Utilizing Prefabrication in Order to Achieve LEED Credits

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This paper is a dissertation on the concept and benefits of utilizing panelization in construction to achieve LEED credits. Panelization is the process of prefabricating construction framing materials, such as walls, floors, and roof systems, to streamline and improve the construction process. This dissertation aims to examine: (1) how prefabrication can optimize construction through effective waste management (2) how prefabrication manufacturing plants are more efficient, cost-effective, and better for the environment with regard to material use and recycling than traditional construction methods (3) how prefabrication can be used to obtain LEED credit points for the Construction and Demolition Waste Management section of the material and resources category. To achieve this, I compiled research and conducted surveys with multiple construction industry professionals, specifically from the general contractor point of view, to gauge their understanding of panelization and whether they would implement it in their jobs to achieve LEED credits. Through this research, I determined that the ideal way to achieve LEED credits is to use panelization in as many aspects of the building process as possible. Benefits discussed by the general contractors and the research included an expedited development process, increased customization, increased structural reliability, and a reduced environmental impact.

Key Words: Prefabrication, Panelization, LEED, LEED Certification, Sustainable Building

Introduction

Panelization and prefabrication refer to the process of producing construction components offsite in factory safe conditions. This process is often conducted by a single trade and then delivered via truck bed or barge to a job site. Similar to this method of construction is modularization. Modularization is similar to prefabrication because the "modules" are prefabricated and manufactured off-site, however, require multiple trades to complete (Brissi Debs 2019). These modules can be made up of multiple panelized components. Panelization or Prefabricated components often include but are not limited to roof, floors, and wall systems.

Prefabrication in construction in its modern definition is a relatively new technological advancement. Prefabrication came about as a way to allow various building elements to be constructed off-site and shipped to a job site, drastically decreasing costs by saving labor and time. This style of construction dates back to the Mesopotamian civilization when the first prefabricated house was shipped from England to Massachusetts (Redshift 2021). By 1837, farm buildings and bungalows were often prefabricated and by 1889 Gustav Eiffel created a temporary tower for the Eiffel Tower constructed out of purely prefabricated iron components (Redshift 2021). Prefabrication did not begin to grow in popularity within the United States until the 1920s after World War I to meet the booming housing demand. Additionally, another rise in modular-built homes came about as a result of the 1929 Wall

Street Crash. Prefabrication proved to be an effective, yet inexpensive way of providing houses in bulk within a concise period of time. This is in part due to the repetitive factory-like mindset panelization applies to construction. The factory-controlled conditions prevent prefabricated components and construction materials from being damaged by the climate conditions or stolen on-site. These factory-controlled conditions also greatly improve the quality and craftsmanship of the work. Furthermore, this method of construction can have a profound benefit to the schedule of the project. Due to the ability to build offsite, construction can occur onsite simultaneously with work being produced offsite. This provides subcontractors ample space to complete the task as safely as possible. Even more modern methods of panelization are still being improved today. Now 3D printing and Building Information Modeling (BIM) are huge components in the prefabrication industry (Redshift 2021).

Literature Review

The United States Green Building Council (USGBC) was established in 1993 as a non-profit trade organization that promotes sustainability in how buildings are designed, built, and operated (Ainsworth 2011). Mike Italiano, David Gottfried, and Rick Fedrizzi, the founders of USGBC, most notable contributions were the inception of an environmentally sustainable building rating system popularly known today as Leadership in Energy and Environmental Design (LEED). USGBC is not government affiliated and operates as a private non-profit trade organization. Their work applies to all sectors of the building industry from commercial all the way to heavy civil and has over 20,000 members nationwide (Ainsworth 2011). USGBC aims to have all structures obtain LEED certification in order to build a healthier sustainable future. Today, LEED is a globally renowned certificate and the most widely accepted of its kind (green building rating systems). There are a host of benefits to choosing a LEED-certified building. These include attracting tenants, ease of operation, more satisfied occupants, reduced pollution, indoor environmental quality, and water conservation.
LEED utilizes a point system to grade buildings on their sustainability efforts. Points are achieved through obtaining credits within nine specific categories. The nine categories include: location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, integrative process, innovation, and regional priority. Each of these nine categories has points attributed to them based on their importance and impact on creating a more sustainable future. The number of total points is tallied up and placed into four levels of LEED credentials recognizing the building and its builders for outstanding work in creating a sustainable future. If the building achieves anywhere from 40-49 points it is awarded a LEED certification and receives Silver for 50-59 points, Gold 60-79 points, or Platinum for 80+ points respectively (Samarasekera 2017).

Waste management is a constant struggle within the construction industry. Construction is one of the most wasteful industries, and as much as 30% of the total weight of all building materials delivered to a typical construction site end up as waste (Osmani 2011) In the United States alone, 170 million tons of construction and demolition waste was generated during 2003 (Osmani 2011). Typically, contractors are unwilling to pay to take steps to counteract, unless they are substantially compensated by the owner. Prefabrication, however, is one such method that does not come at an exorbitant price but reduces waste within the building process. According to a study done in MDPI (Multidisciplinary Digital Publishing Institute), “modular construction reduces the overall weight of waste by up to 83.2%” (Loizou 2021). Modularization is not only an effective solution for reducing waste, but also results in a corresponding 47.9% decrease in the overall cost of waste for large structures (Loizou 2021). This benefit can be seen in almost every trade that prefabrication can be applied to with the most notable benefits in formwork and framing.

LEED credits can be achieved in a variety of ways through the use of prefabrication as opposed to conventional building techniques. Most significantly, the benefits of prefabrication can best assist in achieving LEED certification within the materials and resources category. Within this category, there are two points awarded for Construction and Demolition Waste Management. The purpose of this credit is to, “reduce construction and demolition waste disposed of in landfills and incineration facilities through waste prevention and by reusing, recovering, and recycling materials, and conserving resources for future generations. Furthermore, it is intended to delay the need for new landfill facilities that are often located in frontline communities and create green jobs and materials markets for building construction services” (USGBC 2022). Prefabrication reduces the weight of waste by up to 80%, which makes it an ideal solution to achieve the 2 points for this credit. USGBC specifically states that in order to achieve these two points, the project must generate less than 10 pounds of waste per two feet, which is far exceeded by the prolific waste prevention of panelization compared with a conventionally built project (USGBC 2022).

Methodology

This research project sets out to analyze the concept and benefits of utilizing Panelization in construction to achieve LEED credits. Ultimately, this project aims to encourage general contractors and industry leaders to adopt this style of construction, especially when pursuing LEED certification. Additionally, a sub-goal of this project is to gain an understanding of how the industry currently perceives the effectiveness in receiving LEED credits from USGBC through the use of prefabrication. While it is difficult to gauge the industry’s perception, it is clear that panelization compared to conventional building methods, has a greater impact on reducing the project's overall environmental footprint. Whether USGBC recognizes this or not through rewarding more LEED credits is another question. As a result, a qualitative analysis will be used to gauge industry leaders' perceptiveness to adopting this new, more environmentally friendly style of construction. The data collection used in this project consists of a survey administered to industry professionals such as project engineers, project managers, and superintendents who are familiar with the use of panelization. A LEED Accredited Professional was initially sought after for an interview regarding panelization's role in achieving LEED certification. However, this information is relatively understood and doesn't provide much value to this research project as a whole. As a result, taking a pulse on the industry's understanding and doubts about adopting panelization, as the optimal method of construction for achieving LEED credits, is best achieved through an online survey targeting such individuals.

Results and Analysis

The survey was administered to construction professionals who may be familiar with prefabrication via one of their jobs. Twenty-four members of the industry responded to this survey primarily from the perspective of a general contractor (as opposed to subcontractors, vendors, or consultants). This group was selected because it had the greatest probability of surveying industry professionals who have dealt with prefabrication is some way, shape, or form. The first question categorized the survey respondents into their occupation within the industry as shown in Figure 1.

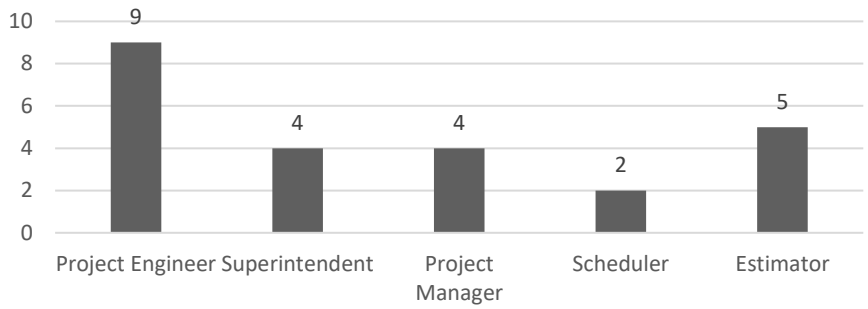

Figure 1: Occupation of Survey Respondents

Due to the range of occupation in survey respondents an accurate hypothesis can be polled on the variety of benefits panelization brings to the jobsite. Specifically getting input from scheduling and estimating departments allowed the greatest opportunity of surveying construction professionals who have experienced the benefits of prefabrication on a previous job.

Following this question, respondents were then asked if they have ever worked with a prefabricated component on a job. In this question, thirteen out of the twenty-four participants responded "yes" to having previously worked with a prefabricated component as depicted in Figure 2. This suggests that prefabrication isn't widely relied upon for its benefits nor for achieving LEED Credits. Due to the demographic of the group surveyed, this includes having scheduled, estimated, or managed the application of a prefabricated component on a job.

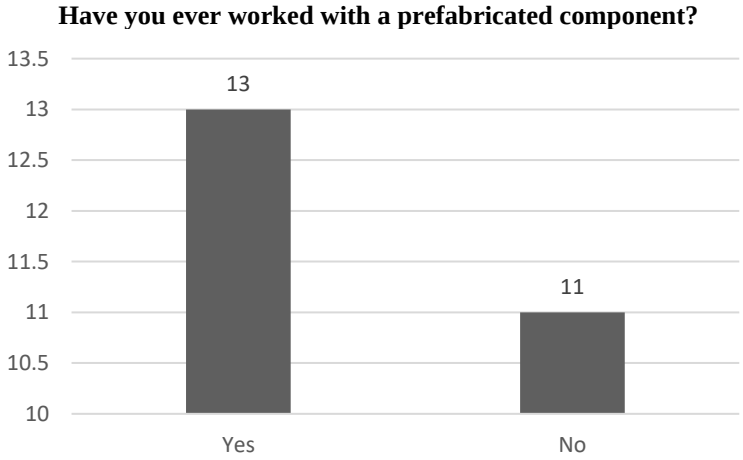

Figure 2: Familiarity with Prefabrication Amongst Respondents

Participants who answered "yes" to the previous question were then asked how prefabrication benefited their past or current projects. All thirteen members who have experience with prefabricated components cited benefits to schedule, cost, quality, and environmental friendliness on the jobs where these components were implemented. The thirteen members who answered "yes" could list any number of benefits allowing for multiple entries for this portion of the survey as a "long answer text box" was provided. The results from this question can be seen in Figure 3, a bar chart listing a variety

of benefits of prefabrication and its allocated number of selections from the group. Only one member from the group of thirteen who have experience with prefabricated components cited safety as being a benefit of utilizing this method of construction. Whereas schedule improvements and environmental friendliness were cited as being some of the most well known and most experienced aspects of utilizing this method of construction. Quality improvement and cost improvement were also listed fairly frequently as being a benefit of using prefabricated components.

If yes, how did it benefit your project? (Schedule, cost, quality, environmental friendliness, safety, etc.)

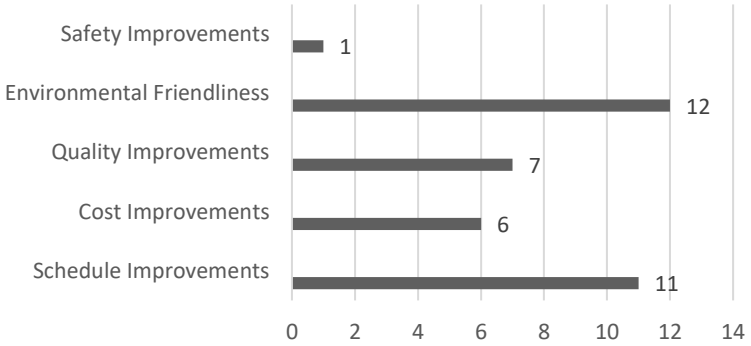

Figure 3: Experience Amongst Respondents with Prefabrication

When the respondents were asked if they thought using prefabricated components would aid in getting a project LEED Credits, twenty-one participants responded "yes". This shows that among construction industry professionals, there is a consensus that there is a correlation between utilizing prefabrication and achieving LEED credits. Additionally, it highlights a notion that contractors believe prefabrication is linked to environmental friendliness as shown in the results on Figure 4.

Do you think using prefabricated components aid in getting a project LEED Credits?

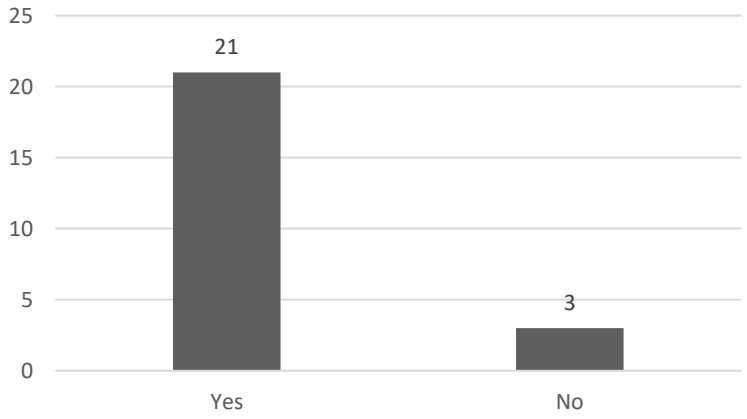

Figure 4: Respondents Understanding of the Correlation Between Achieving LEED Credits and Utilizing Prefabricated Components

All twenty-four members answered "yes" stating that they would seek out a prefabricated method of construction if a correlation was made between prefabricated components and achieving more LEED

Credits. This signifies that a large portion of the construction industry would be willing to a Prefabricated method of construction so long as it assisted in achieving LEED Credits. Getting a job LEED certified is an amazing accomplishment for all parties involved, including future tenants and contractors. Contractors understand the need for optimal ways of achieving LEED certification as seen in Figure 5. However, the results of this question do not certify that USGBC rewards a proportionate number of LEED Credits for utilizing panelized components that is equivalent to its benefits to any given jobsite.

Would you seek out this method of construction if there was a correlation between prefabricated components and achieving more LEED Credits?

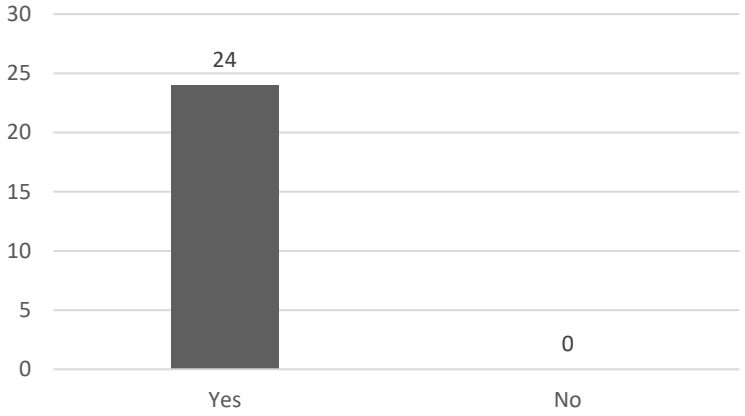

Figure 5: Willingness Amongst Respondents to Adopt Prefabrication

Only eight members answered “yes” to the question of whether they believed that USGBC was sufficiently awarding LEED credits equivalent to the benefits prefabrication provides to a project. Despite the litany of benefits prefabrication adds to a job, it is the general consensus among construction professionals that its benefits are not being fully awarded by the LEED accreditation system. This ultimately could lead to contractors opting to use conventional styles of construction over the prefabricated alternative. USGBC needs to do more to reward prefabrication construction or contractors won't be as willing to opt for this style of construction as seen in the data in Figure 6.

Is USGBC sufficiently awarding LEED credits equivalent to the benefits prefabrication provides to a project?

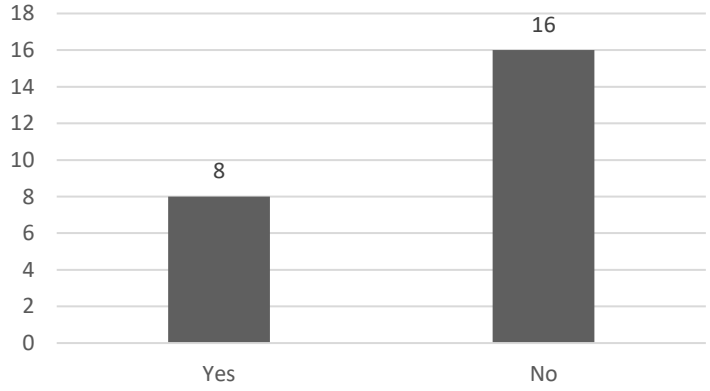

Figure 6: USGBC Efforts in Awarding LEED Credits for Prefabrication Substantial

Conclusions

This paper aimed to illuminate the concept and benefits of utilizing panelization in construction to achieve LEED credits. This was achieved through the use of a literature review and an online survey administered to construction industry professionals. Panelization was shown to be the preferred method of building in construction for its environmental friendliness and impact to the cost and schedule. However, among industry professionals it is not a widely sought-after method to achieve LEED Credits, specifically within the Construction and Demolition Waste Management section. Data collection via a survey conducted with multiple construction industry professionals gauged their understanding of panelization and whether it would be optimal to implement it on their jobs to achieve LEED credits. While it was hypothesized that the ideal way to achieve LEED credits was through the implementation of prefabrication in as many aspects of the building processes as possible, this was not the consensus among practicing contractors. Although most of the contractors recognized the benefit of prefabrication to any particular job, the general consensus was that USGBC was not doing enough to reward LEED Credits for this style of construction, as opposed to conventional construction techniques. Therefore, contractors appear to believe that panelization is not worth veering from more conventional methods. Resultantly, the USGBC needs to do more to reward contractors for undertaking panelization as a method of construction on their upcoming jobs.

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