of the nine companies that responded, all of them are located in the western part of the United States. This makes it difficult to get a sense of industrialized construction and its use across the country where a company that is located in the western region might use it or have completely different knowledge of it from a company that is located in the east, south, or north of the United States. Question 3 asked the respondents to provide the gross revenue that was earned over the last year. The data collected from this question showed more variation with gross revenue of the different companies that responded to the survey. Of the nine companies, one of the companies answered that they earned a gross revenue in between the amounts of five million dollars to twenty-five million dollars over the last year. Five of the companies responded that over the last year, they generated a gross revenue of twenty-five million dollars to one hundred million dollars. For the last three remaining companies, they responded that they earned a gross revenue of one hundred million dollars to five hundred million dollars over that last year. The different amounts of gross revenue earned last year show that there is a good variety of company sizes. The companies that earned between five and twenty-five million dollars are most likely that smallest in size, while the companies that earned between twenty-five and one hundred million dollars and also one hundred to five hundred million dollars are much larger companies. It is safe to assume that from the data collected, the larger companies would have the capacity to implement the strategies of industrialized construction into their project more easily and are all using these strategies as much as possible.

7. How familiar is your company with industrialized construction?

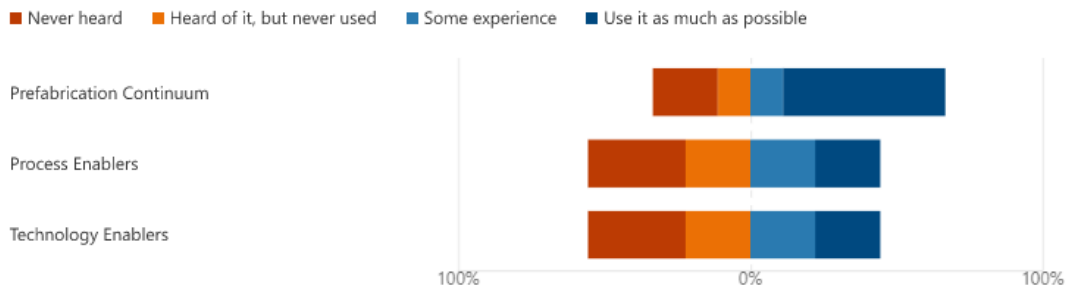


Figure 2. Responses to Question 7

Prefabrication continuum, process enablers, and technology enablers were taken from the graphic shown in figure 1. The main goals of the survey were to collect information about MCAA companies and their knowledge of industrialized construction strategies and their use of them in the past. Figure 2 shows an even distribution of all the available answers listed. Looking further into the details of the results from questions seven, it is shown that the three companies at the top of the revenue range and that their companies generated a gross revenue of one hundred to five hundred million dollars all did not use the industrialized construction strategies as much as possible. One company answered that they use prefabrication continuum, process enablers, and technology enablers as much as possible. Another one said that they only use two of the strategies as much as possible and only some experience in the other. The third company answered that they have never even heard of any of the three strategies listed in question seven. Aside from the three top earners, a few of the companies that earned less than one hundred million in revenue responded that they use these strategies as much as possible. This result denies the previous assumption that the companies with the largest revenue and size would have the capacity to easily implement industrialized construction strategies and that all of

them would be using the strategies as much as possible. This result also shows that mechanical companies do not need to exclusively use industrialized construction strategies to generate large amounts of revenue. The use of industrialized construction strategies may be helpful in generating part of the revenue by making the project run effectively, but it does not mean that the strategies will automatically earn large revenues.

Question eight through question twelve asked in terms of man-hours, how much of the company's work used certain industrialized construction strategies over the last year and how much of that work was done internally. The three strategies of industrialized construction referenced in these questions were BIM, prefabrication, and automation. It was predicted before the survey was sent out that the results would show that the percentage of the company's total work in terms of man-hours would be in the range of zero to twenty percent. This prediction was correct according to the data collected from the survey. For all three strategies, BIM, prefabrication, and automation, the majority of the respondents said the percentage of total work in terms of man-hours was in fact zero to twenty percent. This result makes sense because the total amount of man-hours worked for the entire project is very large and the industrialized construction strategies should only take up a small portion of those total man-hours. As for the percentage of man-hours for the use of BIM and prefabrication that was done internally by the company itself, it was predicted that the percentage done internally would be higher than not. However, this was not the case for BIM as the results show that the percentage of internal use of BIM for majority of the companies answered between zero and twenty percent. There is a similar result for prefabrication and its percentage that is done internally. While the percentages for prefabrication done internally is higher than for BIM, the majority of the answers were between zero and twenty percent. This means that majority of the companies that implement BIM and prefabrication in their projects are most likely sending out this work to third parties.

14. 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)?

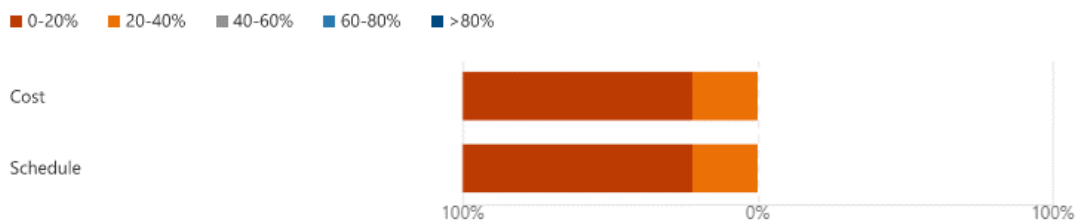


Figure 3. Responses to Question 14

The main goal of using industrialized construction strategies for a construction project is to ultimately save in cost and schedule in comparison to the original bid value and schedule. Figure 3 above shows the percentage of savings in cost and schedule that the respondents experienced from using industrialized construction strategies. It was hypothesized that the results of the survey would show that there is an increase in savings from the original bid value and schedule. From the results, it can be concluded that this hypothesis was correct as twenty-two percent of the respondents said that there was savings in cost and time between twenty and forty percent when comparing to the original bid value and schedule. As for the respondents that chose the option of between zero and twenty percent savings, it is more difficult to know that there was any saving because one end of the range is zero, however, it is safe to assume that there was at least more than zero percent savings.

Finally, question fifteen asked the respondents about their interest in using industrialized construction strategies in the future, and high interest and enthusiasm was the expected result. The response was put on a Likert scale out of five where the lower end was “not interested” and the high end was “very interested”. The results show that there is not as much interest as expected with an average number of 3.22. It was surprising that even the companies that responded that they use industrialized construction strategies as much as possible, scored it less than a five.

## **Conclusion**

The use of industrialized construction is an emerging trend that has yet to take hold and become widespread in the mechanical sector of construction. Mechanical companies can benefit greatly from using industrialized construction because of the nature of their work. The benefits that come along with the use of these strategies will have positive impacts on cost and schedule of the construction project. The main purpose of the survey was to collect information about MCAA firms’ knowledge of industrialized construction strategies, their use of them in the past, and their willingness to use them in the future. It is important that we gauge and study the current use of industrialized construction strategies used by individual mechanical companies to try and figure out the best course of action to implement it into all mechanical work.

The results of this research have shown that mechanical companies of differing sizes are already using the strategies mentioned above such as, using BIM, prefabrication, and automation. However, there were a few respondents that have never heard of industrialized construction. When asked about their company’s interest in using industrialized construction in the future, the average score out of five is 3.22. This was lower than expected, but of the companies that have used these strategies, they have seen up to a forty percent increase in savings on cost and schedule in comparison to their original bid value and schedule. This saving in cost and time is something that no mechanical company can ignore. If the companies that responded that they have never heard of industrialized construction and are not interested see the results and savings, there is no doubt that they would reconsider. Although it may not be an easy task to figure out a path to widespread use of industrialized construction strategies due to a lot of work needed to be done up front, the amount of money and time that will be saved is worth the extra work in the end.

## *Future Research*

For future research, this survey could be sent out again giving more time to collect data from mechanical companies all across the nation instead of just the west coast. The information collected was still very insightful, however, getting the point of view from companies in different locations would speak more to the true viability of industrialized construction and the possibility of its widespread use in the mechanical sector.

Another avenue of research for this topic of industrialized construction would be to do a comparison of the same survey, but for other construction organizations like Associated General Contractors of America (AGC) or National Electrical Contractors Association (NECA). By surveying other construction organizations and comparing them together, a stronger argument could be made for the need to implement industrialized construction into all sectors of construction and not just for mechanical companies.

## References

- BIM for MEP Engineering. (2021, October 21). Retrieved May 29, 2022, from <https://www.autodesk.com/industry/aec/bim/mep#bim-software>
- Buettner, K., & Smith, R. (n.d.). Industrialized Construction. Project Production Institute. Retrieved from <https://projectproduction.org/industrialized-construction/>
- Davis, M. (2022, January 6). What Is Construction Automation, and How Will It Drive the Future of Building? Retrieved May 29, 2022, from <https://redshift.autodesk.com/construction-automation/#what-is-construction-automation>
- Design and build with BIM: Building Information Modeling. (2022, March 23). Retrieved May 29, 2022, from <https://www.autodesk.com/industry/aec/bim>
- Marks, A. (2021, May 27). Industrialized Construction, productization, and transformation. Retrieved May 29, 2022, from <https://www.autodesk.com/autodesk-university/content/Industrialized-Construction-Productization-and-Transformation>
- The Power of Industrialized Construction. (2020, September 21). Retrieved May 29, 2022, from <https://www.autodesk.com/autodesk-university/article/Power-Industrialized-Construction-2019>
- Prefabricated and Modular Construction. (n.d.). Retrieved May 29, 2022, from <https://www.autodesk.com/solutions/architecture-engineering-construction/prefabrication-modular-construction>
- Qi, B., Razkenari, M., Costin, A., Kibert, C., & Fu, M. (2021). A systematic review of emerging technologies in industrialized construction. *Journal of Building Engineering*, 39, 102265. doi:10.1016/j.job.2021.102265
- Razkenari, M., Bing, Q., Fenner, A., Hakim, H., Costin, A., & Kibert, C. J. (2019). Industrialized Construction: Emerging Methods and Technologies. *Computing in Civil Engineering 2019*. doi:10.1061/9780784482438.045



# Appendix

## Industrialized Construction Survey for MCAA Companies

1. Please state the name of your company.

9 Responses

Latest Responses  
 "Benicia Plumbing"  
 "Marelich Mechanical"  
 "Therma"

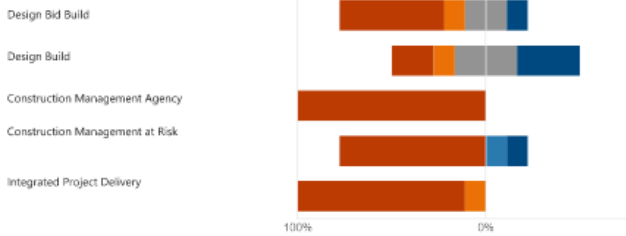
2. Where is your company's primary work located?

West 9  
 Midwest 0



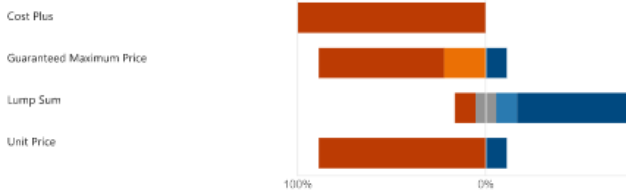
5. In terms of contracts that were awarded to you, what percentage of each delivery methods did your company perform last year?

0-20% 20-40% 40-60% 60-80% >80%



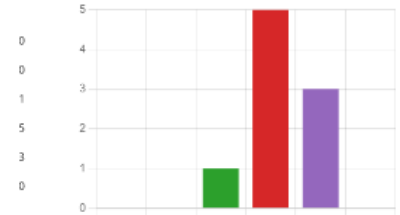
6. In terms of contracts that were awarded to you, what percentage of each contract payment type did your company perform last year?

0-20% 20-40% 40-60% 60-80% >80%



3. What is your company's gross revenue earned last year?

<\$1,000,000 0  
 \$1,000,000-\$5,000,000 0  
 \$5,000,000-\$25,000,000 1  
 \$25,000,000-\$100,000,000 5  
 \$100,000,000-\$500,000,000 3  
 >\$500,000,000 0



4. In terms of gross revenue, what percentage of each project type did your company perform last year?

0-20% 20-40% 40-60% 60-80% >80%



7. How familiar is your company with industrialized construction?

Never heard Heard it, but never used Some experience Use it as much as possible

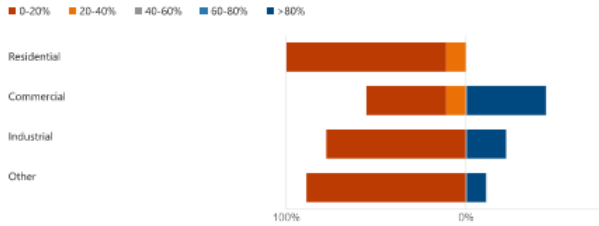


8. In terms of man-hours, what percentage of your company's work was modelled in BIM last year?

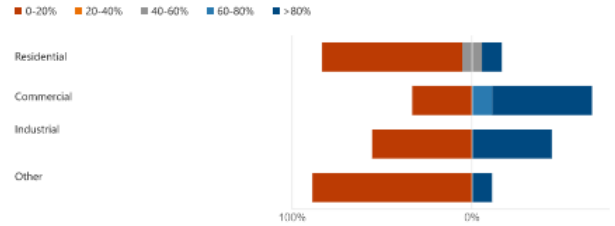
0-20% 20-40% 40-60% 60-80% >80%



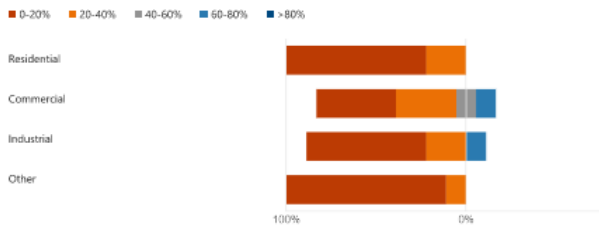
9. In terms of man-hours, what percentage of the projects that implemented BIM was done by your company internally last year?



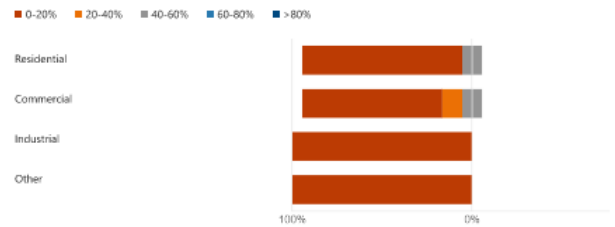
11. In terms of man hours, what percentage of your company's prefabrication was self performed last year?



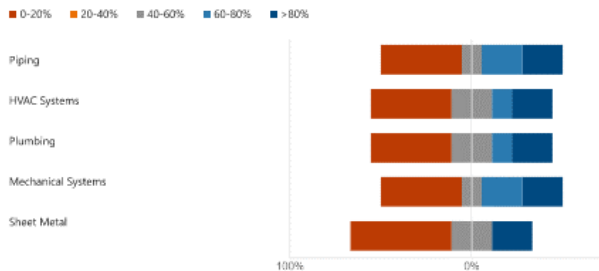
10. In terms of man hours, what percentage of your company's work used prefabrication last year?



12. In terms of man hours, what percentage of your company's work used automation last year?



13. In terms of man hours, what percentage of each area of construction did your company use industrialized construction strategies last year? (BIM, Prefab, Automation, etc.)



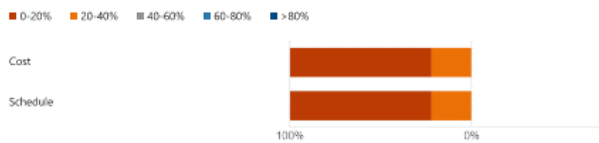
16. Rank your firm's interest in attending a course for education and certification in modern production concepts hosted by California Polytechnic State University.

9 Responses      3.17 Average Number

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

5 Responses

14. 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)?



15. Rank your company's interest in using industrialized construction in the future.

9 Responses      3.22 Average Number