INTERNATIONAL JOURNAL OF INDUSTRIALIZED CONSTRUCTION
2021, VOL. 2, No. 1
https://doi.org/10.29173/ijic252

# Construction Stakeholders' Perceived Benefits of and Barriers to Environmentally-friendly Modular Construction in a Hospitality-centric Environment

Shreyansh PALIWAL[1], Jin Ouk CHOI[2], James BRISTOW[3], Hyun Kyung CHATFIELD[4], Seungtaek LEE[5]

[1] *MSc, Department of Civil and Environmental Engineering and Construction, University of Nevada, Las Vegas*
[2] *Assistant Professor, Department of Civil and Environmental Engineering and Construction, University of Nevada, Las Vegas*
[3] *MSc, Department of Civil and Environmental Engineering and Construction, University of Nevada, Las Vegas*
[4] *Associate Professor, Harrah College of Hospitality, University of Nevada, Las Vegas*
[5] *Postdoctoral Scholar, Department of Civil and Environmental Engineering and Construction, University of Nevada, Las Vegas*

## ABSTRACT

Modular construction techniques can improve not only project costs, schedules, and performance quality significantly but also sustainability, by reducing site disruption and waste generated, creating better relocatability and reusability. However, developing and implementing modularization in a hospitality-centric environment still carries difficulties. Thus, the primary goal of this research is to identify the opportunities and challenges of implementing sustainable modular construction techniques in a hospitality-centric environment, such as in terms of contractor experience and transportation. In this study, the approach included the formulation of a survey, which was distributed to 600 industry professionals in Las Vegas and completed by 63 industry professionals, followed by three personal interviews. The results showed the following: 1) Of the survey participants, 85% expected an improved schedule, and 65% of participants who elected to use a form of modularization actually experienced an improved schedule. 2) Additionally, 62% of the participants claimed that they would keep using modular methods, and 44% of the participants claimed they would increase their use of modularization in the future. 3) Two of the top five expected sustainable benefits included less site disruption and reduced waste. 4) Transportation/logistics was selected as a key barrier in the implementation of modular construction. 5) Finally, if construction professionals gained more experience on modular projects, the benefits and barriers of modularization they perceived could increase and decrease, respectively. The research results provide valuable insights for implementing sustainable modular methods in hospitality-centric environments.

**Submitted** February 16, 2021
**Accepted** May 21, 2021
**Published** June 2021

**Corresponding Author**
Seungtaek Lee, Ph.D
seungtaek.lee@unlv.edu

Department of Civil and Environmental Engineering and Construction
University of Nevada, Las Vegas
4505 S. Maryland Pkwy
Las Vegas, NV 89154

DOI
http://doi.org/10.29173/ijic252
Pages 15-29
ISSN 2563-5034



## KEYWORDS

Modular construction; Off-site construction; Sustainable construction; Lean construction

## Introduction

The construction industry provides a significant contribution to the economy of any country. In 2019, around 7.2% of the total workforce of the United States, i.e., 11 million people, worked in the construction industry [1]. The total value of US building and infrastructure construction was approximately $1.6 trillion in 2018 [2]. However, the enormous industry is confronted with various difficulties, such as shortage of workforce and low productivity relative to other industries [3]. There is also a growing demand for the construction industry to provide improved quality and better value projects. For these reasons, interest in modularization has been growing recently, and the modular market is expanding because of its various benefits. Modular methods can help the industry by building prefabricated modules in a controlled environment, such as a factory or a fabrication shop, which is located away from the construction site. In 2011, the value of the permanent modular construction market in Asia was estimated at $10 billion US dollars annually [4]. In Europe, the modular construction market accounted for approximately US $6 billion that year [4].

Perhaps more importantly, modularization can help practitioners to take a leap toward sustainable construction, as attention to sustainable construction has been increasing rapidly [5]. Modularization can reduce the amount of materials used and waste generated, as compared to traditional stick-built methods. In addition, it reduces site disruption and disruption to the surroundings by moving a large share of site-based work to an off-site facility. Because most of the construction work is carried out in a contained facility, there is also less dust and noise creation on site. Modules are transported to construction sites and assembled like building blocks [6]. In this way, modular construction helps in reducing construction-related disturbances. Moreover, buildings built with modular units are relocatable and reusable, so modular buildings can be dismantled and reused. Using this technique nearly eliminates the waste and contamination caused by building demolition. Environmental regulations have become increasingly stringent [7], so contamination can negatively affect cost and schedule performance [8]. If the local environmental regulatory agency discovers a contaminated site in a project's vicinity, the project could stop until field investigations are finished or the problems are solved [7,8]. In addition to these benefits, modularization can also increase productivity and reduce construction costs, durations, and accidents [3,5,9–19].

With this recent trend, the authors investigate the opportunities and challenges of implementing modular construction techniques in a hospitality-centric environment by evaluating the current situation and characteristics of construction in Las Vegas. Hospitality facilities tend to include structures with repetitive elements, such as hotels or dormitories; therefore, the hospitality industry can benefit from using modular methods of construction more than many other types of construction. Moreover, the greater the number of repeated modules with repetitive design and layout, the higher the cost-effectiveness of modular construction [20]. Aligned with this opportunity, the Marriott and Hilton hotel chains recently initiated modular construction programs [21]. The city of Las Vegas has been selected for this study, as it has the highest number of hotel rooms for any city in the world, consisting of over 160,000 rooms [22,23]. The Las Vegas construction industry demands improvement in construction quality for the hospitality industry, as it is a prominent tourist attraction for the world.

Thus, the primary goal of this research is to identify the constraints and opportunities when using sustainable modular methods within the focal area of a hospitality-centric environment. To accomplish the main objective, this research achieved five sub-objectives: 1) verification of which modular elements were incorporated in the modular projects in a hospitality-centric environment; 2) comparison between expected and actual benefits for industry professionals from modularization; 3) investigation of the ranking of barriers in implementing sustainable modular construction; 4) determination of the primary decision-makers in implementing sustainable modular construction; and 5) suggestion to achieve higher levels of modularization in a hospitality-centric environment, based on the results.

This research is organized as follows: an in-depth literature review was conducted to understand the relationship between sustainability and modular construction, as well as the current status of modular construction in a hospitality-centric environment. It also demonstrated how modular methods of construction can aid in achieving higher levels of sustainability in the construction sector. Next, the research methodology adopted for this study is outlined, including the preliminary investigation conducted before the survey, formulation of the main survey, data analysis, discussion of face-to-face interviews, and description of the survey participants. Subsequently, the study's findings from the survey and interviews follow. The last section includes the conclusion and recommendations for future research.

## Literature Review

In order to understand and present the existing research, this section reviews the current situation of modular construction in a hospitality-centric environment. Also, it describes how modular construction relates to sustainability.

### *Modular construction in a hospitality-centric environment*

The hospitality industry is a service industry that includes traveling, lodging, and hotels within the tourism industry.

One of the most critical points within the hospitality industry is achieving customer satisfaction [24]. However, tourists' satisfaction can be critically harmed by an unattractive view, noise, or dust from construction sites around the hotels and resorts. Hospitality-centric environments, which are becoming more competitive, rely on tourism for the economy, so dissatisfaction can critically damage the hospitality industry [25]. In such an environment, a modular construction method can be the best solution because modularization creates much less disturbance, dust, and noise than traditional stick-built methods [26]. Moreover, hospitality facilities, such as hotels, have substantial amounts of repetitively same shaped rooms, so a modular construction method is highly suitable [20].

Taking the hospitality industry into consideration, more and more owners, contractors, and project managers are implementing modular methods in their hotel projects, in and outside of the United States. One of the first hotels built by modularization was the Hilton Palacio del Rio Hotel for the Texas World's Exposition of 1968 in San Antonio, Texas. The hotel, which has about 500 rooms, was built in only 202 working days, and the room modules were placed in 46 days by cranes [3,4]. The Canyons Lodge and Cabins in Yellowstone National Park is a $90 million project, which was fabricated by Guerdon Modular Buildings in their Boise, Idaho facility. Out of the five total structures, three were fabricated in the first six months. The estimated stick-built time was proposed to be 30 months. After adopting modular construction methods, they were able to finish the project in one-third of the proposed stick-built time [27]. They also reported a reduction in construction waste of 85% [27]. A Hampton Inn and Suites built in Harrison, New Jersey, saved approximately three to four months of schedule using modular construction, which led to an earlier generation of revenue [28]. The Folsom Fairfield Inn and Suites by Marriott, a 97-room hotel constructed in Folsom, California, was also completed nearly five months early, as compared to the projected stick-built time [29,30]. Kings Park Accommodations in Queensland, Australia, saved 40% of the expected cost by adopting modular construction methods [31]. The modules were prefabricated within 50 days in Shanghai, China and assembled at the site in just one week.

As can be seen in various past cases, many hotels are being built by modular techniques. One of the main reasons is that if there are substantial repetitive components in a design, such as bathrooms, a modular construction project is highly likely to succeed [32]. Thus, hospitality facilities are best suited, as structures with repetitive elements. Numerous studies have verified the benefits of implementing modular construction practices, which are reduced project duration, improved labor productivity, and improved efficiency of jobsite management [9,10,12–14,17]. A study of general contractors' perceptions of off-site construction also discusses the benefits of modular construction. The benefits include: reduced overall project schedule by sidestepping the unforeseen delays in conventional construction methods such as weather; increased product quality; increased labor productivity through a shortened learning curve; increased on-site safety; reduced on-site disruption; and reduced negative impacts on the environment [5,7,9–16,18]. Thus, the reason to use modularization far outweighs the reasons not to in a hospitality-centric environment.

Nevertheless, many barriers and limitations in applying modular methods still exist. According to O'Connor et al., (2014), modular projects have barriers related to weather, logistics challenges, labor issues, regulating impact, and so on [33]. Moreover, Choi et al. (2017) identified the three most critical barriers for implementing modular construction: site access and on-site storage area, transportation and logistics, and distance from the modular factory to the construction site [34]. In the case of the hospitality environment, about 18.46% of off-site elements were being used in 2018. That ratio decreased compared to 2014, which was 23%, and the portion was much less compared to other construction fields, such as commercial (53.85%) and industrial (33.33%) construction [35]. Moreover, only a limited number of researchers have focused on the benefits and barriers of using modular methods in a hospitality-centric environment. Choi et al., (2017) [34] researched using modular design and construction in the dense urban environment of Hong Kong, with a focus on both the challenges and opportunities available. However, the characteristics of a hospitality-centric environment differ substantially from a dense urban environment, so this research cannot be generalizable to other environments, without considerations of their characteristics. Therefore, additional research needs to be done to evaluate the opportunities and challenges of implementing modular methods in hospitality-centric cities, such as Las Vegas, Orlando, Paris, Macau, Singapore, etc., specifically as it related to environmental differences of each.

*Sustainability and modular construction*

Sustainability is a process of avoiding the reduction of natural resources to maintain an ecological balance. It is a type of progress that meets the needs of the current generation without compromising the needs of future generations [36]. Unfortunately, the construction industry has an adverse influence on the environment. According to the United States Green Building Council (USGBC), approximately 40% of energy-related carbon dioxide is generated by buildings [37]. Moreover, the construction industry is consuming about 40 to 60% of the total raw materials [15]. It also accounts for approximately 35% of the total landfill waste stream [15,38]. However, because of heightened awareness of the environment, sustainability for construction is

considered a significant factor in areas of traditional performance, such as cost and schedule [5]. Therefore, numerous researchers have studied how to reduce and avoid negatively impacting the environment, and most have only focused on the occupancy phase. This is reasonable because most of the negative environmental impact has derived from this phase. For example, in the use phase, buildings consume 70 to 98% of their energy use, compared to the material production and construction phase, which accounts for 2 to 26% [15,39]. Thus, due to the efforts of these studies, the energy efficiency of buildings is increasing by applying energy-efficient technologies and renewable energy resources [15]. There continues to be a growing emphasis on the production and construction phases for sustainable construction [15]. According to Gustavsson and Joelsson [40], the production and construction phases for advanced energy-efficient buildings are responsible for approximately 60% of the entire building's energy use during the life cycle.

Modular construction can substantially contribute to sustainability aspects by reducing the impacts of construction on the environment during the production and construction phase [41–43]. First, construction waste can be reduced significantly by effectively calculating and purchasing the materials required and reusing any material wasted [26,43,44]. Modular construction practices help in reducing, reusing, and recycling waste, as the materials remaining unused from one project can be stored in the inventory to be reused in the next project. For hotel projects, and other structures with substantial amounts of repetition involved, constructing bathrooms, or entire rooms, in the form of pods off-site will reduce waste at the construction site by 50%. Also, most of the waste generated in an off-site facility is either reused or recycled [32]. Second, using prefabricated components like sandwich exterior walls can help reduce construction dust emissions by 30% [26]. Third, modular components can also help reduce construction noise by manufacturing off-site [26]. Additionally, by adopting modular construction, the total construction period of a project is reduced, which leads to reduced construction disturbance for the surrounding areas during that period. Fourth, a project with high levels of prefabrication will provide less traffic interruption at the site because there will be a limited and planned number of trips to the site from the fabrication shop [45]. Fifth, modular construction promotes reuse of materials by providing the ability to deconstruct, relocate, and reconstruct an entire structure [46]. Sixth, adopting modular construction methods can lead to achieving a Leadership in Energy and Environmental Design materials and resources credit through the optimum utilization of natural resources [47]. For example, LEED has a Materials and Resources section, and some variables are highly related to modular construction, such as Building Life-Cycle Impact Reduction and Construction and Demolition Waste Management. Thus, modular buildings provide opportunities to obtain Leadership in Energy and Environmental Design certifications of higher levels [48]. Lastly, off-site construction ensures the energy management flows better and can increase energy efficiency by reducing energy consumption during construction phase [41].

## Methodology

In order to achieve the research objective, the research was developed as shown in Figure 1. First, the research problems were identified and a literature review was conducted. Subsequently, a questionnaire for the survey was prepared. After this stage, the data collection process was carried out in three stages:

(1) Preliminary Investigation: to determine the willingness of industry professionals in survey participation and to get feedback on the survey questionnaire.

(2) Survey: this stage included sending the survey to the experienced construction managers, superintendents, and project owners in Las Vegas. Then descriptive statistics were used to summarize the data collected from the survey. It was useful to find the patterns in the set of data and summarize them in a meaningful way. Statistical analysis was conducted for each question asked in the survey.

(3) In-Depth Interviews: these were organized to get detailed data based on information gathered in the main survey stage.

These three stages are explained in the sections below.

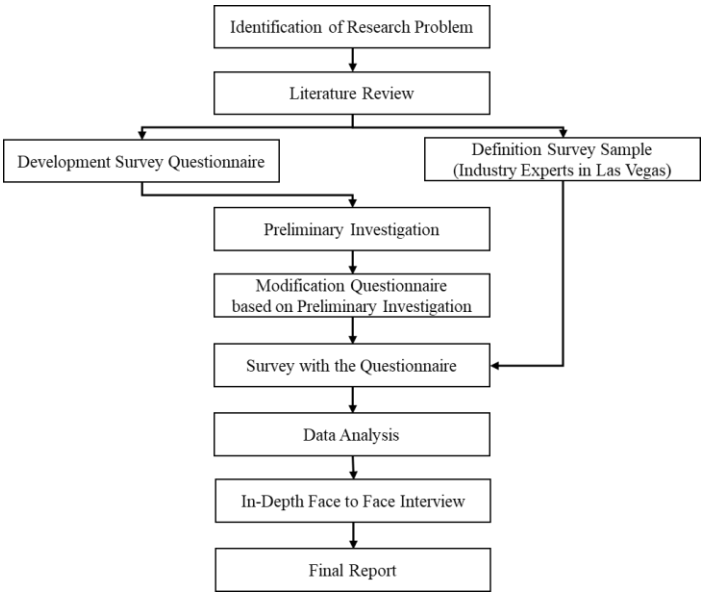


**Figure 1**. Research flow


**Figure 2.** Survey questionnaire example

*Preliminary investigation*

The main aim of the preliminary investigation was to identify the prospects and difficulties of using modular methods in a hospitality-centric environment. This included a discussion of the formulated questionnaire. Through the preliminary investigation, valuable feedback was received, so the survey questionnaire could be further improved for the main survey.

*Main survey*

The survey questionnaire was developed using a well-established questionnaire from a paper, "Opportunities and Challenges of modular methods in dense urban environment" [34], as the basis, with some changes made. For information about the detailed development process of the survey questionnaire, please check "Opportunities and Challenges of modular methods in a dense urban environment" [34]. To keep the survey simple, the descriptions and definitions were specified after each question, in order to avoid misinterpretation. Figure 2 shows a survey questionnaire example, and all the questions can be found in Appendix. The data collection was conducted from August 2018 through November 2018. The data analysis was done in November and December 2018. A web-based survey platform, Survey Monkey (https://www.surveymonkey.com), was used to distribute the survey to the participants. The aim of the research was explained in an email that was sent with the link to the survey.

The survey was distributed to 600 industry professionals in Las Vegas. Two reminder emails were sent to the participants after the original email, in the total span of six weeks. The survey collection was aimed for 50 individual responses from experts with varied industry experience, and no more than five participants working at the same company. A total of 63 survey responses from 38 different companies were received. The response rate from the construction professionals in Las Vegas was more than 10%. The survey data were collected from experienced professionals in Las Vegas. Hence, our survey data represents a hospitality-centric environment, which is our population of interest. Table 1 provides detailed descriptions of the survey participants.

**Table 1.** Detailed descriptions of the survey participants

| **Indicator** | |
|---|---|
| **Company's Primary Service** | |
| Owner/developer | 8 |
| Contractor/construction manager | 26 |
| Architecture | 4 |
| Engineer | 23 |
| Subcontractor | 1 |
| Structural designer | 1 |
| **Construction Industry Experience** | |
| Less than 10 years. | 6 |
| 10 - 30 years | 39 |
| More than 30 years | 18 |
| **Project size generally undertake** | |
| Less than $100 million | 48 |
| $100 million - $1 billion | 13 |
| More than $1 billion | 2 |
| **Modular projects experience** | |
| Less than 10 modular projects | 38 |
| 11-100 modular projects | 21 |
| 100 projects and above | 4 |
| **Modular Project Experience in 1 year** | |
| Yes | 42 |
| No | 21 |
| **Modular Project Experience in 5 years** | |
| Yes | 51 |
| No | 12 |
| **Total** | **63** |

*In-depth expert interviews*

To get more detailed perspectives of the professionals in the Las Vegas construction industry, three face-to-face interviews were conducted after the survey. The interview participants were: one project manager of an engineering firm and two project superintendents from two different construction firms. The interview with the project manager was held at the company's main office, while the interviews with the project superintendents were held at the construction trailers located at their construction sites. The face-to-face interviews aimed to discuss the benefits observed and barriers faced in adopting modular methods in any of their construction projects.

*Data analysis and method*

A total of 63 surveys were collected and analyzed through descriptive statistical analysis methods. The results were visualized and analyzed using bar charts for modular elements implemented in the last 12 months, the expected and actual benefits, and the decision-makers. The barrier scores were ranked, and the significant barriers in implementing modular construction were found. Based on the stakeholders' experience, experienced and inexperienced groups were separated, and their viewpoints on modular construction were compared.

## Analysis of Results and Discussion

The following topics of findings are presented in this section: (1) modular elements; (2) expected and actual benefits of using modular methods; (3) barriers to implementing modular methods; (4) responsible decision-makers in using modular methods; and (5) comparison industrial professionals' viewpoints. The results were also compared to similar previous research of Choi et al., (2017) [34] related to a dense urban environment.

*Modular elements*

Figure 3 shows the modular elements that were incorporated into the projects in the last 12 months. The five modular elements which were most implemented were: (1) precast concrete elements; (2) prefabricated exterior wall assemblies; (3) steel assemblies (frame, roof truss, etc.); (4) concrete panel systems; and (5) headwall assemblies; these were followed by equipment skids; HVAC; plumbing and electrical racks, risers, etc.; and precast concrete elements (piles and pad foundations). The other precast elements specified by survey participants consisted of: box culverts; drop inlets; manholes; modular communication cabinet; electrical panel assemblies; and bridge girders for a monorail. An industry expert working for a prominent home builder in Las Vegas pointed out that residential construction is currently not utilizing prefabricating in this region. Another industry expert from a general contracting company mentioned that prefabricated wood assemblies failed in one of their projects. As approximately 90% of residential buildings in the United States are light-frame wood construction [49], they are facing challenges in fully implementing modular methods.

The modular elements implemented were compared between the general environment [35], a dense urban environment [34], and a hospitality-centric environment. The points of similarity include the following: a) precast concrete elements were the most used modular elements; prefabricated exterior walls, steel assemblies, heating, ventilation, and air conditioning (HVAC), plumbing, and electrical rack elements were also widely used for all environments; and b) the most applied modular elements are non-volumetric applications that do not enclose usable space.

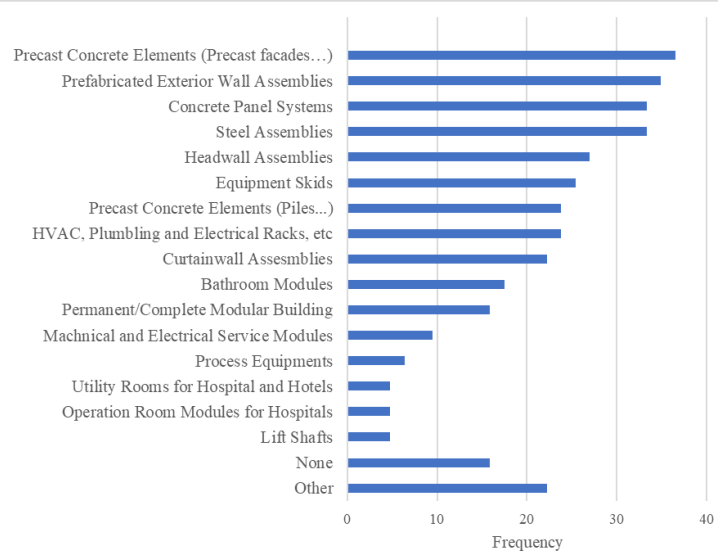


**Figure 3**. Modular Elements implemented in last 12 months

The points of a discrepancy between hospitality and other environments include the following: a) curtainwall assemblies were not applied as frequently as in general and dense urban environments; and b) headwall assemblies and equipment skids were relatively applied more in the hospitality environment.

*Benefits*

There are many advantages of modular techniques, and those have been reported and confirmed by numerous research studies. Therefore, this study verified the types of benefits that were expected and perceived by industry professionals. Figure 4 shows the expected benefits compared to the actual benefits in a hospitality-centric environment. The X-axis means the percentages of workers expected or perceived the benefits. For example, the improved schedule of expected benefits is about 80%, meaning 8 of 10 workers expected schedule improvement.

**General benefits**

The analysis aimed to assess the expectations of the industry professionals who are willing to implement modular methods, and the actual benefits realized by industry professionals after implementing those modular methods. The experts were asked to select their expected benefits from pre-construction, as well as the realized actual benefits after using modular methods in their projects in the past five years.

The first four expected and actual benefits were: improved schedule, lower cost, better quality, and improved productivity. The improved schedule was selected as the most significant benefit of implementing modular methods in a hospitality-centric environment. The general and dense urban environment also expected

the same benefits of schedule, quality, productivity, and cost [34,35]. In addition, some expected benefits almost achieved. For example, the sufficient labor supply of expected benefit is about 15%, and the perceived actual benefit is also about 15%, meaning the professionals' expected sufficient labor supply benefit is actually achieved. The survey results suggest the top five expected benefits achieved (variance < 5%) are: sufficient labor supply, reduced site-based permits, reduced waste, less site disruption (noise/traffic, dust, etc.), and increased safety.

However, most of the perceived actual benefits fell short of expectations. This might be because the practitioners encountered difficulties accomplishing their expected benefits when implementing modular techniques [34]. In the case of increased productivity, the expected benefit was almost 50%, but it achieved only 30%. The modular concept is a newer method, so some practitioners may be unfamiliar with it [35]. However, if they gain more modularization experience, the gap between the expected and actual benefits could be reduced.

**Benefits in terms of sustainability**

Sustainability is one of the significant benefits of modularization. The benefits from the survey reflect the contribution of modular construction towards sustainability by reducing construction waste, noise, traffic, dust, site disruption, and materials used for off-site construction. Generally, the evaluation of sustainable benefits was relatively low. The expected reduced materials benefit was chosen the least, and reduced waste and less site disruption were also low in the ranking. What is worse, the perceived actual benefits were much lower than expected. This result not only applied for the hospitality environment but general and dense urban environments as well; that is, the expectation for sustainability is quite low [34,35]. This might be because project participants were not fully aware of the benefits of modular construction. This result is comparable with the previous research [5]. According to numerous researchers, the sustainable benefits of off-site construction were proven in practice. They verified that less waste, noise, dust, and congestion, along with fewer greenhouse gas emissions, reusable units, and energy-consumption benefits were offered in modular construction [50]. It was also concluded that prefabrication construction can minimize the construction waste effectively by reducing on-site activities, such as plastering, timber formwork, concreting and reinforcement [51,52]. Thus, it is essential that project stakeholders understand the benefits. Then more owners and project managers will consider using the modular construction method, and the construction industry will become greener.

*Barriers*

The questionnaire asked the industry experts to rate the barriers of implementing modular methods in the Las Vegas construction industry on a scale of 1-4 (1 – no barrier, 2 – small barrier, 3 – moderate barrier, 4 – significant barrier). As mentioned above, the survey list of barriers was adopted from the previous research [34], and the question was asked in a matrix/rating scale.

The five most recognized barriers for implementing modular methods in Las Vegas are: (1) contractor capability/leadership/experience; (2) program of the building; (3) owner tendency; (4) transportation/logistics; and (5) distance from factory to site.

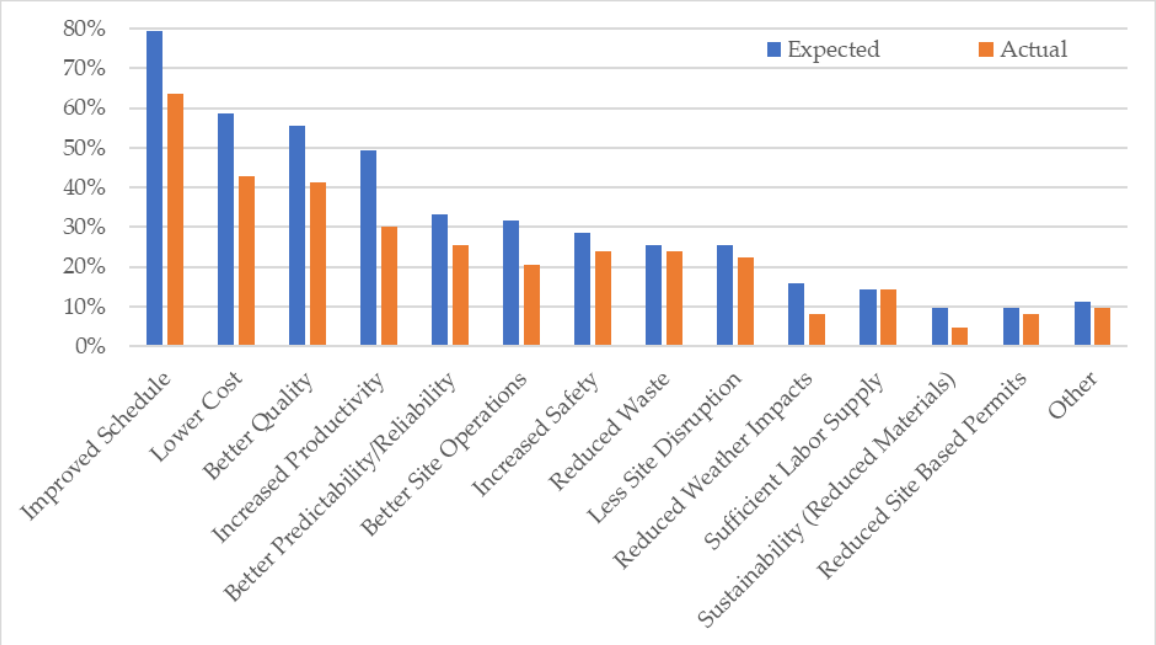


**Figure 4**. Expected benefits vs. Actual benefits

The barrier of an urban site (site access and on-site storage area) ranked 16th in Las Vegas. The experts were also asked to rate the site laydown space for their projects as generous, tight, adequate, or inadequate. Approximately 16% of survey participants claimed the site laydown space was generous, and 32% claimed it to be adequate. The least identified barriers were a concern for quality, along with financing and insurance, which were respectively ranked 20 and 21 in Las Vegas (Table 2).

The barrier in implementing modular construction was also compared to other environments. The points of similarity include the following: First, the tendency of contractor and owner, capability, and experience were considered the biggest barriers. As an explanation for these barriers, contractors are still learning how to apply modular elements; modular construction is maturing and requires more time for practitioners to adapt to the modularization environment [35]. To overcome the barriers, off-site construction education is necessary, but researchers have shown that more than 60% were never or only sporadically educated about off-site construction [53]. Thus, education about modular construction seems to be necessary. Second, researchers also examined the distance from factory to site and claimed that transportation is a critical barrier. La and Goger [54] also confirmed that transportation presents one of the biggest challenges in using off-site constriction techniques for architects or engineers.

**Table 4.** Ranking of barriers in implementing modular construction with their corresponding scores

| Rank | Barrier | Score |
|---|---|---|
| 1 | Contractor Capability/Leadership/Experience | 2.65 |
| 2 | Program of the building | 2.65 |
| 3 | Owner Tendency | 2.64 |
| 4 | Transportation/Logistics | 2.61 |
| 5 | Distance from factory to site | 2.58 |
| 6 | Industry Knowledge | 2.55 |
| 7 | A/E's Tendency | 2.52 |
| 8 | Cost vs. Value | 2.52 |
| 9 | Fabricator Capability/Leadership/Experience | 2.51 |
| 10 | Regulations + Codes + Approval from Authorities | 2.48 |
| 11 | Design + Construction Culture | 2.43 |
| 12 | Supply Chain + Procurement | 2.41 |
| 13 | Labor Union | 2.39 |
| 14 | Design Freeze | 2.29 |
| 15 | Coordination | 2.29 |
| 16 | Urban Site (Site Access and on-site storage area) | 2.1 |
| 17 | Initial Investment | 2.1 |
| 18 | Manufacturing Technology | 1.97 |
| 19 | Site Operations | 1.97 |
| 20 | Concern for Quality | 1.92 |
| 21 | Financing + Insurance | 1.77 |

If there is no modular factory, the construction project cannot apply a modular method. Additionally, transportation regulations vary significantly from state to state. Therefore, industry professionals may feel there are barriers. The differences between hospitality and other environments include the following: First, some industry professionals claimed that the design freeze barrier is critical, but the rank significantly differed between other environments. The hospitality-centric environment ranked it 19th, but it ranked first and sixth in the general and dense urban environment. Due to the characteristics of modular construction, design change can be extremely critical. Thus, it could be assumed that other barriers are more critical for hospitality construction. The barrier score in the hospitality environment (2.29) is even higher than in the dense urban environment (2.23). Otherwise, it may be thought that there was much less design change in the hospitality environment. Second, site operation achieved unexpectedly low scores in the hospitality environment. This might be because the population density of Las Vegas is relatively low. Thus, the project could have had a construction site that was big enough, and it might have been easier to operate the construction site.

*Decision-Makers*

The survey participants were asked to answer the question "During the project planning phase of your project, who was responsible for the decision to use modular methods?" [34]. The result of the survey in Las Vegas (Figure 5) stated that the decision is primarily made by owner/client (35%), followed by a construction manager (24%). The responses received as "others" in this survey were predominantly "Integrated Lean Project Delivery" or "Engineer." Thus, it is crucial to educate the owner/client and construction manager about modular construction. One of the reasons that the use of off-site constriction methods is limited is that construction practitioners do not understand it well [5]. However, according to a study on critical decision-making factors, integrated project delivery can make it easier to implement modularization, as all stakeholders are on board in the early project planning phase [55].


**Figure 5**. Decision-makers in implementing modular construction

*Different viewpoints based on modular project experiences*

This research also verified that viewpoints differ between the experienced and inexperienced groups. If the professional had three or more modular project experiences, he or she was classified as an experienced worker. If the professional had less than three modular project experiences, he or she was classified as an inexperienced worker. There were 42 experienced and 21 inexperienced workers.

1. Anticipation using a modular construction method—This research showed that the experienced group was more positive about applying a modular method in the future. More than 85% of the experienced professionals intended to use modular techniques at the same frequency or more often than now in 12 months, and 90% intended to do so in 5 years. However, 85% of the professionals who did not have prefabricated project experience were completely unwilling to use the modular method in 12 months.

2. Benefits—Tables 3 and 4 show the difference in perceived expected and perceived actual benefits from modular techniques between industry professionals. Both groups had similar ranks; for instance, the top benefits were improved schedules, lower costs, and better quality. However, the experienced workers expected and recognized the benefits much more than the inexperienced workers did. More than 85% of the experienced stakeholders expected that the modular construction would bring about an improved schedule, and 78% recognized it in practice. On the other hand, the inexperienced workers' rates were only 66% and 33.3%. Furthermore, the overall percentages of experienced professionals were significantly higher. Thus, it can be inferred that the more experienced the workers were with modularization, the more they perceived and expected benefits from it Additionally, there were several significant differences between the expected and actual benefits for experienced workers, such as increased productivity (23.8%), better quality (14.3%), and lower cost (14.3%). This means that modularization did not sufficiently satisfy the professionals in terms of productivity, quality, and cost performance.

3. Barriers—It was verified that inexperienced workers were more critical about barriers than experienced workers. Table 5 compared the perceived barriers between the experienced and inexperienced professionals. Almost all the inexperienced workers' barrier scores were higher than those of the experienced workers. For example, the contractor capability/leadership/experience factor had the highest barrier score for inexperienced (2.95) and overall workers (2.65), which means that the professionals who did not have enough modular construction experience considered this factor the most significant barrier. The experienced stakeholders also regarded it as a crucial barrier, but their score of 2.45 makes it only the seventh-highest barrier. There were two barriers that experienced workers' barriers score was higher than inexperienced, but the differences were minuscule (lower than 0.1). Thus, it can be concluded that the more experienced the workers were with modular construction, the less its barriers were perceived. Also, there are significant differences in the perceived barriers between experienced and inexperienced workers.

According to the comparison, it is possible to confirm that the viewpoints of modular construction between experienced and inexperienced workers differ. This shows that experienced professionals anticipate and recognize the benefits much more and have fewer barriers to implementing modularization. Moreover, they tend to use modularization more frequently in the future. Based on these results, it can be concluded that the high barriers and low perceived benefits issued from the inexperienced workers' lack of knowledge. Unfortunately, the workers had no chance to experience modular construction, so they were unfamiliar with it and felt more uncertain about it. Thus, the best way to improve this would be to gain modularization experience. If it is difficult to accumulate enough modularization experience, then education is another alternative. In doing so, modularization in a hospitality-centric environment will be implemented more frequently.

**Table 3.** Comparison of perceived expected benefits between professionals

| Benefits | Experienced | Inexperienced |
|---|---|---|
| Improved Schedule | 85.7% | 66.7% |
| Lower Cost | 66.7% | 42.9% |
| Better Quality | 64.3% | 38.1% |
| Increased Productivity | 59.5% | 28.6% |
| Better Predictability/Reliability | 42.9% | 14.3% |
| Better Site Operations | 38.1% | 19.0% |
| Increased Safety | 35.7% | 14.3% |
| Less Site Disruption (Noise/Traffic, Dust, Etc.) | 33.3% | 9.5% |
| Reduced Waste | 26.2% | 23.8% |
| Sufficient Labor Supply | 16.7% | 9.5% |
| Reduced Weather Impacts | 16.7% | 14.3% |
| Reduced Site-Based Permits | 14.3% | 0.0% |
| Sustainability (Reduced Materials) | 11.9% | 9.5% |

**Table 4.** Comparison of perceived actual benefits between professionals

| Benefits | Experienced | Inexperienced |
|---|---|---|
| Improved Schedule | 78.6% | 33.3% |
| Lower Cost | 52.4% | 23.8% |
| Better Quality | 50.0% | 23.8% |
| Increased Productivity | 35.7% | 14.3% |
| Better Site Operations | 26.2% | 9.5% |
| Better Predictability/Reliability | 31.0% | 14.3% |
| Increased Safety | 28.6% | 14.3% |
| Sufficient Labor Supply | 19.0% | 4.8% |
| Reduced Site-Based Permits | 14.3% | 0.0% |
| Reduced Waste | 28.6% | 14.3% |
| Less Site Disruption (Noise/Traffic, Dust, Etc.) | 26.2% | 14.3% |
| Sustainability (Reduced Materials) | 7.1% | 0.0% |
| Reduced Weather Impacts | 7.1% | 9.5% |

**Table 5.** Comparison of perceived barriers between professionals

| Barriers | Experienced | Inexperienced | Difference |
|---|---|---|---|
| Manufacturing Technology | 1.79 | 2.33 | 0.55 |
| Contractor Capability/Leadership/Experience | 2.45 | 2.95 | 0.50 |
| Urban Site (Site Access and on-site storage area) | 1.95 | 2.40 | 0.45 |
| Design + Construction Culture | 2.29 | 2.71 | 0.43 |
| A/Es Tendency | 2.39 | 2.80 | 0.41 |
| Supply Chain + Procurement | 2.28 | 2.67 | 0.39 |
| Coordination | 2.17 | 2.55 | 0.38 |
| Transportation/Logistics | 2.49 | 2.86 | 0.37 |
| Financing + Insurance | 1.67 | 2.00 | 0.33 |
| Industry Knowledge | 2.44 | 2.76 | 0.32 |
| Design Freeze | 2.11 | 2.42 | 0.32 |
| Labor Union | 2.29 | 2.60 | 0.31 |
| Fabricator Capability/Leadership/Experience | 2.41 | 2.71 | 0.31 |
| Initial Investment | 2.00 | 2.30 | 0.30 |
| Distance from factory to site | 2.49 | 2.76 | 0.27 |
| Site Operations | 1.91 | 2.10 | 0.20 |
| Owner Tendency | 2.59 | 2.78 | 0.19 |
| Cost vs. Value | 2.46 | 2.62 | 0.16 |
| Concern for Quality | 1.91 | 1.95 | 0.05 |
| Program of the building | 2.68 | 2.60 | -0.08 |
| Regulations + Codes + Approval from Authorities | 2.51 | 2.43 | -0.08 |

## Conclusion

In a hospitality-centric environment, with a large chunk of repetitive building components such as bathroom pods or entire hotel rooms, modular construction can help in reducing the construction schedule by building these modules simultaneously, away from the site. This study surveyed industry professionals in a hospitality-centric environment to identify the opportunities and challenges in implementing modular construction methods. In order to assess the opportunities and challenges of implementing modular construction techniques in a hospitality-centric environment, a survey was conducted with 63 participants from 38 different companies in Las Vegas.

The findings from this study are: firstly, the five commonly implemented modular elements in Las Vegas are precast concrete elements, prefabricated exterior wall assemblies, steel assemblies, concrete panel systems, and headwall assemblies. Compared to the projects in a dense urban environment, the modular elements incorporated in Las Vegas are mostly similar. Secondly, the top four actual benefits of implementing modular methods in a hospitality-centric environment are improved schedule, lower cost, better quality, and improved productivity. The improved schedule was selected as the most significant benefit of implementing modular methods in Las Vegas, as compared to better site operations in a dense urban environment. Thirdly, the five most recognized barriers in implementing modular methods are contractor capability/leadership/experience, a program of the building, owner tendency, transportation/logistics, and distance from factory to site. Additionally, the key decision-makers in Las Vegas for using modular methods are owner/developers, followed by general contractors. In Hong Kong, the key decision-makers are architects/engineers, which is completely opposite, as compared to Las Vegas. The results from the study also

suggest the integrated project delivery method is most beneficial in the implementation of modular construction with the team coordinating at the initial stage of the project. As a result, fewer conflicts make it easier to adopt prefabrication at the beginning of the project.

This study also provides evidence of the contribution of modular construction methods to sustainability. Some of the stakeholders perceived the sustainable benefits of modularization, such as reducing construction waste, noise, traffic, dust, site disruption, and materials used for off-site construction. However, the evaluation of sustainable benefits was lower than other benefits, and a similar result was shown in dense urban environments research. The sustainable benefits of modular construction are obvious and proven in practice. Thus, it could be concluded that project stakeholders did not completely understand the sustainable benefits of modular construction. Besides, it is necessary to make project stakeholders understand the sustainable benefits of modularization.

The study contributes to sustainable modular construction by identifying the opportunities and challenges of the implementation of modular methods in a hospitality-centric environment. Additionally, this study presents the industry's standpoint on the expectations, benefits, and barriers for implementing modular methods. Also, this study provides a comparison of the results of this study, with a similar study conducted in a dense urban environment. Through the comparisons, it is possible to identify how the hospitality-centric environment differs from other environments. Lastly, according to the comparison between the experienced and inexperienced workers' viewpoints, it is possible to verify that the way in which their thoughts differ and suggests a way to reduce the barriers of modular construction for inexperienced professionals. Furthermore, it can deliver a better understanding of modular construction in a hospitality environment.

This study identifies the need for future researchers to improve the construction industry's sustainability. Researchers have conducted extensive in-depth research on modular construction in hospitality-centric environments, but applying such knowledge has limitations. Industry professionals in Las Vegas, Nevada, completed the survey, so the results could be different in other cities. Thus, more case studies must be conducted to better relate the environmental benefits of using prefabricated and modular construction methods. In particular, survey data collected from various states in the United States or other countries could be used to generalize the results even more. Besides, various barriers exist to implementing modular construction, so it is essential to provide proper suggestions regarding how to overcome these barriers. In particular, building code compliance and jurisdiction acceptance were prominent barriers to implementing modular construction in Las Vegas. Compliance is more stringent due to multiple jurisdictions in the Las Vegas Valley. To overcome this barrier, further studies must be conducted on managing building code compliance and the acceptance of modules by jurisdictions.

## References


[1] U.S. Bureau of Labor Statistics, Labor Force Statistics from the Current Population Survey. Retrieved from https://www.bls.gov/cps/cpsaat18.htm (Accessed on 12 Feb 2019).

[2] Bureau of Economic Analysis. Available online: https://apps.bea.gov/iTable/iTable.cfm?ReqID=51&step=1 (Accessed on 12 Feb 2019).

[3] Azhar, S., Maulik Y., A., Lukkad, M. Y., Ahmad, I. (2013). An investigation of critical factors and constraints for selecting modular construction over conventional stick-built technique. *International Journal of Construction Education and Research*, 9(3), 203–225. https://doi.org/10.1080/15578771.2012.723115

[4] Bernstein, H. M., Gudgel, J. E., Laquidara-Carr, D. (2011). *Prefabrication and modularization. Smart market report*. McGraw-Hill Construction http://www.nist.gov/el/economics/upload/Prefabrication-Modularization-in-the-Construction-Industry-SMR-2011R.pdf (Accessed on 12 Feb 2019).

[5] Kamali, M., Hewage, K. (2017). Development of performance criteria for sustainability evaluation of modular versus conventional construction methods. *Journal of Cleaner Production*, 142, 3592–3606. https://doi.org/10.1016/j.jclepro.2016.10.108

[6] Lawson, R. M., Ogden, R. G., Bergin, R. (2012). Application of modular construction in high-rise buildings. *Journal of Architectural Engineering*, 18(2), 148–154. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000057

[7] Choi, J. O., Bhatla, A., Stoppel, C. M., Shane, J. S. (2015). LEED credit review system and optimization model for pursuing LEED certification. *Sustainability*, 7(10), 13351–13377. https://doi.org/10.3390/su71013351

[8] Tilford, K. R., Jaselskis, E. J., Smith, G. R. (2000). Impact of environmental contamination on construction projects. *Journal of Construction Engineering and Management*, 126(1), 45–51. https://doi.org/10.1061/(ASCE)0733-9364(2000)126:1(45)

[9] Tatum, C., Vanegas, J., Williams, J. (1987). *Constructability improvement using prefabrication, preassembly, and modularization*. Construction Industry Institute, The University of Texas at Austin, US.

[10] Song, J., Fagerlund, W. R., Haas, C. T., Tatum, C. B., Vanegas, J. A. (2005). Considering prework on industrial projects. *Journal of Construction Engineering and Management*, 131(6), 723–733. https://doi.org/10.1061/(ASCE)0733-9364(2005)131:6(723)

[11] Choi, J., and Song, H. (2014). Evaluation of the modular method for industrial plant construction projects.

International *Journal of Construction Management*, 14(3), 171–180. https://doi.org/10.1080/15623599.2014.922728

[12] O'Connor, J., O'Brien, W., Choi, J. (2015). Standardization strategy for modular industrial plants. *Journal of Construction Engineering and Management*, 141(9), 04015026. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001001

[13] Choi, J. O., O'Connor, J. T., Kim, T. W. (2016). Recipes for cost and schedule successes in industrial modular projects: Qualitative comparative analysis. *Journal of Construction Engineering and Management*, 142(10), 04016055. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001171

[14] O'Connor, J. T., O'Brien, W. J., Choi, J. O. (2016). Industrial project execution planning: Modularization versus stick-built. *Practice periodical on structural design and construction*, 21(1), 04015014. https://doi.org/10.1061/(ASCE)SC.1943-5576.0000270

[15] Kamali, M., Hewage, K., Sadiq, R. (2019). Conventional versus modular construction methods: A comparative cradle-to-gate LCA for residential buildings. *Energy and Buildings*, 204, 109479. https://doi.org/10.1016/j.enbuild.2019.109479

[16] Wuni, I. Y., Shen, G. Q., and Mahmud, A. T. (2019). Critical risk factors in the application of modular integrated construction: a systematic review. *International Journal of Construction Management*, 1–15. https://doi.org/10.1080/15623599.2019.1613212

[17] Ghannad, P., Lee, Y. C., and Choi, J. O. (2020). Feasibility and implications of the modular construction approach for rapid post-disaster recovery. *International Journal of Industrialized Construction*, 1(1), 64-75. https://doi.org/10.29173/ijic220

[18] Rausch, C., Edwards, C., and Haas, C. (2020). Benchmarking and improving dimensional quality on modular construction projects–A case study. *International Journal of Industrialized Construction*, 1(1), 2-21. https://doi.org/10.29173/ijic212

[19] Ghimire, R., Lee, S., Choi, J. O., Lee, J. Y., and Lee, Y. C. (2021). Combined Application of 4D BIM Schedule and an Immersive Virtual Reality on a Modular Project: UNLV Solar Decathlon Case. *International Journal of Industrialized Construction*, 2(1), 1-14. https://doi.org/10.29173/ijic236

[20] Liew, J. Y. , Chua, Y. S., Dai, Z. (2019). Steel concrete composite systems for modular construction of high-rise buildings. *Structures*, 21, 135–149. https://doi.org/10.1016/j.istruc.2019.02.010

[21] Marriott-International. (2017). *Marriott International expands modular construction initiative*. https://news.marriott.com/2017/05/marriott-international-expands-modular-construction-initiative/ (Accessed on 12 Feb 2019).

[22] Albawaba Business. (2017). *Dubai makes it to world's top 10 cities with most hotel rooms*. https://www.albawaba.com/business/dubai-makes-it-worlds-top-10-cities-most-hotel-rooms-955290 (Accessed on 12 Feb 2019).

[23] Statista. (2018). *Number of lodging rooms in Las Vegas in the United States from 2000 to 2017*. Retrieved from https://www.statista.com/statistics/221045/room-inventory-in-las-vegas/ (Accessed on 12 Feb 2019).

[24] Oh, H., and Parks, S. C. (1996). Customer satisfaction and service quality: A critical review of the literature and research implications for the hospitality industry. *Hospitality Research Journal*, 20(3), 35-64. https://doi.org/10.1177%2F109634809602000303

[25] Janes, P. L., and Wisnom, M. S. (2003). The use of importance performance analysis in the hospitality industry: a comparison of practices. *Journal of Quality Assurance in Hospitality & Tourism*, 4(1-2), 23-45. https://doi.org/10.1300/J162v04n01_02

[26] Li, L., Sui, S. (2015). Comprehensive benefits evaluation of sandwich exterior wall panel. *Sustainable Buildings and Structures: Proceedings of the 1st International Conference on Sustainable Buildings and Structures*, Suzhou, PR China, October 29-November 1, pp. 167.

[27] Guerdon-Modular-Buildings. (2018). *Canyons Lodge, Yellowstone National Park, Wyoming.* http://www.guerdonmodularbuildings.com/our-work/canyon-lodge/ (Accessed on 12 Feb 2019).

[28] Deluxe-Built. (2004). *Construction simplified*. https://www.deluxemodular.com/portfolio/hampton-inn-and-suites (Accessed on 12 Feb 2019).

[29] Anderson, M. (2016). *Here's how a new Folsom hotel topped out in just four days*. https://www.bizjournals.com/sacramento/news/2016/05/03/heres-how-a-folsom-hotel-topped-out-in-just-days.html (Accessed on 12 Feb 2019).

[30] Guerdon-Modular-Buildings. (2016). *Folsom Fairfield Inn and Suites*. http://www.guerdonmodularbuildings.com/our-work/folsom-fairfield-inn-suites/ (Accessed on 12 Feb 2019).

[31] Prefabmarket. (2016). *How this builder saved 40% by choosing modular container construction*. http://www.prefabmarket.com/builder-chooses-modular-container-construction/ (Accessed on 12 Feb 2019).

[32] Mtech Consult Group. (2012). *Waste reduction potential of offsite manufactured pods*, 1–10. http://www.wrap.org.uk

[33] O'Connor, J. T., O'Brien, W. J., Choi, J. O. (2014). Critical success factors and enablers for optimum and maximum industrial modularization. *Journal of Construction Engineering and Management*, 140(6), 04014012. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000842

[34] Choi, J. O., Chen, X. B., Kim, T. W. (2017). Opportunities and challenges of modular methods in dense urban environment. *International Journal of Construction Management*, 1–13. https://doi.org/10.1080/15623599.2017.1382093

[35] National Institute of Building Sciences (NIBS). 2018. *2018 Offsite Construction Industry Survey*. NIBS, Washington, DC.

[36] HEC Global Learning. http://www.globalfootprints.org (Accessed on 12 Feb 2019).

[37] U.S. Green Building Council. (2019). *Benefits of green building*. https://new.usgbc.org/press/benefits-of-green-building (Accessed on 12 Feb 2019).

[38] Bribián, I. Z., Capilla, A. V., Usón, A. A. (2011). Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. *Building and Environment*, 46(5), 1133–1140. https://doi.org/10.1016/j.buildenv.2010.12.002

[39] Scheuer, C., Keoleian, G. A., Reppe, P. (2003). Life cycle energy and environmental performance of a new university building: Modeling challenges and design implications. *Energy and Buildings*, 35(10), 1049–1064. http://dx.doi.org/10.1016/S0378-7788(03)00066-5

[40] Gustavsson, L., Joelsson, A. (2010). Life cycle primary energy analysis of residential buildings. *Energy and Buildings*, 42(2), 210–220. https://doi.org/10.1016/j.enbuild.2009.08.017

[41] Zhai, X., Reed, R., and Mills, A. (2014). Embracing off-site innovation in construction in China to enhance a sustainable built environment in urban housing. *International Journal of Construction Management*, 14(3), 123–133. http://dx.doi.org/10.1080/15623599.2014.922727

[42] Boafo, F. E., Kim, J. H., Kim, J. T. (2016). Performance of modular prefabricated architecture: case study-based review and future pathways. *Sustainability*, 8(6), 558. https://doi.org/10.3390/su8060558

[43] Jiang, Y., Zhao, D., Wang, D., Xing, Y. (2019). Sustainable Performance of Buildings through Modular Prefabrication in the Construction Phase: A Comparative Study. *Sustainability*, 11(20), 5658. https://doi.org/10.3390/su11205658

[44] Cameron, P. J., Di Carlo, N. G. (2007). Piecing together modular: understanding the benefits and limitations of modular construction methods for multifamily development (Doctoral dissertation, Massachusetts Institute of Technology).

[45] Chen, Y., Okudan, G. E., Riley, D. R. (2010). Sustainable performance criteria for construction method selection in concrete buildings. *Automation in Construction*, 19(2), 235–244. https://doi.org/10.1016/j.autcon.2009.10.004

[46] NRB. (2014). *7 sustainable building benefits of off-site construction*. 17–19. Retrieved from https://www.nrb-inc.com/modular-construction-blog/7-sustainable-building-benefits-site-construction/ (Accessed on 12 Feb 2019).

[47] Lee, J. H., Kim, J. S., Lee, H. J., Lee, Y. M., Kim, H. G. (2019). Small-scale public rental housing development using modular construction-Lessons learned from case studies in Seoul, Korea. *Sustainability* (Switzerland), 11(4), 1–18. https://doi.org/10.3390/su11041120

[48] Velamati, S. (2012). Feasibility, benefits and challenges of modular construction in high rise development in the United States: a developer's perspective (Doctoral dissertation, Massachusetts Institute of Technology).

[49] Ellingwood, B. R., Rosowsky, D. V., Li, Y., Kim, J. H. (2004). Fragility assessment of light-frame wood construction subjected to wind and earthquake hazards. *Journal of Structural Engineering*, 130(12), 1921–1930. https://doi.org/10.1061/(ASCE)0733-9445(2004)130:12(1921)

[50] Kamali, M., Hewage, K. (2016). Life cycle performance of modular buildings: A critical review. *Renewable and Sustainable Energy Reviews*, 62, 1171–1183. https://doi.org/10.1016/j.rser.2016.05.031

[51] Tam, C. M., Tam, V. W., Chan, J. K., and Ng, W. C. (2005). Use of prefabrication to minimize construction waste-A case study approach. *International Journal of Construction Management*, 5(1), 91–101. https://doi.org/10.1080/15623599.2005.10773069

[52] Tam, V. W. and Hao, J. J. (2014). Prefabrication as a mean of minimizing construction waste on site. *International Journal of Construction Management*, 14(2), 113–121. https://doi.org/10.1080/15623599.2014.899129

[53] Smith, R. E., Grosskopf, K., Elliott, J. (2015). *Off-site construction education*. https://www.nibs.org/page/oscc_resources (Accessed on 12 Feb 2019).

[54] La, L., Goger, W. L. (2008). Designers' and general contractors' perceptions of offsite construction techniques in the United State construction industry. *International Journal of Construction Education and Research*, 4(3), 177-188. https://doi.org/10.1080/15578770802494565

[55] Azhar, S., Lukkad, M. Y., Ahmad, I., Lukkad, M. Y., Ahmad, I. (2012). Modular v. stick-built construction: Identification of critical decision-making factors. *48th Annual Conference of Associated Schools of Construction*, Birmingham, UK.

## Appendix

**Q1.** Your Name?

**Q2.** Industry Experience (Years)?

**Q3.** Approx. Number of Modular Projects worked on in career?

**Q4.** Company Name?

**Q5.** Company's Primary Service?
- Owner/Developer
- Contractor/CM
- Architecture
- Engineering
- Subcontractor
- Other: _____

**Q6.** Have you incorporated Modular methods (Prefabrication/Preassembly/Off-site fabrication/Permanent Modular Construction) in one or more projects in last 12 months?
- Yes
- No

**Q7.** Have you incorporated Modular methods in one or more projects in last 5 years?
- Yes
- No

**Q8.** Have you incorporated the following modular elements in one or more projects in the last 12 months? (check all that apply)

Non-volumetric applications (items that do not enclose usable space
- Precast concrete elements (Precast facades, staircases, slabs, balconies, cooking bench units, internal partitions)
- Precast concrete elements (piled and pad foundations)
- Concrete panel system
- HVAC, Plumbing and Electrical racks, risers, etc. (non-volumetric)
- Steel assemblies (frame, roof trusses, etc.)
- Raised floor and suspended ceiling systems
- Equipment skids
- Curtainwall assemblies
- Prefabricated exterior wall assemblies

Volumetric applications (units that enclose usable space)
- Headwall assemblies
- Bathrooms module
- Utility (Plant) rooms for hospitals or hotels
- Operation room modules for hospitals
- Lift shafts
- Mechanical and Electrical service modules for horizontal distribution (building services riser shafts)
- Process equipment

**Q9.** In your experience, what were the **pre-construction expected benefits** in terms of using Modular Construction Method?
- Improved Schedule
- Better Quality
- Lower Cost
- Better Site Operations
- Increased Safety
- Sufficient Labor Supply
- Sustainability (Reduced Materials)
- Reduced Site Based Permits
- Increased Productivity
- Reduced Waste
- Reduced Weather Impacts
- Better Predictability/Reliability
- Less Site Disruption (Noise, Traffic Dust, etc.)
- Others: _____

**Q10.** What were the **actual benefits** realized after using Modular Construction method?
- Improved Schedule
- Better Quality
- Lower Cost
- Better Site Operations
- Increased Safety
- Sufficient Labor Supply
- Sustainability (Reduced Materials)
- Reduced Site Based Permits
- Increased Productivity
- Reduced Waste
- Reduced Weather Impacts
- Better Predictability/Reliability
- Less Site Disruption (Noise, Traffic Dust, etc.)
- Others: _____

**Q11.** According to you, what are the **barriers for the implementation** of using Modular Construction by Hospitality Industry here in Las Vegas?

| Barriers | No Barrier | Small | Moderate | Significant |
|---|---|---|---|---|
| *Design+ Construction Culture* | | | | |
| *Distance from Factory to Site* | | | | |
| *Program of the Building* | | | | |
| *Transportation / Logistics* | | | | |
| *Industry Knowledge* | | | | |
| *Supply Chain + Procurement* | | | | |
| *Cost vs. Value* | | | | |
| *Regulations + Codes + Approval from Authorities* | | | | |
| *Site Operations* | | | | |
| *Concern for Quality* | | | | |
| *Owner Tendency* | | | | |
| *Contractor Capability/Leadership/Experience* | | | | |
| *Fabricator Capability/Leadership/Experience* | | | | |
| *A/Es Tendency* | | | | |
| *Design Freeze* | | | | |
| *Manufacturing Technology* | | | | |
| *Urban Site (Site access and on-site storage area)* | | | | |
| *Financing + Insurance* | | | | |
| *Initial Investment* | | | | |
| *Coordination* | | | | |
| *Labor Union* | | | | |

Other Barriers for implementing modular construction in Las Vegas:

**Q12.** What schedule benefits did you get after adopting Modular Construction? **(% Schedule Savings)**

**Q13.** What cost benefits did you get after adopting modular construction? **(% Cost Savings)**

**Q14.** During the planning phase for your project, who was **responsible for the decision** to use Modular Method?

**Q15.** What is the approximated **% Modularization** of the project?
(Ref: % Modularization: Portion of original site-based work hours exported to fabrication and module shops)

**Q16.** What is the **location of the site** of the project?

**Q17.** What is the **location of Module shop**/ factory/ yard of the project?

**Q18.** How critical is Building Information Modeling (BIM) to your ability to prefabricate assemblies?
- We have not used BIM
- Little Bit
- Very Critical
- Not Sure

**Q19.** What is the **quality** of the labor market where the module shop/ factory/ yard is located?
- High Quality
- Medium Quality
- Low Quality

**Q20.** What is the **quality** of the labor market where the module shop/ factory/ yard is located?
- Excess Supply
- Adequate Supply
- Inadequate/Non-Existent Supply

**Q21.** In the next 12 months, how often do you anticipate using modular method**?**
- Not at all
- Less
- The Same
- More

**Q22.** In the next 5 years, how often do you anticipate using modular method?
- Not at all
- Less
- The Same
- More