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Implement BIM in Off-Site Construction

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Abstract

Building Information Modelling (BIM) developments in providing that it can be used not just for geometric modeling of a building's performance, but also for project management. The construction industry benefits greatly from modular building technologies. also, in BIM the entire process of planning, design, preparation of shop drawings, manufacture, and construction might be expedited. Early in the design process, physical incompatibilities between the structure, mechanical, electrical, and plumbing systems can be easily discovered. The main purpose of this article is to see how far the use of BIM has resulted in reported benefits on various offsite construction projects (OCP). Secondary data from enormous BIM-enabled offsite construction projects is used to conduct this analysis. A set of project success criteria was created, and content analysis was performed to assess how well each project met each of the criteria. Throughout the project life cycle, the most commonly reported benefit has cost reduction and management. There have also been significant time savings noted. The use of BIM software was cited as one of the major drawbacks. Cost-benefit analysis, as well as education and training, are essential activities in tackling the problems of BIM implementation. Furthermore, while processes for new construction are in place, the great majority of existing structures have yet to be maintained, rehabilitated, or demolished utilizing BIM. The prospective benefits of effective resource management spur study into how to solve the typical problems of building condition uncertainty and inadequate documentation in today's constructions.

Keywords: BIM; Off-site Construction; Modular Construction; Prefabrication Construction.

1. Introduction

Building projects are getting increasingly complicated and challenging to manage. According to the industry, off-site modular construction improves project quality and safety. To construct a unit such as a bathroom pod, walls with electrical and plumbing installed, or mechanical systems, various disciplines must collaborate. A system can be built off-site with prefabrication, but it only involves one trade, such as plumbing.

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Designer, and contractors polled, those who use off-site production include: Costs will be easier to control if off-site modular building becomes increasingly frequent. According to Konchar, off-site manufacturing makes sense for everyone in the building industry[1, 2]. A 32-story residential tower in Brooklyn, New York as shown figure01, is one of the more noticeable modular construction projects under underway. According to Konchar, Balfour Beatty has many projects where it is both the contractor and a partner with ongoing duties for building management and maintenance. Fewer people working in and around one other, less construction traffic, and increased safety are all advantages of modular construction.

Figure 01: 32story, Brooklyn, New York

The improved integration of the many components of the construction process distinguishes the American construction industry from that of the United Kingdom or Europe[3]. When introducing off-site production, contractors must overcome a variety of obstacles. According to Ryan Smith[4], author of Prefab Architecture: A Guide to Modular Design and Construction, modular construction is more widespread in the United Kingdom, where land prices have surged and labor expenses have risen[5, 6]. research will look at 18 modular building projects and compare their key performance metrics to traditional construction projects[7]. The purpose is to outline best practices and provide modular construction knowledge to builders. Modular construction is more popular in the United Kingdom[7], where land prices have soared, labor costs have risen, and the construction industry has begun to contract sooner than in the United States, Smith says[4]. The manufacturing process is carried out in a series of distinct stages, which is referred to as linear production. The fabrication of the wall, floor, and ceiling panels is the initial stage, after which they are integrated into three-dimensional pieces. Manufacturers who focus on high-volume, repeatable projects, such as hotels and student housing, prefer to use more complex production techniques. The three basic types of manufacturing systems are referred to as 'static,' 'linear,' and 'semi-automated linear.' Static production refers to the manufacturing of modules at a single location, with materials, services, and workers delivered to the module. The area surrounding the modules for local material storage is usually five times the module area[2].

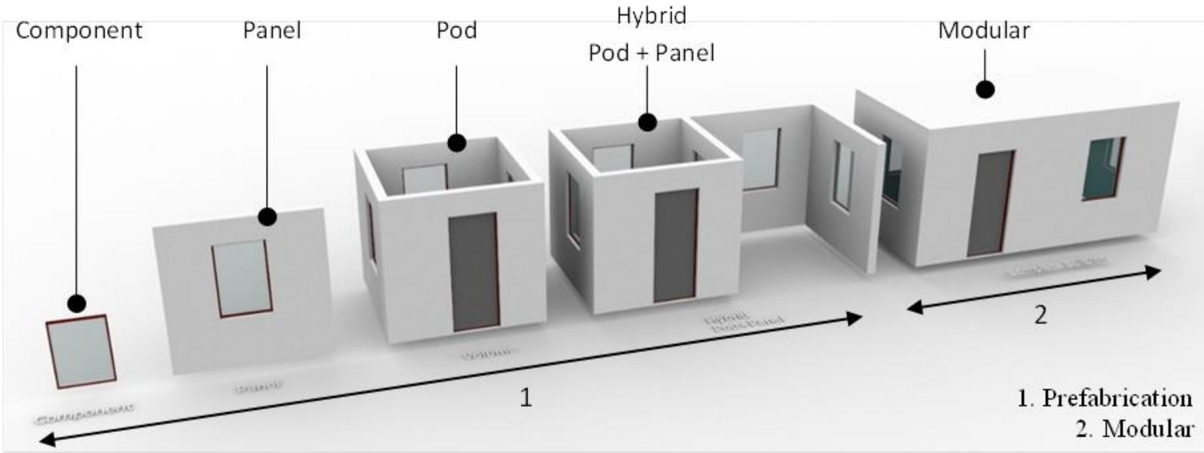

Figure 02: process of prefabrication to modular .

1.2. The Modular Building Institute's Definitions

1.2.1. Permanent Modular Building;

A design and construction procedure carried out in a manufacturing facility to produce building components or modules that will be moved to a permanent construction site[8]. Permanent Modular Construction (PMC) is an innovative, sustainable construction delivery system that prefabricates single or multi-story entire building solutions in deliverable module portions using offsite, lean manufacturing processes. PMC structures are made in a safe and regulated environment and can be made of wood, steel, or concrete[9]. The structures are finished 60 to 90% in a factory-controlled environment before being transported and erected on the job site[8]. PMC modules can be integrated into site-built projects or delivered as a turn-key solution, with MEP, fixtures, and interior finishes delivered in less time, with less waste, and with better quality control. compared to projects using exclusively standard site-build methods. In the last few years, a lot of research has come out proving that modular construction is a cost-effective construction method that will help the industry flourish.

1.2.2. Relocatable Modular Building;

A partially or fully assembled building that complies with applicable codes or state laws and is built utilizing a modular construction procedure in a building manufacturing facility[10]. Relocatable modular buildings are built to be reused or repurposed and transferred to different construction sites. A Relocatable Modular Building (RMB) is a partially or fully erected building that fits with applicable regulations or state regulations and is built utilizing a modular construction procedure in a building manufacturing facility[10]. Relocatable modular buildings are built to be reused or repurposed and transferred to different construction sites. Schools(dormitory), low rise offices, Healthcare, public buildings, and any other application where a relocatable building can meet a temporary space need are all places where relocatable modular buildings are used. Fast delivery, ease of mobility, low-cost reconfiguration, expedited depreciation schedules, and huge flexibility are all features of these buildings. rather than being permanently affixed to real estate. These structures are vital when speed, temporary space, and the capacity to relocate are required. BIM use maximizes improvements as can be seen in the graph below, a greater percentage of companies who make use of BIM have reported cost and schedule performance benefits as a result of prefabrication throughout the course of the past three years.

Investors need efficient structures built using sustainable processes, hence the sustainability and green agenda is a likely driver for BIM. Practitioners must also consider BIM's possibilities in a larger environment. An integrated design approach and an effective engagement process, which incorporates the demands of the users throughout the design phase, are essential.

1.3. Safety of offsite Construction

Constructing with modules offers an alternative that is safer. Workers in conventional construction are frequently required to perform their jobs in less-than-ideal conditions, which may include exposure to harsh temperatures, precipitation, wind, or any other natural occurrence. Working safely in this setting is significantly more difficult due to the nature of the environment itself. In addition to this, the likelihood of sustaining an accident, the most prevalent risk associated with working environments, such as falls, is significantly increased. Each worker in a factory setting is normally given a workstation that is stocked with all of the proper equipment required to provide the safest working environment possible. This ensures that the factory setting is as risk-free as it can possibly be. Off-site construction also avoids the risks connected with materials, equipment, and an incomplete construction process, which are typical of construction sites and can draw curious and undesirable bystanders. Off-site construction takes place in a controlled environment[11]. Construction time and on-site responsibility can both be cut down significantly with the help of the prefabrication sector and its BIM feature. Because construction time is reduced, neighbors are less affected than if the project were completed normally. Conventional distribution involves more staff and cars, which disrupts the neighborhood. There's less construction noise, dust, and big machinery. Off-site construction benefits the crew socially. Having a stable job location, the factory, encourages a healthier lifestyle than moving to multiple sites each morning. Permanent construction workers may cut their travel by moving closer to the factory, potentially even walking[12]. A normal workday may also encourage work-life balance. Modular prefabrication has a socioeconomic benefit because it requires more knowledge and skill than traditional on-site building. By closely supervising and training construction employees, accidents can be reduced, making these tasks safer. People who previously wouldn't have considered a profession in the building may now be intrigued. This may increase diversity in factory-based construction jobs in the future[12].

2. Methodology

The review was conducted to introduce and investigate the building information model (BIM) in offsite construction, as well as methods for the efficiency of BIM in the construction field. In order to achieve a targeted and systematic review of the literature, the relevant journals were selected, and databases Scopus, Google Scholar, Taylor & Francis Online, Science Direct, and Web of Science were utilized to conduct an exhaustive search. Several keywords, including "BIM" "modular Construction," "prefabrication Construction," and "Safety," were assessed in order to encompass a wide range of interrelated disciplines[13]. The research methodology will center on data collection from an off-site construction firm survey. In this instance, data collection will be conducted regarding the impact of BIM on offsite construction, such as schedule, cost, etc.[13]; furthermore, the study attempts to examine the influence of BIM on modular buildings and prefabrication buildings. a description of the strengths, weaknesses, and possible components of this form of structure.

3. Result

3.1. BIM Benefit

The Macleamy Curve, Efficient Design, Prefab has long been a part of the real estate market (REM), and it's worth noting that BIM had its start in prefab. In the 1990s and early 2000s, the steel and MEP market developed models first and primarily to improve their own coordination and production processes creating comprehensive shop drawings, material estimation, and automated production equipment. In the 2000s, the majority of designers and contractors followed suit, producing visualizations, simulations, drawing production, and REM coordination, eventually broadening BIM's early trade applications. With the expansion of prefabrication to include more disciplines, REM, and material items in the modern offsite process, it's only natural that the complete lifespan[14] of BIM applications be integrated at the same time.

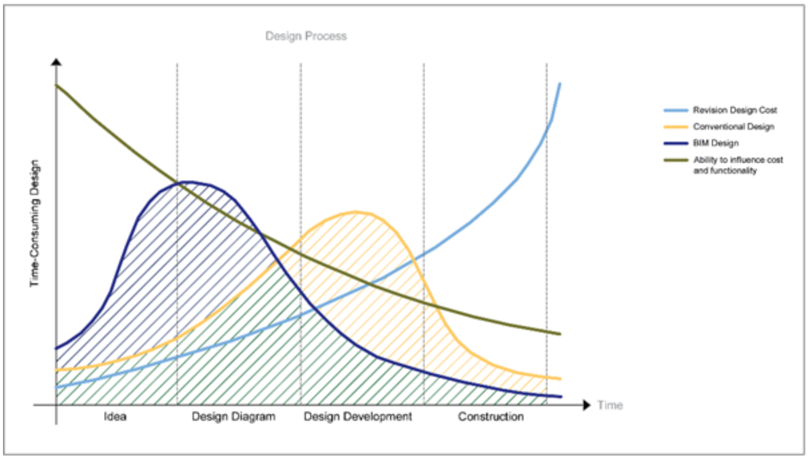

Figure 04: MacLeamy Curve, Design Process.

There is a reduction in overall expenses as a direct result of the investment made during the design phase in the BIM process. This investment enables a better ability to affect both cost and performance. The BIM workflow has the potential to save a significant amount of time, effort, and resources by shifting the focus of work earlier on in the design phase. One of advance feature of BIM is Detection of Clashes (DOC) Made More Straightforward, the project team has the ability to detect inconsistencies across the various disciplines earlier in the process[15]. This allows them to prevent redoing later on, which would increase both the price and the amount of time required. For instance, if a structural beam were to come into conflict with a mechanical duct, this issue might be identified inside the BIM model and fixed before the building was constructed. BIM technology won't improve construction, but it will improve designing. All project participants must grasp BIM's objective[3].

3.2. Improve Time and Cost with BIM

When using prefabrication or modular construction, the impact of BIM on cost and time performance is significant. All parts of the design and construction sector are being influenced by modeling technologies. This research demonstrates a substantial link between BIM use and the degree to which organizations benefit from prefabrication or modular construction in terms of schedule and money. Because the findings are similar for both prefabrication and modular construction users, the percentages in the Figure 05 reflect their combined reporting of positive impacts, divided by their level of BIM implementation.

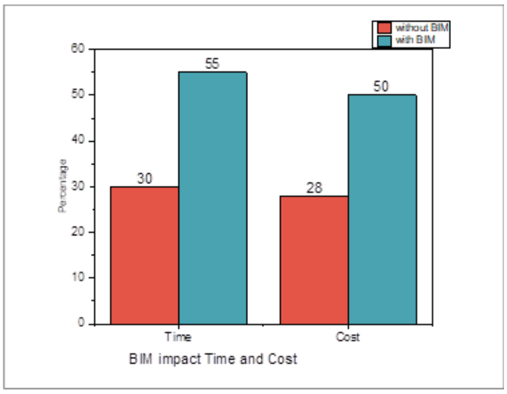

Figure 05: BIM Impact Time and Cost.

The most Impact of Building Information Modeling (BIM) on Prefabrication Forecasts by Building Type The results reveal a clear link between design firms' and trade contractors' usage of BIM and the frequency with which they all expect a high level of prefabrication, particularly on commercial and institutional projects where BIM is becoming more widespread. five of case studies categories the top ten building types have a direct relationship, as shown Figure 06 below. This emphasizes BIM's critical role in enabling model-determined prefabrication.

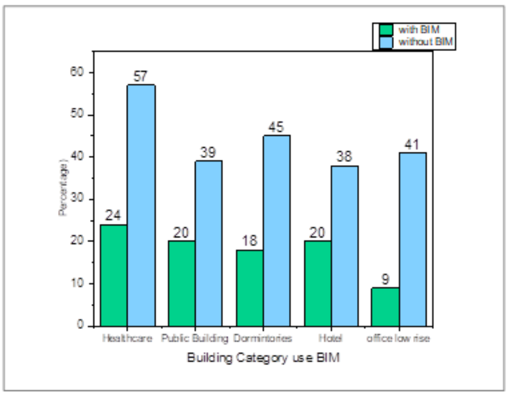

Figure 06: Most Building Category use BIM.

3.3. Factors BIM Influenced

The graph 04 shows, on an average basis across all seven of these factors, the percentage of all respondents who report high or very high positive impact from their use of prefabrication, broken down by their level of BIM usage. This allows one to see the impact that BIM has on those who are receiving the highest levels of benefits. Considerably less than half (44%) of the businesses who are not utilizing BIM at the present time say that they are gaining this high degree of benefit from prefabrication. Companies that are still expanding their BIM implementation are outperforming those that have not yet adopted it (44%), with well over half seeing improved performance levels as a result of prefabrication. In contrast, almost two-thirds of those who report using BIM frequently are enjoying high levels of these performance improvements from prefabrication. This percentage stands at 64%. Moreover, companies that report using BIM frequently are outperforming those that are still growing their BIM implementation.

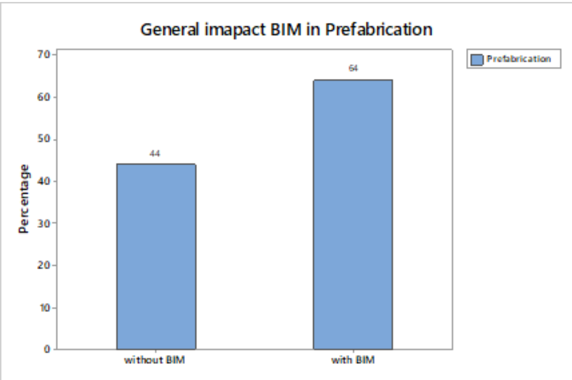

Figure 07: General Impact BIM in Prefabrication.

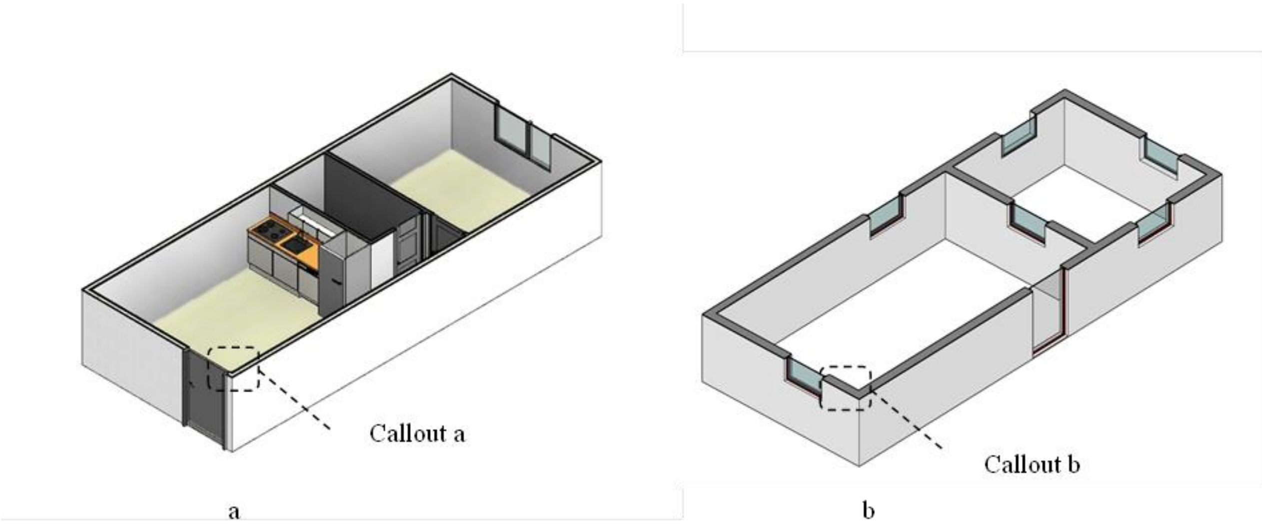

Figure 03: a. with BIM. B. without BIM.

Level Of Design (LOD)

In same time to drawing 3d view a prototype modular unit in different platform commercial engineering software, in figure 03, show level of design (LOD), drawing in BIM system can switch to different level of design and sorting from LOD100 to LOD500. There are five different levels of LOD, and they are referred to as LOD 100, LOD 200, LOD 300, LOD 400, and LOD 500 respectively. All of these layers, from the conceptual to the as-built, as well as facilities management, are covered. this drawing has the maximum level of information and can help readers comprehend much more about the subject, as seen in figure 04.

3.3.1. BIM in Prefabrication

The vast majority of the organizations who participated in this study make use of BIM on at least some portion of the projects that they undertake. Companies in that group were additionally questioned about how BIM is being used explicitly for prefabrication. These findings are discussed in this section of the study. BIM for Prefabrication: Current and Future Implementation The chart 07, illustrates the percentages of BIM users who are now using model-determined prefabrication at various degrees of implementation, as well as the percentages that believe they will be doing so within the future. In the recent years, the percentage of companies employing BIM for prefabrication on at least a quarter of their projects will rise considerably, from 42% to 74%. Almost all BIM users (99%) will be engaged in model- determined prefabrication from 2020 to 2023 years. Company-Type Implementation at a High Level The graph 05, depicts the current and projected percentages of companies who utilize BIM for prefabrication on 50% or more of their projects. The most deeply engaged are trade contractors, with over half (50%) expecting a high level of implementation in the years. Despite being the least active at the moment, design firms will nearly quadruple their present number of high-level implementers over the next e few years, indicating that they will be doing more to actively facilitate prefabrication in their design solutions. BIM technology can be used to integrate diverse manufacturing chains and achieve all-around information integration in prefabricated buildings. In an era when the connection between industrial and informational elements is becoming increasingly close, BIM technology will be seamlessly integrated with prefabricated buildings to promote construction industry innovation and development, potentially overturning the traditional construction industry. In the BIM Platform, create various standard BIM prefab libraries. Using BIM components from a standard library to meet the various needs of the prefabricated design[16]. Standard BIM prefabricated components, both to fulfill factory scale and automated processing requirements, as well as to assemble high-efficiency prefabricated site needs[16].

3.3.2. BIM in Modular

The vast majority of the organizations who participated in this study make use of BIM on at least some portion of the projects that they undertake. Companies assigned to the modular construction line of inquiry were also questioned on how BIM is being used specifically for that activity. These findings are discussed in this section of the study. BIM for Modular Construction: Current and Future Implementation the graph depicts the percentages of BIM users who are now involved in BIM- determined modular construction at various degrees of implementation, as well as the percentages that believe they will be there within the years. In the recent years, the percentage of companies adopting BIM for modular construction on at least a quarter of their projects will jump from 55% to 75%. Almost all (99%) BIM users will be using it for modular building within three years.

Company-Type Implementation at a High Level. The graph 10. depicts the current and future percentages of BIM users who utilize it for modular construction on 50% or more of their projects, per company type. The results are similar to those for model-determined prefabrication, but with a higher percentage of respondents anticipating future use (average 60% compared around 40%). The most deeply engaged are trade contractors, with nearly six out of ten (59%) forecasting a high level of implementation in the from 2020 to 2023 years. The number of design firms with a high level of implementation will nearly double, approaching contractor levels. This should encourage project teams to choose an integrated modular construction strategy. Graph 06 shows the areas of BIM that can improve various aspects of prefabrication construction. These areas include time improvement, which can be seen in the constructor vs. designer at a rate of 44–28 percent, but the biggest improvement can be seen in the designer vs. constructor when it comes to quality, at a rate of 34–25 percent. Additionally, this graph shows that BIM has the most effect on the contractor, which reduces onsite rework by 34–18 percent and costs by 24-to 23 percent respectively. However, when comparing coordination, the designer's score of 38% to the constructor's score of 38%, it demonstrates that BIM has made a sufficient progress in prefabrication construction. Also, Graph 09 shows the areas of BIM that can improve various aspects of modular construction. These areas include time improvement, which can be seen in the constructor vs. designer at a rate of 38–54 percent, but the biggest improvement can be seen in the designer vs. constructor when it comes to quality, at a rate of 35–22 percent. Additionally, this graph shows that BIM has the most effect on the contractor, which reduces onsite rework by 31–17 percent and costs by 26-to 14 percent respectively. However, when comparing the designer's score of 47% to the constructor's score of 41%, it demonstrates that BIM has made a sufficient progress in modular construction.

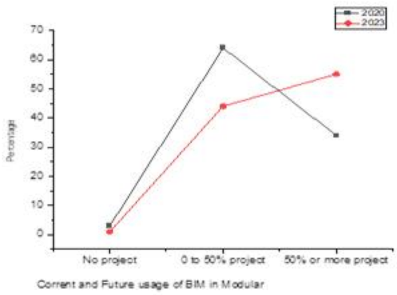

Figure 08: Current and future usage of BIM

Table 03: Current and future usage of BIM in Modular

Year	2020	2023
No project	3%	1%
0 to 50% project	64%	44%
50% or more project	34%	55%

Table 04: BIM Implementation by type of responsibility for Modular

Year	2020	2023
Designer	29%	50%
Constructor	38%	53%

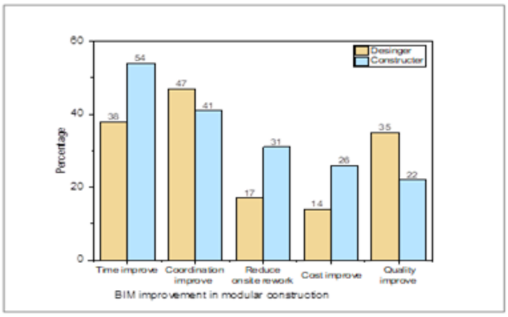

Figure 09: BIM improved Modular

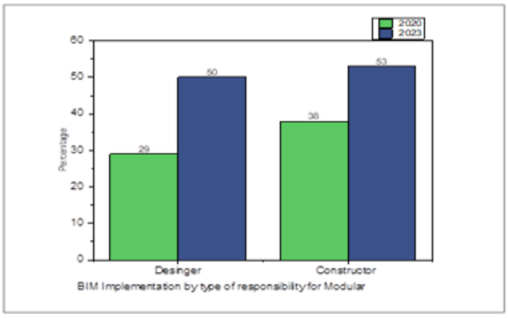

Figure 10: BIM Implementation by type of responsibility

By employing a single BIM model that contains information such as architectural, structural, electro mechanical, and so on, BIM in modular can achieve comprehensive professional collaborative design and optimization of fabricated modular buildings. Furthermore, all disciplines can assess all processes in a timeline, reducing redo work and ensuring that the project meets its deadlines.

4. Conclusion

In this paper considered workflow of building information modeling (BIM) and offsite construction and look over two sustainable approaches (Modular and Prefabrication construction) can introduce new path to bring new methodology of construction. which is safer and predictable. The Architecture, Engineering and Construction (AEC) industry is trying to adopt BIM as the future standard for building design, construction, and operation. However, adoption rates are lower than predicted. Various implementation challenges have been addressed. No single impediment hinders BIM adoption. The influence of these barriers on adoption varies from project to project. The study showed that BIM companies' design fees will likely rise. This is due to the increased burden early in a collaboratively created project. The owner can benefit the most from BIM, hence they should be pushed to use it. Local governments in several countries require all new public projects to use BIM to a certain extent. When project owners realize the benefits of BIM-based facility management, they'll deploy it as early as possible.

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