

Proceeding Paper

Contractor Perceptions of Off-Site Modular Construction in Kuwait: An Investigation of Current Practices [†]

Areej AlBanwan * , Nourah AlMutawaa and Abdullah AlFoudari

Energy and Building Research Center, Sustainability and Reliability of Infrastructure Program, Kuwait Institute for Scientific Research, P.O. Box 24885 Safat, Kuwait City 13109, Kuwait; nmutawaa@kisr.edu.kw (N.A.); afoudari@kisr.edu.kw (A.A.)

* Correspondence: abanwan@kisr.edu.kw

[†] Presented at the 2024 IEEE 4th International Conference on Electronic Communications, Internet of Things and Big Data, Taipei, Taiwan, 19–21 April 2024.

Abstract: Kuwait faces a pressing challenge in expanding its existing buildings to meet growing demands. The rising popularity of modular construction systems, with their off-site construction approach, offers promising solutions. In this research, we explored the characteristics of Kuwait's modular construction industry, including clients' awareness levels, preferences, and key motivations for adopting modular construction over the traditional construction approach. This research addressed a critical gap in the current literature by providing an outlook on Kuwait's modular construction industry, which has been notably absent in existing literature. Valuable insights gained through questionnaire surveys distributed to industry contractors highlighted the off-site construction methods used, the sectors they serve, and the key advantages of using modular construction in Kuwait. These findings contribute to researching unexplored aspects of modular construction in Kuwait. They also provide stakeholders with valuable insights, enabling them to make well-informed decisions for their construction projects.

Keywords: modular construction; prefabrication; off-site construction; contractor perception; Kuwait



Citation: AlBanwan, A.; AlMutawaa, N.; AlFoudari, A. Contractor Perceptions of Off-Site Modular Construction in Kuwait: An Investigation of Current Practices. *Eng. Proc.* **2024**, *74*, 16. <https://doi.org/10.3390/engproc2024074016>

Academic Editors: Shu-Han Liao, Teen-Hang Meen and Cheng-Fu Yang

Published: 27 August 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Like many rapidly developing countries, Kuwait faces a substantial challenge in expanding its existing infrastructure to meet the demands of a growing population. With urbanization on the rise and a pressing need for housing and infrastructure development, the construction industry is under constant pressure to deliver efficient, cost-effective, and sustainable solutions [1]. Consequently, the rising popularity of off-site modular construction for expanding residential buildings in Kuwait has drawn attention requiring a potential solution to these challenges. Thus, we explored the current state of the off-site modular construction industry in Kuwait, focusing on contractor perceptions and their role in shaping the industry's development. Modular construction, characterized by its off-site assembly of prefabricated components, is becoming prominent on a global scale due to its potential to enhance construction efficiency, reduce costs, and minimize environmental impact. In the modular construction approach compared with traditional on-site construction, most building components are fabricated and assembled at the construction site [2]. Modular construction systems allow various building elements to be manufactured in a controlled factory environment, transported to the construction site and rapidly assembled [3]. These benefits are particularly pertinent in Kuwait, where rapid construction is crucial to the increasing demand for building expansions while prioritizing both quality and cost-effectiveness. In this study, we addressed a significant gap in the current literature as there is limited information available on the off-site modular construction industry in Kuwait. While more research has been done on modular construction globally, Kuwait's specific conditions and practices remain largely unexplored.

2. Literature Review

2.1. Key Definitions and Principles

In recent years, the adoption of off-site and modular construction techniques has significantly increased, primarily due to the advantages of modularization and prefabrication, which improve efficiency, reduce time, minimize cost, and enhance the quality of construction projects [4]. The terms “off-site construction”, “modular construction”, and “prefabrication” are interconnected due to their shared goal of improving the efficiency and quality of construction projects. While they have distinct features, they often overlap and complement each other in various ways:

- Off-site construction encompasses a range of techniques to move construction activities away from the construction site. Buildings and the majority or all of their primary components are manufactured and pre-assembled, or partially assembled, in the factory. This pre-assembly includes attaching fixtures, wiring, plumbing, and other necessary elements. This means that the components, elements, or modules are ready for installation once they arrive at the construction site [5];
- Modular construction is a subset of off-site construction that involves fabricating pre-designed building units or ‘modules’ at an off-site location, which are then transported to the construction site as components and assembled to complete buildings or structures. This construction method capitalizes on modularization and breaks down a larger system, structure, or project into smaller, self-contained modules or components [6];
- Prefabrication involves manufacturing building components at a distance from the final location, often in a factory, before they are transported to the construction site for assembly. These prefabricated elements include wall panels, roof trusses, and plumbing systems. While prefabricated components may be used in modular construction, prefabrication is not limited to off-site work. It involves the production of pre-manufactured elements assembled on-site, which is also a part of traditional construction methods [7].

In summary, off-site construction involves manufacturing components away from the construction site. Modular construction is a specific type of off-site construction focusing on pre-designed modules for assembly, and prefabricated construction encompasses a wide range of prefabricated building elements used in various construction methods in both on-site and off-site approaches.

2.2. Modular Construction Industry

Off-site modular construction can be used for either permanent or temporary building structures. Permanent modular construction (PMC) involves the use of prefabricated modules to construct permanent buildings, such as residential and commercial buildings [6]. On the other hand, temporary modular construction (TMC), or relocatable buildings, involves the use of prefabricated modules to construct temporary buildings that can be relocated, such as disaster relief housing, clinics, medical facilities, and temporary residential or commercial spaces [6].

The modular construction industry comprises manufacturers, manufacturer-directors, and dealers. Manufacturers produce modules for general contractors or modular dealers. Manufacturer-direct entities, on the other hand, cater to general contractors and dealers but also engage directly with property owners to offer modular solutions, often assuming the role of a general contractor [8]. Both manufacturers and manufacturer-directing organizations may have specializations focusing on specific building types, such as residential or commercial, and may serve the relocatable or permanent construction markets.

Modules are fabricated from various materials, including wood framing, cold-formed steel framing, hot-rolled steel, concrete, or a blend of materials [8]. Not all manufacturers engage in the production of modules across all these materials. Instead, manufacturers often specialize in a specific type of construction to optimize their factory operations and efficiencies. The selection of module materials is typically dictated by the project’s specific

needs, site-related factors, and budget considerations, making it a contingent decision by project stakeholders [8]. Notably, in Kuwait, wood is excluded as a construction material due to its inability to withstand the country's high temperatures, which often exceed 50 °C in the summer.

Off-site modular construction offers a range of advantages that cater to specific market sectors that particularly require speed of construction, cost-efficiency, and minimal disruption of the building process. This approach finds significant applications in various sectors, including residential buildings, mixed residential and commercial structures, private and social housing, hotels, military accommodations, health sector facilities, and educational institutions. Moreover, modular construction is also well-suited for rooftop extensions on existing buildings and the addition of new balconies and lifts to enhance the functionality of established structures. The diverse applications of modular construction make it an attractive choice for meeting the unique demands of different market segments while ensuring rapid and cost-effective project delivery [9].

2.3. Classification of Off-Site Construction Methods

Different types of off-site construction can be classified based on the degree of prefabrication. Five sub-categories are described in this approach, as shown in Figure 1 [10]. This classification ranges from component (the lowest level of prefabrication) to panel, volume, hybrid, and complete building (the highest degree of prefabrication). This classification highlights the versatility of prefabrication methods in construction as follows:

- Prefabricated components include individual building elements and parts that are produced in a factory setting. These components can include beams, columns, windows, or smaller sections of walls and floors [9];
- Panelized construction involves the prefabrication of linear or flat, two-dimensional panels, used mainly for structural frames and walls. These are often prefinished with their insulation and boarding attached before being transported to the construction site and assembled to form the expanded building structure [9];
- Volumetric construction involves the prefabrication of fully completed, three-dimensional modules, which are then transported to the site for installation to create significant sections of the building [9];
- Hybrid construction combines various elements, including linear components, panels, and modules, to create a mixed-construction system. This method blends different prefabrication techniques to achieve a customized and efficient building solution that leverages the strengths of each element used [9];
- Complete building systems involve the assembly of modular components into fully finished structures before they are delivered to the construction site. In this method, the building or structure is essentially prefabricated to a high degree of completion in a factory setting, and it arrives at the site ready for installation and immediate use [9].

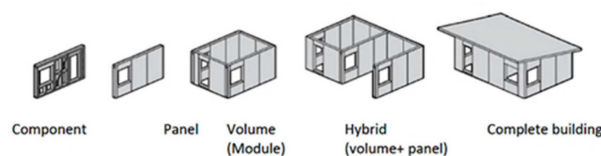


Figure 1. Off-site construction methods based on degree of prefabrication [10].

In summary, panelized construction is more suitable for smaller expansions or renovations, offering greater design flexibility and customization options. Volumetric construction is more suitable for larger expansions, allowing for rapid assembly and reduced on-site labor. Hybrid construction can offer the benefits of both panelized and volumetric methods, making it versatile and suitable for a wide range of project types. Complete building systems are characterized by exceptional efficiency, quality, and speed, making them suitable for applications such as modular homes or portable structures. Overall, off-site construction

offers a flexible and efficient way to expand existing buildings, and these methods provide a range of modularization options for achieving this goal.

2.4. Advantages and Disadvantages of Modular Construction

One of the main advantages of modular construction is its speed, which is up to 50% faster than traditional construction methods [11]. This accelerated construction pace is accompanied by better quality control, as the modules are constructed in a controlled factory environment, reducing the risk of errors and defects. Moreover, as components are prefabricated off-site, the reduction in on-site installation processes increases installation efficiency and simultaneously enhances working conditions and productivity [12]. This approach also significantly reduces the need for on-site labor, which results in reduced labor expenses and enhances overall project cost-effectiveness. Similarly, the modular construction approach reduces waste, noise, and dust on site, minimizing the impacts on the community while simultaneously improving the environmental quality [4]. Since most project activities are completed off-site, modular construction minimizes the disruptions to ongoing activities, making it particularly beneficial for expanding existing buildings where occupants need to continue their activities without significant interruptions.

While modular construction offers numerous advantages, it has challenges and limitations. One significant challenge pertains to transportation logistics, particularly for larger components or modules. Transporting oversized modules to the construction site requires specialized equipment and can cause delays, incur extra costs, and add complexity to the construction process [13]. Therefore, careful planning with explicit scope and design details is required before the start of the project. Furthermore, resizing or reshaping modules on the construction site is challenging. Additionally, modular construction may not be suitable for all types of buildings, particularly high-rises or structures in areas prone to strong seismic activity [4]. While off-site construction offers cost savings compared to traditional on-site methods, it necessitates the establishment of a fabrication plant, which leads to increased capital expenses [14]. Furthermore, the non-acceptance of this construction technology by the general and sometimes professional public are disadvantages of modular construction [15].

3. Methodology

To achieve the research objectives, a literature review was conducted to gather relevant information for the development of a structured questionnaire. The questionnaire was divided into two main sections. The first section was designed to gather information regarding respondents and organizational profiles. The second section was designed to gather insights into Kuwait's industry characteristics by exploring topics such as client awareness, the type of modular construction adopted, the sectors where off-site construction was implemented, the types of off-site construction offered by contracting companies, and the key advantages driving the adoption of off-site modular construction in Kuwait. Printed questionnaires were distributed to contracting companies involved in off-site and modular construction across various sectors in Kuwait. A total of 18 surveys from 6 different companies were analyzed, and a descriptive approach was used to evaluate, sort, and present the information gathered. The data has been presented using columns and pie charts. These visual representations were chosen because they effectively illustrate the distribution and proportions of the responses, making it easier to identify patterns and trends within the data.

4. Results and Discussion

4.1. Respondent and Organization Profile

In the initial section of the survey, respondents were asked about their professional roles, organization type, industry experience, and the types of projects their organizations had undertaken to understand the diverse landscape of the surveyed companies. The most prevalent job title among respondents was "Engineer", constituting 50% of the responses,

followed by “Architect” and “Manager”, each representing 22.2%. An additional 5.6% of respondents belonged to the category of “Other”, which included company owners, as illustrated in Figure 2. In the analysis of organization types, 61.1% of respondents identified as general contractors, and 38.9% identified as sub/specialty contractors, as outlined in Figure 3.

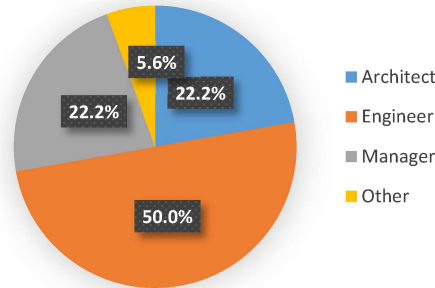


Figure 2. Professional background of respondents.

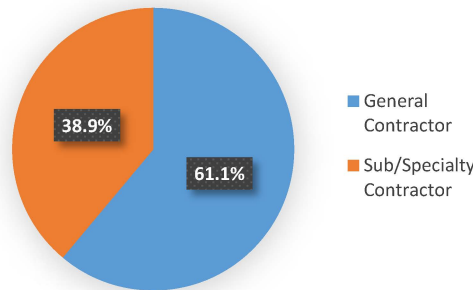


Figure 3. Type of organization of respondents.

In terms of industry experience, a majority (61.1%) of respondents were affiliated with companies that have been operating for 10–20 years, followed by 22.2% of respondents who worked in companies with over 20 years of experience, and 16.7% were associated with companies operating for 5–10 years. Notably, none of the surveyed companies reported operating for less than 5 years, as depicted in Figure 4. When examining project experience, a substantial portion of the respondents (77.8%) represented companies that had been involved in more than 20 projects featuring modular components. A smaller fraction (16.7%) had undertaken 5–10 projects, and the least represented group of respondents (5.6%) reported company involvement in 10–20 modular construction projects, as depicted in Figure 5.

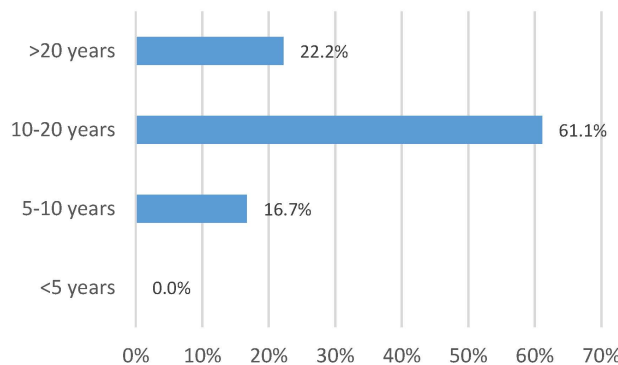


Figure 4. Years of operation in the construction industry.

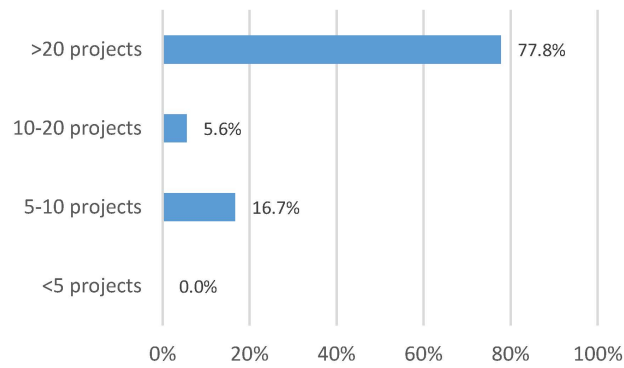


Figure 5. Number of off-site modular construction projects executed.

The respondents were further questioned about the types of projects undertaken by their companies to identify the sectors served by modular construction firms in Kuwait. Based on the findings, a significant majority (45.6%) of respondents’ companies were equally involved in residential and commercial building projects, followed by medical building projects (6.7%), institutional building projects (1.1%), and other projects (1.1%), including chalets, as illustrated in Figure 6.

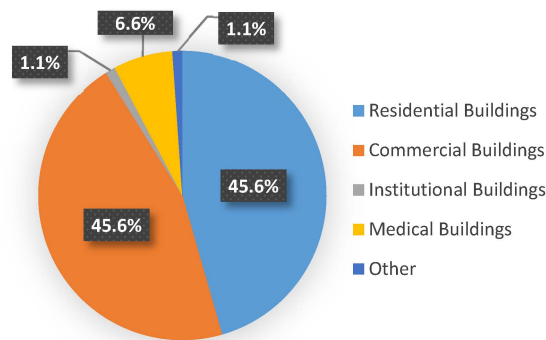


Figure 6. Types of off-site modular construction projects carried out by respondents’ companies.

4.2. Client Awareness of Modular Construction

In the second segment of the questionnaire, respondents were directed to provide insights on clients’ awareness of modular construction as a building construction method. The findings revealed a notably low level of client awareness of modular construction, with 83.3% of respondents stating a lack of awareness among their customer base, and only 16.7% of respondents found some awareness among their customer base, as shown in Figure 7.

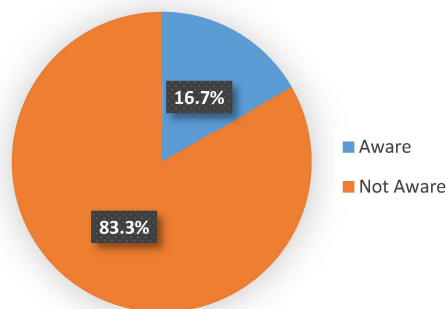


Figure 7. Client awareness level as perceived by contractors.

4.3. Type of Modular Construction

Figure 8 indicates the type of modular construction method adopted by the surveyed respondents according to client demand. According to the results, most respondents (66.7%) adopted permanent modular construction. In comparison, 33.3% adopted temporary/relocatable modular construction, indicating client preference for permanent applications in modular construction.

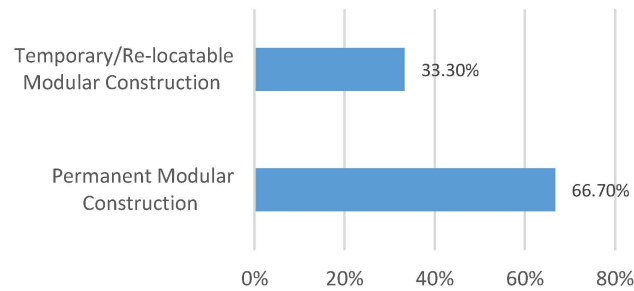


Figure 8. Type of modular construction adopted by respondents' companies.

4.4. Client Preferences and Motivations

We delved into the types of clients that request off-site modular construction and the key advantages motivating clients to adopt this construction method in Kuwait. The responses to the questionnaire survey were analyzed to identify respondent preferences and priorities. By assessing the frequency and ranking of the selected options, a total score was computed to establish the average rank for each option. Figure 9 depicts client demand for off-site modular construction across various sectors, as perceived by the surveyed respondents. The findings revealed a hierarchical preference with residential clients securing the top rank, followed by commercial, medical, institutional, and other clients (such as chalet and farm owners). The residential demand suggested a robust market for modular construction within the residential sector.

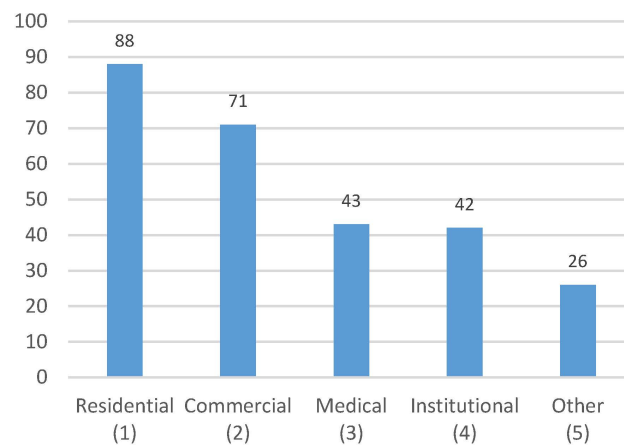


Figure 9. Client-driven ranking of sectors utilizing modular construction.

Figure 10 illustrates the key advantages influencing clients to opt for off-site modular construction. Notably, shorter construction time emerged as the top-ranked factor, followed closely by the considerations of minimized waste and noise during execution. The third-ranking position was contended between shorter material supply time and reduced costs. These insights from respondents showed the intricacies of client decision-making processes, offering a clearer understanding of the factors influencing client adoption of off-site modular construction methods in Kuwait.

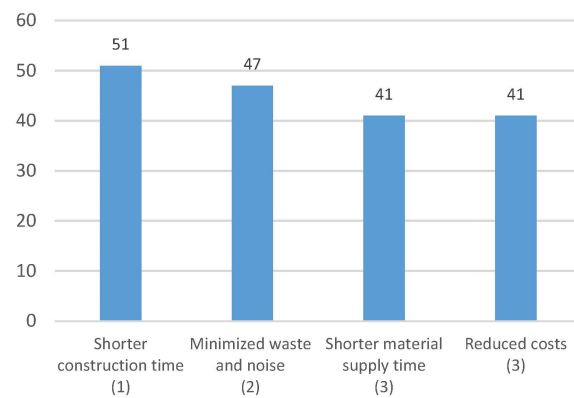


Figure 10. Client-driven ranking of key advantages influencing modular construction adoption.

4.5. Off-Site Construction Methods

Diverse off-site construction methods can be classified based on the degree of prefabrication, as demonstrated in Figure 1. During the survey, respondents were asked about the off-site construction options offered by their organizations. The results revealed a close but distinct hierarchy in the prevalence of these options, as depicted in Figure 11. Notably, 83.3% of respondents identified panelized construction as the most prevalent type of off-site construction offered by Kuwaiti contracting firms. Following closely behind, hybrid construction was provided by 77.8% of the respondents' companies, prefabricated components offered by 72.2%, and lastly, volumetric construction, while slightly less common, was provided by 66.7% of the companies of the respondents. These results indicated the prevalence of off-site construction practices of the surveyed contracting companies in Kuwait and highlighted the spectrum of options available to stakeholders.

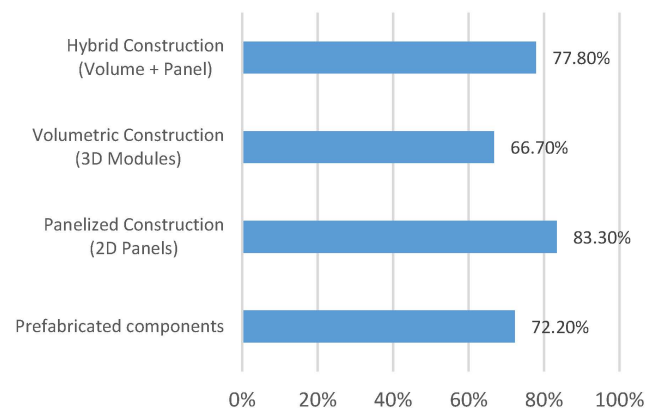


Figure 11. Types of off-site construction provided by contractors in Kuwait.

5. Conclusions

This research provided a fundamental overview of the state of off-site modular construction in Kuwait, focusing on the perceptions of contractors. It also addressed a significant gap in the existing literature by exploring the off-site construction landscape in Kuwait, including industry characteristics, the modular construction methods employed, the sectors served, and the key advantages offered. The findings underscored the prevalence of specific off-site construction methods, with panelized construction emerging as the most widely employed type, followed closely by hybrid construction, prefabricated components, and volumetric construction. A low level of client awareness regarding modular construction as a construction method was found, with most respondents indicating a lack of awareness among their customer base. Despite this, there is a clear demand for off-site modular construction in various sectors in Kuwait, with residential buildings taking the lead, followed

by commercial buildings, medical buildings, and institutional buildings. The motivations behind clients adopting modular construction were explored, with a significant percentage indicating a preference for permanent use over temporary applications. The key advantages influencing client adoption of this construction technology included shorter construction time, minimized waste and noise during execution, and reduced costs, respectively.

As a pathway for future investigation, more in-depth research is needed on the materials employed for modular construction in Kuwait, with a focus on the technical factors influencing its selection, such as cost, time, and overall quality. Additionally, evaluating the existing regulations and exploring the drivers and barriers to implementing off-site modular construction in Kuwait is essential for a more detailed understanding of the industry's dynamics. Adopting a qualitative approach through interviews with industry experts, policymakers, and key stakeholders would offer deeper insights and perspectives on these multifaceted aspects and play a crucial role in fostering the efficient adoption of modular construction practices in Kuwait.

Author Contributions: Conceptualization, A.A. (Areej AlBanwan) and N.A.; methodology, A.A. (Areej AlBanwan); validation, A.A. (Abdullah AlFoudari); formal analysis, N.A. and A.A. (Abdullah AlFoudari); investigation, N.A.; resources, A.A. (Abdullah AlFoudari); data curation, A.A. (Areej AlBanwan); writing—original draft preparation, A.A. (Areej AlBanwan); writing—review and editing, N.A. and A.A. (Abdullah AlFoudari); visualization, N.A.; supervision, A.A. (Abdullah AlFoudari); project administration, A.A. (Areej AlBanwan) All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All the data used in the experiment has been made available in the present article.

Acknowledgments: The authors wish to acknowledge the invaluable contribution of the contractors who participated in this study, without whom this research would not have been possible.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Alghais, N. Developing Urban Models to Address Population Growth Impacts and Assisting with Future Urban Planning in Kuwait and Other Arabian Gulf Countries. Ph.D. Dissertation, School of Earth and Environmental Sciences, The University of Queensland, Brisbane, Australia, 19 October 2018. [CrossRef]
2. Chen, C. Advantages and barriers of modular construction method in constructing buildings. *Smart Infrastruct. Constr.* **2023**, *176*, 75–84. [CrossRef]
3. Goodier, C.; Gibb, A. Future opportunities for off-site in the UK. *Constr. Manag. Econ.* **2007**, *25*, 585–595. [CrossRef]
4. Salama, T.; Moselhi, O.; Al-Hussein, M. Overview of the Characteristics of the Modular Industry and Barriers to Its Increased Market Share. *Int. J. Ind. Constr.* **2021**, *2*, 30–53. [CrossRef]
5. National Institute of Building Sciences. Available online: <https://www.nibs.org/oscc> (accessed on 1 November 2023).
6. Modular Building Institute. *Permanent Modular Construction 2022 Annual Report*; Modular Building Institute: Charlottesville, VA, USA, 2022.
7. Serrats, M. *PreFab Houses DesignSource*; Harper Design International: New York, NY, USA, 2012.
8. Whole Building Design Guide. Available online: <https://www.wbdg.org/resources/site-and-modular-construction-explained> (accessed on 1 November 2023).
9. Lawson, M.; Ogden, R.; Goodier, C. *Design in Modular Construction*; CRC Press: London, UK, 2019.
10. Moradiboustouni, M.; Gjerde, M. Potential for Prefabrication to Enhance the New Zealand Construction Industry. In *Back to the Future: The Next 50 Years: Proceedings of the 51st International Conference of the Architectural Science Association, Wellington, New Zealand, 29 November–2 December 2017*; Victoria University of Wellington: Wellington, New Zealand, 2017.
11. Modular Building Institute. Available online: <http://www.modular.org/what-is-modular-construction> (accessed on 2 November 2023).
12. Pasquire, C.; Connolly, G.E. Leaner construction through off-site manufacturing. In Proceedings of the IGLC-10, Gramado, Brazil, 8 August 2002.

13. Karthik, S.; Sharareh, K.; Behzad, R. Modular Construction vs. Traditional Construction: Advantages and Limitations: A Comparative Study. In Proceedings of the Creative Construction e-Conference, Opatija, Croatia, 28 June–1 July 2020. [[CrossRef](#)]
14. Ferdous, W.; Bai, Y.; Ngo, T.D.; Manalo, A.; Mendis, P. New advancements, challenges and opportunities of multi-storey modular buildings—A state-of-the-art review. *Eng. Struct.* **2019**, *183*, 883–893. [[CrossRef](#)]
15. Hořínková, D. Advantages and Disadvantages of Modular Construction, including Environmental Impacts. *Mater. Sci. Eng.* **2021**, *1203*, 032002. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.