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DEPARTMENT OF CONSTRUCTION MANAGEMENT

# **BENEFITS AND BARRIERS OF OFF-SITE CONSTRUCTION IN HOSPITAL PROJECTS**

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A photograph of a construction worker in a high-visibility yellow jacket and safety harness, working on a building's steel framework. The worker is positioned on a horizontal steel beam, with a large concrete wall in the background. The image is partially obscured by a white diagonal graphic element.

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## Executive Summary

As with any organization that sets out on a capital project, hospital organizations are concerned with delivering projects on time, under budget; while still delivering a quality project, safely.

Alternative construction methods such as off-site construction (OSC), a term that includes prefabrication, modularization, and industrialization, can provide benefits to project owners. One particularly important and potential industry sector that stands to benefit from the use of OSC is the healthcare sector. Surveys conducted by McGraw Hill Construction (2011) and Dodge Data Analytics (2020) show that the industry professionals surveyed are using OSC on nearly half of their healthcare projects. Consequently, these results imply that there is an advantage or benefit to using prefabrication and modularization for the construction of hospital facilities. Bearing in mind that roughly half of all healthcare projects incorporate OSC and considering that healthcare projects are in the best position to use prefabrication and modular construction, why are some hospital owners not using OSC, and for those who do use it, why are they only using OSC on select projects?

There is an abundant amount of research about the topic of off-site construction, but relatively little data about the benefits and barriers of off-site construction, specifically as it relates to hospital projects. Therefore, the aim of this study was to understand the *benefits that motivate* hospital owners to incorporate off-site construction and to understand the *barriers that influence* hospital owners to not use modular construction on hospital projects.

This research began with an in-depth literature review followed by interviews and qualitative data analysis. The research team used coding and mind mapping techniques in the analysis of the data in order to articulate the themes discovered in this study. The target population included experienced leaders who were leading some of the largest organizations across the country. These leaders were from a national design firm, three large health care providers, a large general contractors, a federal agency two industry associations, and a prominent educator and author in the OSC industry. Nearly all the participants had incorporated off-site construction on a hospital project or had extensive knowledge in the practices of off-site construction. This industry experience provided reliable data about off-site construction and its use on hospital projects.

Analysis of the data collected during the interviews indicated that there are many important benefits and barriers related to off-site construction. Much of the findings in this study validated the current knowledge (benefits and barriers) that surround off-site construction; especially as it relates to schedule, cost, quality, and safety. This study confirmed that the number one reported benefit that hospital owners can achieve from using off-site construction is a reduced construction schedule. McGraw Hill's 2011 SmartMarket Report also concluded that "a shorter project schedule was the most commonly reported productivity benefit of prefabrication/modularization. . ." (McGraw Hill Construction 2011). Owners can

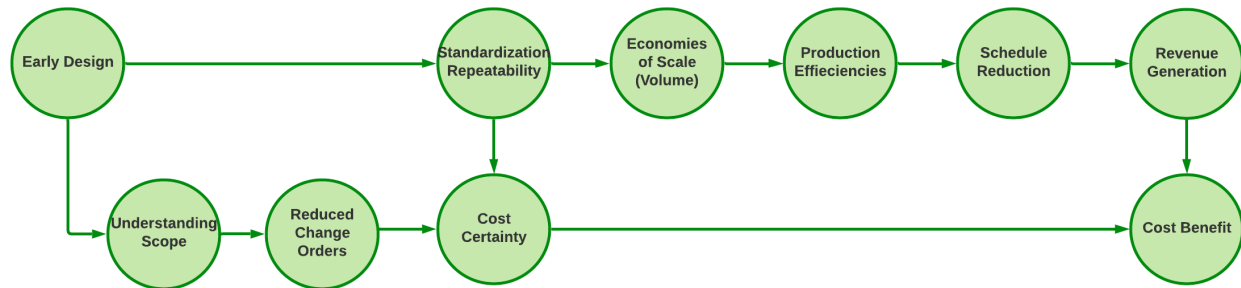
achieve cost savings on projects as a result of a reduced construction schedule; however, owners are not likely to save directly on off-site construction costs. The *Report of Results of the 2014 Off-Site Construction Industry Survey* validates that off-site construction has historically not been a low-cost solution.

Quality is incredibly important and can positively influence hospital owners to use off-site construction. As indicated in McGraw Hill Construction's 2011 SmartMarket Report, seventy percent of all respondents showed that project quality improvements were a factor driving future use of prefabrication and modularization (McGraw Hill Construction 2011). This study found that safety is important but not likely a primary influencer on an owner's decision to use off-site construction. This finding aligns with the results in McGraw Hill's 2011 SmartMarket Report, which indicated that only fifty-eight percent of industry experts surveyed, and who were already using OSC, reported that increased safety was a factor in driving future use of prefabrication and modularization (McGraw Hill Construction 2011).

This study revealed that there appears to be a gap in knowledge with respect to off-site construction and hospital projects. To that end, the construction industry needs to place more emphasis on building codes, education, and experience with respect to off-site construction. This study found that the construction industry needs to work to update current building codes, which will result in more adoption of off-site construction on projects. In addition, more education and experience will result in better off-site knowledge, and this will lead to an increased understanding and implementation of off-site construction.

In this report, we present detailed findings related to 9 categories: Cost, Labor, Schedule, Quality, Safety, Design, Knowledge, Regulatory Code Compliance, and Transportation.

## Cost



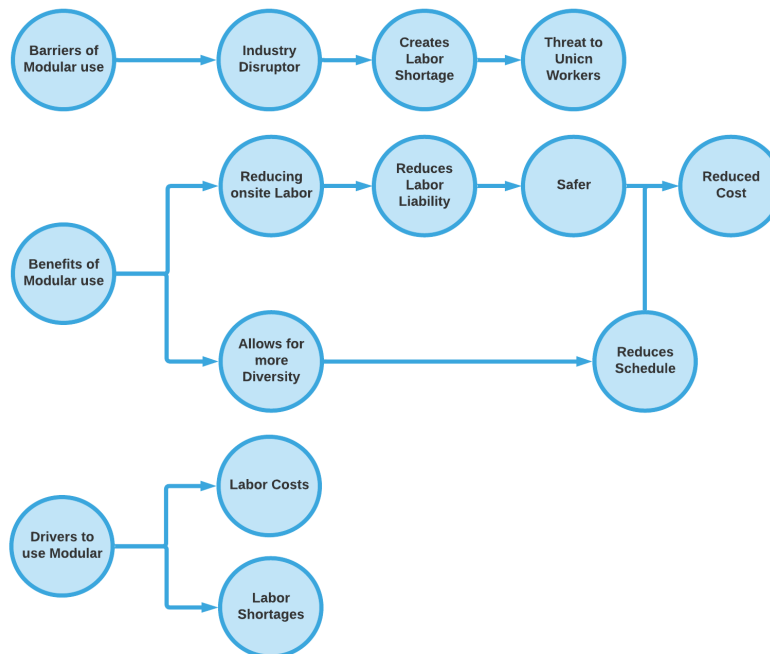
This study found that cost can influence owners to use off-site construction. Nearly all the respondents indicated that off-site construction was not less expensive than stick-built or on-site construction. Instead, cost savings are a result of time savings. One of the major construction firms said to be cautious of any data that suggests that off-site construction can save owners money; instead, they suggested looking for data that shows how many hours were saved in construction activities by diverting work off-site.

Most interviewees reported that in order to realize the cost benefits of off-site construction, owners should incorporate off-site early in the planning or design phase. This will lead to a better understanding of the project scope, which ultimately leads to reduced change orders, improves cost control, and gives owners more cost certainty.

All the interviewees indicated that standardization and repeatability were important with respect to off-site construction. Standardizing modular or prefabricated building components results in more cost certainty, whereas customization will increase project costs. Standardization, or repetitive systems, supports the notion of economies of scale or mass production. Consequently, larger volumes of modular or prefabricated units will lead to greater production efficiencies and ultimately schedule reduction. One researcher interviewed found the off-site construction starts pricing out at about 200 units and said that 50 units are probably questionable. This is simply a result of economies of scale; an increase in quantity leads to a decrease in average production costs.

All these factors lead to schedule reduction, which will lead to earlier project completion, which leads to earlier access to patient care and essentially allows owners to begin generating revenue sooner. Ultimately all these factors will lead to cost benefits on an off-site project.

## Labor



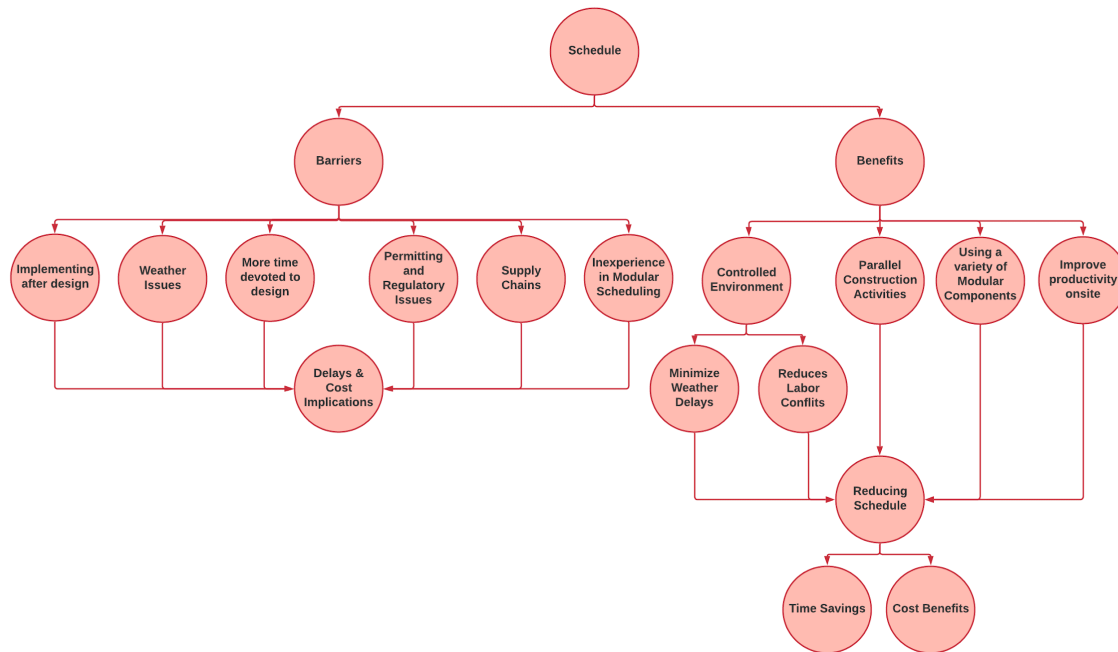
There were three primary areas related to labor that can influence hospital owners to use or not use off-site construction. Labor shortages and labor costs were the main drivers of using off-site construction. Overall, interviewees suggested that the construction industry is having a hard time finding labor; especially because the workforce is either aging or workers migrate to where there is a labor demand. This causes contractors to look towards alternative construction methods.

Despite shortfalls in labor, contractors want to reduce the amount of labor onsite, because it reduces labor liability and promotes a safer working environment, and ultimately reduces costs. Several respondents said that reducing onsite labor creates scheduling efficiencies and reduces the number of trades who have to wait for other trades to finish their tasks. In addition, many of the interviews mentioned that off-site construction can eliminate trades from having to work in less than ideal or cramped working spaces. Overall reducing onsite labor leads to schedule efficiencies which lead to reduced costs.

Despite the advantages of reducing labor, there are some disadvantages. Reducing labor, or decreasing demand for labor can potentially create a threat to markets that have a strong union presence. When a project employs modular manufacture versus using the local union, it essentially takes work from the unions and gives it to the modular manufactures. Consequently, this could lead to increased negative perceptions about the off-site industry.



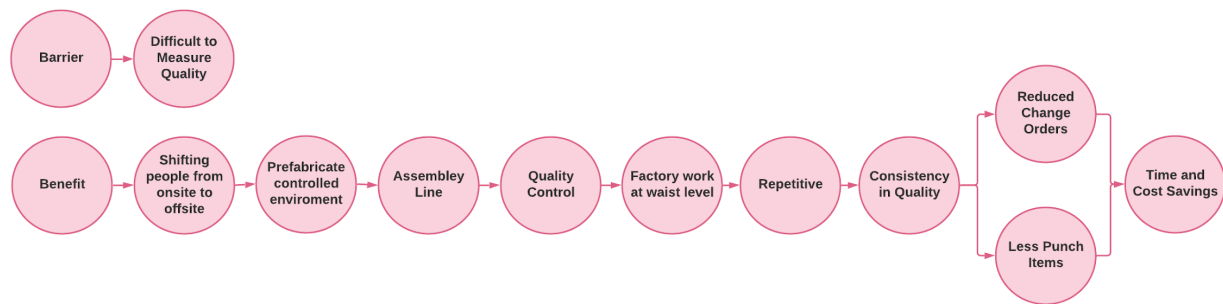
## Schedule



All the respondents indicated that schedule was likely the number one benefit to using off-site construction. The professor from Washington State University indicated from his studies that on average there is about a 35-40% schedule savings when using off-site. Many of the interviewees mentioned that off-site eliminates many of the coordination and labor issues that you have onsite. Off-site construction affords laborers to work around the clock in a controlled environment and schedule is more predictable; it minimizes weather delays and reduces labor conflicts. Interviewees mentioned that fast-tracking also improves the construction schedule. Overall, a large health care provider and large general contractor, and many of the others suggested that off-site construction improves the productivity onsite and ultimately leads to a reduced schedule, and cost savings.

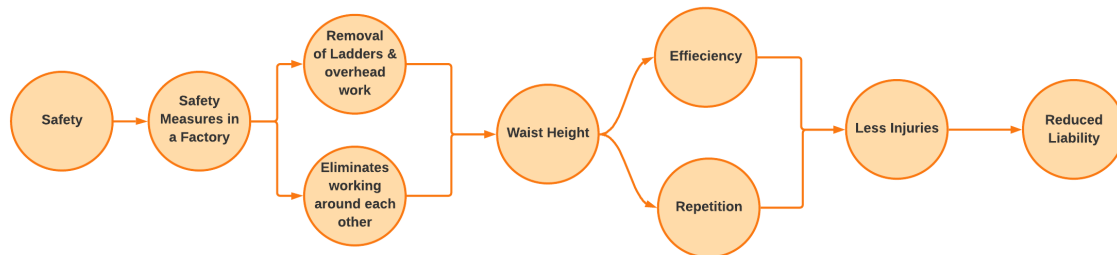
There were some notable barriers with respect to schedule. For example, using off-site construction requires more time devoted to design; weather can impact installation of modular and prefabricated components; disruptions in the supply chain can inhibit delivery of modular and prefabricated components, and contractors who were inexperienced in off-site construction may not have the know how to properly schedule the delivery and installation of modular and prefabricated components. Another factor that can impact the schedule is trying to incorporate off-site after the design has started, which leads to more redesign work and of course added time. All of which can lead to additional time and cost.

## Quality



Perceptions about quality and off-site construction were positive. Interviewees suggested that shifting people from onsite to off-site increases the ability to control quality and stated that it is easier to conduct quality control in a factory-controlled environment. Most of the interviewees suggested that working on an assembly line promotes a quality product; especially because a worker has their work at waist level versus trying to work overhead. The assembly line promotes repetition and experience allowing workers to consistently produce better-quality products with each repetition. Lastly, interviewees suggested that off-site construction reduces or eliminates the number of change orders and punch list items that often occur during and at the end of projects. Factors related to quality will inevitably lead to increased time and cost savings.

## Safety

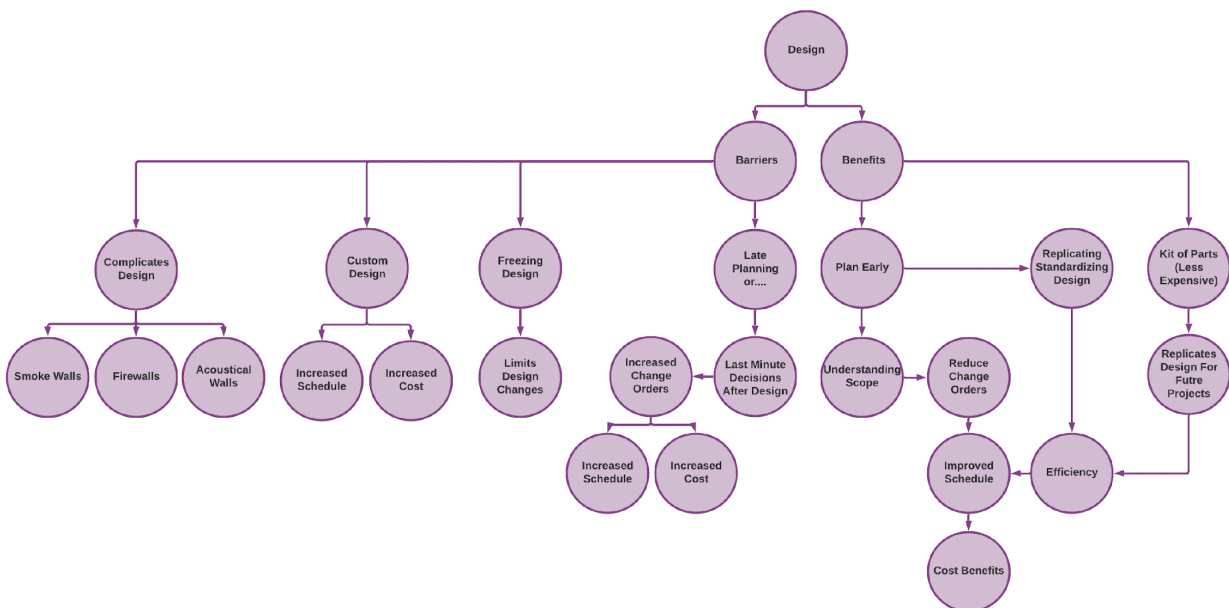


Interviewees stated that safety was a benefit to using off-site construction. This is because the controlled environment promotes predictability compared to that of the onsite environment. Onsite construction has a multitude of various trades and people who are unfamiliar with each other. It is highly probable that a project will not have the same two people migrating from one job to the next. Thus, this introduces unpredictability from job to job, which can create an increased possibility for injury. Whereas in the controlled environment you might work on one station or work on one repetitive task day in and day out. In addition, the controlled environment eliminates ladders, overhead work and puts work at waist height, which makes work more efficient. One interviewee mentioned that there are even safety mechanisms in place, such as, yellow markings on the floor and laser detectors that stop machines. All these factors lead to fewer injuries, reduced liability, and finally decreased costs.



Despite these advantages, there are some barriers to off-site with respect to safety, especially as it pertains to installation and unfamiliarity with off-site construction on the job site. One interviewee illustrated safety is compromised when the workforce is not experienced in installing modular or prefabricated components; especially when there are high winds or bad weather.

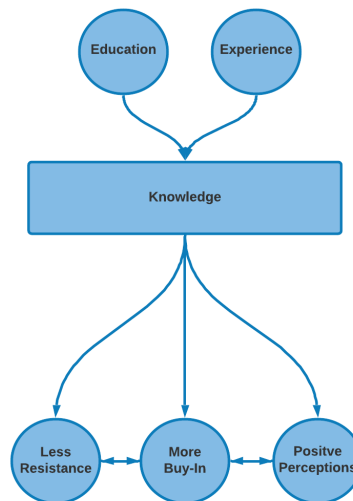
## Design



This study found that design can influence an owner's decision to use or not use off-site construction. To realize the cost and schedule benefits of off-site construction, owners should incorporate off-site early in the design phase. As discussed in the cost section, incorporating off-site construction early on leads to a better understanding of scope and delineation, which leads to reduced change orders and improved schedule. Design repetition and standardizing design stood out as a benefit with respect to design efficiency. Planning early coupled with design repetition will reduce change orders and lead to improved schedule and cost benefits.

On the other hand, incorporating off-site construction after the design has started, or making last-minute design changes after manufacturing has begun is not advantageous. This leads to increased change orders results in negative impacts on both cost and schedule. Other barriers related to design include the need to freeze design early, which limits design changes after initiating off-site production. Furthermore, design changes or customization will lead to increase in schedule and cost. Lastly, off-site construction can complicate an already complex design, specifically when incorporating or accounting for items such as smoke walls, firewalls, and acoustic walls.

## Knowledge



The topic of knowledge was especially important to all respondents. This study found that education and experience lead to knowledge, which in turn leads to having a full understanding of off-site construction. An increase in knowledge will lead to less resistance, more buy-in, and positive perceptions of off-site construction in all stakeholders, especially for owners and architects.

Every interviewee agreed that there needs to be more education surrounding off-site or modular manufacturing. Specifically, the industry needs to learn how to design with the manufacturers; change the way we think about how we build, and just generally educate and inform owners about off-site construction. Most agreed that data is just not readily available, which leaves unsavvy owners unable to make informed decisions.

Furthermore, contractors with limited experience in off-site construction are less likely to offer up off-site construction as an alternative building method, unless an owner specifically asks for it. One interviewee mentioned that project teams (especially the owner and architect) need to be able to conceptualize or articulate the off-site objectives or modular design, otherwise, the builder will not know what to build.

Some of the Interviewees suggested that some owners want to go with the tried and true and resist off-site construction and ultimately do not buy-in to the method. In addition, architects may resist off-site construction because they feel it strips them of their design creativity. However, most of the interviewees suggested that as more “good news” stories are told about off-site construction the more people will be more likely or willing to embrace the method. Lastly, every interviewee agreed that there are negative perceptions about off-site but, most indicated that perceptions are getting better.

## Regulatory Code Compliance

Regulatory code compliance and the barriers associated with permitting did not emerge in the literature review, however, this became an important theme in the interviews. This study found that Authorities Having Jurisdiction (AHJs) tend to complicate the process and are reluctant to permit off-site construction because of state or municipal codes. Interviewees suggested that codes and regulations are outdated. In addition, some inspectors tend to be set in their ways; for example, they often want to see how the factory is fastening plumbing or electrical components together or the length and gauge of a screw or nail. Thus, modular or prefabricated components manufactured in another state or country can really complicate the inspection process. Furthermore, building inspectors from Ohio are not likely going to fly to California or Toronto, Canada to inspect a modular component. Lastly, some interviewees suggested that some AHJs will not even accept inspections that are done outside their jurisdiction. This is likely because AHJs have a responsibility for building safety.

Overall, there was a general sentiment among the interviewees that local, state, and national codes need to reflect the current technologies surrounding modular manufacturing. Lastly, many interviews reflected on the importance of experience and education with respect to modular and prefabrication manufacturing and regulatory code compliance and permitting. Thus, regulatory code compliance permitting is central to knowledge and the future success of off-site construction.

## Transportation

The study found that transportation can influence an owner's decision to use modular and prefabrication manufacturing; especially as it relates to the distance from the factory to the project site. Some interviewees suggested that transportation can sometimes price the project straight out because it might be too costly to ship the product to the site. One researcher in the interview had conducted their own research and suggested that the off-site factory should be within at least 200-300 miles of the project; anything more would not be economical. The characteristics of a component are also important with respect to cost and shipping. For example, it is more expensive to ship a volumetric component versus shipping a prefabricated flat panel or flat packed components. Volumetric modules are more expensive because they take up more space on a truck and owners are essentially paying to ship air.

Some other barriers related to transportation included a states' department of transportation regulations and fees. Certain size and weight restrictions can limit or restrict the shipment of modular and prefabricated components and fees can vary from state to state. Some states may even require lead cars or require that transportation occur during a certain time of day.

Interviewees also discussed other potential barriers such as location and coordination with other construction projects in the region. For example, some project may be located in a rural area with limited access or dense urban areas with tight spaces and high traffic volume; each of the locations has their

own challenges. Some interviewees touched on the increased importance of sustainability and how transportation could lead to environmental concerns with respect to stakeholders and other agencies such as the Leadership in Energy and Environmental Design (LEED).

Many of the interviewees emphasized the importance of proper pre-planning and the reliance on knowledge. A contractor or modular and prefabrication manufacturer with education and experience is far more likely to be successful.

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