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Exploring Contemporary Challenges and Approaches in Adopting Modular Construction System (MCS) in Malaysia

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ABSTRACT

Modular construction system (MCS) is gaining traction in developed countries due to its ability to reduce carbon emission, construction time and costs while enhancing quality control. It is a promising solution for addressing housing shortages. However, the adoption in developing countries is limited by financial challenges such as restricted access to capital, high initial costs, and a lack of established financial institutions willing to support the system. This study aims to dive into the challenges of adopting MCS in Malaysia and explore strategies to improve the situation. Semi-structured interviews were performed with experienced MCS professionals across Malaysia and the data were analysed using thematic analysis. The findings reveal strong potential for MCS in Malaysia but identify major structural barriers, particularly the misalignment between conventional progress-payment financing systems and the factory-based production workflow of modular construction. Key challenges include limited modular-specific financing options, lack of institutional awareness among banks, shortage of technical expertise, design inflexibility, and low market acceptance. The study proposes policy and finance-oriented strategies including the development of modular-specific loan products tied to certified factory-stage progress, CIDB-led modular certification systems, government-backed incentives such as tax relief and grants, and Public–Private Partnership (PPP) models to share early-stage risks. With appropriate policy and financial reform, MCS adoption in Malaysia could be increased to 25–30% of selected public projects, potentially achieving 30–40% time savings and 10–20% cost efficiency. The study contributes by linking industry experience to financing model development and construction policy reform. Future research should pilot modular financing frameworks, evaluate incentive effectiveness, and conduct longitudinal case studies to assess long-term performance and sustainability.

Keywords: Modular Construction System; construction; construction project management

INTRODUCTION

The Malaysian construction sector is predominantly characterized by traditional practices that often result in inefficiencies, delays, and cost overruns (Aziz et al. 2015). These conventional methods are labor-intensive and rely heavily on on-site construction that leads to low-quality outcomes, elevated expenses, and extended project timelines. Furthermore, the industry suffers from a lack of standardization, contributing to inconsistencies in quality and performance (Azman et al. 2019).

The Modular Construction System (MCS) offers a promising alternative to the traditional methods. MCS involves the prefabrication of building components or modules in a factory setting, which are then transported and assembled on-site (Aziz et al. 2019). This approach promises numerous advantages, including improved quality, reduced environmental impact, and enhanced

operational efficiency. By minimizing on-site construction activities, MCS not only decreases the environmental footprint but gives more sustainable construction solution (Fleisher et al. 2023).

The Malaysian government has recognized the potential benefits of MCS and has undertaken several initiatives to promote its adoption. The Construction Industry Development Board (CIDB) has actively supported MCS through training programs, incentives, and the publication of guidelines for Volumetric Module Houses (Hwang et al. 2018). Additionally, the Ministry of Works has integrated the promotion of new technologies, including MCS, into the National Construction Policy 2030 (NCP 2030) to foster sustainable infrastructure growth (Ministry of Works 2019).

Despite these efforts, the adoption of MCS in Malaysia remains limited. A recent study by CIDB found that only 10% of construction projects in the country have implemented MCS, with the majority still adhering to traditional methods (Bello et al. 2023). Key challenges that hinder its broader adoption include the high initial cost of establishing modular construction facilities, the lack of standardization in MCS, and insufficient awareness among industry stakeholders (Paliwal et al. 2021). The high financial barriers associated with MCS pose a significant obstacle, particularly for smaller contractors and developers. Lenders may be hesitant to finance projects with uncertain outcomes or those that deviate from conventional methods, exacerbating the difficulty of securing funding (Generalova et al. 2016). Moreover, the reluctance to shift from traditional construction practices further impedes the traction of MCS in the Malaysian market (Zhou 2022).

Failure to address these financial and structural challenges could have adverse effects on Malaysia's growth in the industry. The construction sector is a crucial component of the country's Gross Domestic Product (GDP) and it stands to benefit significantly from the increased productivity and sustainability that MCS offers. Conversely, continued reliance on outdated methods may lead to heightened costs, delays, and environmental degradation, ultimately impacting economic growth and reducing competitiveness on the global stage (Mohammad et al. 2016).

Given the potential benefits of MCS and the pressing need for its wider adoption, this research aims to explore the challenges associated with the implementation of MCS in Malaysia. By identifying these challenges and proposing strategies to overcome them, the study seeks to facilitate the broader adoption of MCS, thereby enhancing productivity, sustainability, and economy within the Malaysian construction industry.

This study extends beyond identifying barriers and focusing specifically on financing structures and policy alignment within Malaysia's construction ecosystem. Unlike prior studies that examine MCS adoption at a general level, this research investigates how Malaysia's bank-based progress-payment culture, regulatory frameworks, and government incentive structures interact with the cash-flow realities of modular construction. By grounding findings in local stakeholder experiences, this study delivers evidence-based insights that can inform the design of modular-specific financing instruments and policy interventions tailored to Malaysia's construction and housing development.

LITERATURE REVIEW

MODULAR CONSTRUCTION IN MALAYSIA

The introduction of Industrialized Building System (IBS) to Malaysia in the mid-1960s marked a pivotal development in the country's construction industry (Rahim & Qureshi 2018). Within the IBS framework, the Modular Construction System (MCS) or commonly referred to as offsite manufacturing emerges as a critical element (Wuni et al. 2022). MCS has been increasingly getting attention from construction professionals in Malaysia, who consider it a viable alternative to traditional construction methods due to its efficiency in terms of both cost and time (Aziz et al. 2019).

Modular construction as defined by Aziz & Abdullah (2015), involves the assembly and fabrication of buildings using pre-fabricated three-dimensional units, or modules, which are produced in a factory setting. This method is also known by various other terms, including 'offsite construction (OCS)', 'prefabrication', 'prefabricated construction', 'modular building system', 'prefabricated prefinished volumetric construction (PPVC)', 'preassembled', and ' on-site assembly' (Khan et al. 2023). The fundamental principle of modular construction is to produce custom-designed modules in a controlled factory environment, which are then transported to the construction site for assembly.

A distinguishing characteristic of modular construction is the use of standardized three-dimensional units. These units are mass-produced in a factory under stringent quality control standards, ensuring consistency and minimizing waste (Aziz & Abdullah 2015). The pre-assembly of these volumetric units in a controlled setting enables a significant acceleration of the construction process, potentially reducing project completion time by up to fifty percent compared to traditional methods. Additionally, modular construction supports sustainability by substantially reducing waste and minimizing the environmental impact commonly associated with conventional building practices.

Factory-based production facilitates more efficient material management and waste reduction. Furthermore, modular buildings can be dismantled, refurbished, and relocated, thereby conserving raw materials and decreasing energy consumption associated with new construction.

Although modular construction reduces the need for on-site material and labor resulting in notable cost savings, these advantages are somewhat counterbalanced by transportation expenses. The issue is particularly pressing in Malaysia where the public relies heavily on road transportation and access for sizeable modules is fairly limited (Ramli et al. 2021). The logistics of transporting large, heavy modules are regulated by national road authorities, and on-site storage is typically impractical.

Consequently, modular units must be installed immediately upon arrival at the construction site.

The success of modular construction relies on comprehensive early-stage planning, coordination, and communication among all project stakeholders, including clients, design teams, modular unit manufacturers, suppliers, and contractors (Ribeiro et al. 2022). Effective design of mechanical and electrical (M&E) systems prior to module production is essential to avoid costly modifications later in the project. Furthermore, thorough discussions regarding the connections between modular units are crucial to prevent issues during assembly.

Despite some skepticism regarding the adoption of modular construction in Malaysia, the system holds significant promise for the local construction industry. With appropriate policy support and infrastructure development, MCS could experience rapid expansion like trends observed in more advanced nations (Bello et al. 2023). The advantages of modular construction, particularly in terms of sustainability and productivity, underscore its potential (Teh et al. 2021). In the context of residential development, Malaysian consumers increasingly seek versatile, innovative, and cost-effective home designs that can be constructed rapidly (Aziz et al. 2015). MCS offers a compelling solution to these demands. Experts anticipate a growing trend towards modular construction and modular housing in Malaysia, reflecting a rising acceptance and demand for these systems (Mohammad et al. 2016).

TYPES OF MODULAR CONSTRUCTION SYSTEM

Manufacturers of modular units are primarily categorized into two distinct segments based on the type of modular buildings they produce: Permanent Modular Construction (PMC) and Relocatable Modular buildings (RB).

PMC represents a progressive approach to building design and assembly. It employs advanced manufacturing techniques that embrace lean practices, enabling the efficient prefabrication of single or multi-story structures. These modular units are designed for swift assembly upon arrival at the construction site. The PMC approach can either be utilized as a standalone method or integrated with traditional site-built techniques to enhance waste reduction compared to conventional methods that rely solely on on-site construction (Paliwal et al. 2021). PMC structures exhibit a remarkable versatility, allowing for integration with various site construction methods such as pre-engineered steel buildings or concrete tilt-wall systems. This hybrid approach facilitates the development of mixed-use facilities, expanding the functional potential of modular constructions (Omurtay et al. 2024). Supporting this view, Feldmann et al. (2022) emphasizes the effectiveness of combining PMC with pre-engineered steel buildings to produce versatile and functional hybrid facilities.

In contrast, RB is engineered for temporary applications. It is manufactured through a factory-based process where the structures are assembled to a high level of completion, often exceeding 80% including the installation of internal and external finishes, and sometimes even sanitary fittings. This approach is particularly beneficial for emergency and disaster relief scenarios, offering a rapid and fully equipped solution for temporary spaces (Nguyen et al. 2023). RBs are thus well-suited for diverse applications such as sales centers, construction site offices, mobile clinics, and restroom facilities, demonstrating their flexibility and readiness for deployment in various contexts.

MCS offers significant advantages, including faster project completion, cost efficiency, enhanced safety, higher productivity, and environmental sustainability (Blismas & Wakefield 2009). By enabling concurrent task execution and minimizing weather-related delays, MCS can reduce project timelines by up to 40% compared to traditional methods, with much of the work performed indoors, shielded from environmental factors (Enshassi et al. 2019). Cost savings are achieved through standardized, mass-produced units, which lower commissioning, defect, and repair costs compared to conventional methods that often suffer from poor workmanship and inferior materials (Aziz & Abdullah 2015). The controlled factory environment also enhances productivity by ensuring consistent quality and enabling rapid production. In terms of safety, MCS reduces on-site labour, thereby decreasing the risk of occupational accidents, although Gunasagaran et al. (2016) notes that the safety benefits should be critically assessed against real-world data. Environmentally, modular construction minimizes waste and reduces the overall environmental impact of construction through efficient resource management and reduced material transportation, which decreases noise, dust, and greenhouse gas emissions.

CHALLENGES AND APPROACHES TO ADVANCE MCS ADOPTION

The adoption of Modular Construction Systems (MCS) in Malaysia presents both significant opportunities and substantial challenges. MCS is acclaimed for its potential to enhance efficiency and sustainability within the construction sector. However, several critical barriers obstruct its widespread implementation. A primary challenge is the substantial initial capital investment required (Ambartsumyan et al. 2023). The establishment of off-site manufacturing facilities and the procurement of advanced technology entail considerable financial outlays. Traditional financing models are inadequately designed to accommodate these substantial upfront costs, resulting in difficulties in securing the necessary funding. Despite the potential for long-term cost savings, the high initial expenditure frequently deters contractors and investors (Teh et al. 2021).

Government support is crucial for facilitating the adoption of MCS. Although Malaysia has introduced green building initiatives such as the Green Building Index (GBI) and GreenRE, these initiatives suffer from inadequate enforcement (Aziz et al. 2019). This enforcement gap contributes to limited awareness and a slow uptake among construction professionals. Furthermore, the absence of comprehensive policies and targeted incentives specifically for modular construction exacerbates the challenges to its progress (Thurairajah et al. 2023).

Learning from international developments, a strong government–finance alignment is critical for modular construction success. Singapore's Building and Construction Authority (BCA) mandates PPVC adoption in selected projects and supports financing through risk-sharing mechanisms. In Sweden, modular housing growth is supported by long-term government-backed housing finance and standardized modular certification systems. Malaysia, however, relies primarily on general green-building incentives without modular-specific regulatory, financial, or procurement mandates. This absence of modular-focused policy architecture weakens investor confidence and discourages banks from developing modular-specific financing instruments. Unlike jurisdictions where modular construction is embedded into public procurement and housing delivery strategies, Malaysia's modular policies remain promotional rather than structural. This limits their effectiveness in transforming financing effectiveness.

Effective implementation of MCS also necessitates a specialized set of skills and knowledge that are currently deficient in Malaysia's construction sector (Mohammad et al. 2016). The shortage of experienced personnel and insufficient training represent significant obstacles to successful MCS deployment (Wuni & Shen 2023). Additionally, MCS is frequently viewed with skepticism due to uncertainties related to off-site logistics, including module manufacturing, storage, and transportation. These uncertainties can lead to disruptions in construction schedules and increased costs, thereby diminishing confidence among investors and financial institutions (Salama et al. 2018). Traditional financing models often fail to meet the specific needs of modular construction, resulting in a limited availability of funding. Financial institutions frequently perceive modular construction projects as high-risk, which contributes to their reluctance to provide adequate financing (Silva et al. 2024).

Nevertheless, research has identified several strategies to promote the adoption of MCS. Implementing innovative financing mechanisms is critical for overcoming financial barriers. Approaches such as sustainable financing, financial engineering, and alternative models like peer-to-peer lending and investment platforms Generalova et al. (2016) can offer new funding avenues and address capital constraints. Enhancing awareness and understanding of MCS among stakeholders is also essential. Educational initiatives, workshops, and the dissemination of successful project case studies can foster confidence and encourage market acceptance (Mohammad et al. 2016). Engaging with financial institutions to improve their understanding of MCS can further enhance financing opportunities.

The role of government policies and incentives is pivotal in advancing MCS adoption (Bello et al. 2023). The implementation of clear regulations and targeted incentives can create a supportive environment for modular construction, mitigating associated risks and uncertainties. By promoting investment through financial incentives and supportive policies, the government can facilitate the broader adoption of MCS (Arowoiya & Oyefusi 2023).

Although international studies propose innovative financing mechanisms such as sustainable finance and alternative investment platforms, there is limited empirical evidence on how these models can be operationalized within Malaysia's highly regulated, bank-dominated construction financing system. Existing Malaysian studies tend to identify financing as a barrier without translating findings into policy-aligned financing structures or implementation frameworks (Ismail et al. 2024). This reveals a critical research gap that is the absence of a context-sensitive financing model that aligns modular construction workflows with Malaysia's regulatory, banking, and development approval systems.

Addressing the stated research gap is utterly important to stay competitive internationally. While international studies demonstrate that financing barriers can be mitigated through tailored financial instruments (Elghaish et al. 2022), Malaysia continues to rely heavily on conventional

progress-payment structures that are incompatible with the production-driven nature of modular construction. For instance, in the United Kingdom, modular housing projects benefit from Homes England funding schemes that recognize factory-stage completion as valid progress milestones. Similarly, Singapore's PPVC adoption is supported by government-backed financing guarantees and standardized valuation protocols that allow banks to disburse loans based on certified offsite production stages.

In contrast, Malaysian banks predominantly recognize only on-site physical progress, thereby excluding up to 80–85% of modular project value created at factories from formal financing recognition. This structural mismatch positions Malaysia behind comparable economies despite having similar industrial capacity and policy ambitions. Consequently, there is limited guidance for policymakers, banks, and developers on how modular construction can be structurally embedded into Malaysia's financing and regulatory systems.

METHODOLOGY

A qualitative method was chosen to gain in-depth insights into the MCS in Malaysia from the perspectives of contractors and manufacturers. This approach allows the researcher to investigate the challenges strategies in an exploratory setting rather than confirmatory (Tungka 2020). Data collection was conducted through semi-structured interviews with fourteen respondents, including a site engineer, and a managing director, all of whom have experience in construction projects related to modular construction. One respondent is the Head of Sales and Marketing which was selected based on its deep understanding of the market and the issue of low demand for MCS in Malaysia.

The final sample size of ten respondents was determined based on the principle of data saturation (Ahmed, 2025), where no new themes or insights emerged from subsequent interviews. After the eighth interview, responses became repetitive, with participants reiterating similar challenges and strategies related to modular construction financing, awareness, and logistics. Two additional interviews were conducted to confirm saturation. This approach aligns with qualitative research standards suggesting that in homogeneous expert populations, thematic saturation can often be achieved within 8–12 interviews (Hennink & Kaiser, 2022). Given the specialized nature of modular construction in Malaysia, where the pool of experienced practitioners is limited, a focused sample of industry experts was considered methodologically sufficient to generate rich, credible insights.

The study focused on the Johor and Selangor areas and the research population consists of manufacturers and contractors. Johor and Selangor were selected as study locations because they represent the highest concentration of industrial activity, housing development, and modular manufacturing initiatives in Malaysia (DOSM 2025). These states host major modular factories, logistics corridors, and large-scale residential and infrastructure projects, making them appropriate contexts for investigating modular construction practices and financing challenges.

Snowball sampling technique was used, where initial participants referred other potential participants, eventually leading to a sample size of 10 individuals. This method was chosen to reduce costs and time in planning the research.

Snowball sampling was particularly suitable for this study due to the niche nature of modular construction expertise in Malaysia (Ahmed, 2024). Since modular construction projects remain limited, identifying experienced practitioners through formal registries was challenging. Initial respondents were therefore used as gatekeepers to access other knowledgeable actors within the modular construction network (Ismail et al. 2024). This approach ensured access to information-rich cases rather than statistically representative samples, consistent with the exploratory and qualitative nature of the study. The details of respondents are provided in Table 1.

TABLE 1. Details of respondents

Interviewee	Positions	Experience (years)
P1	Head of Sales and Marketing	5
P2	Site Agent	14
P3	Managing Director	30
P4	Production Senior Manager	10
P5	Project Manager	7
P6	Project Director	15
P7	Assistant Project Manager	7
P8	General Manager	10
P9	Quality Engineer	5
P10	Site Engineer	6

Data analysis involved thematic analysis, particularly the deductive approach, where data is analyzed based on pre-determined themes and codes (Motlhatheldi & Nel, 2019). Qualitative data coding played a crucial role, helping to streamline the interpretation of open-ended questions from semi-structured interviews. The gathered data was summarized and coded into specific categories and themes to achieve the research objectives. The process of thematic analysis is shown in Figure 1.

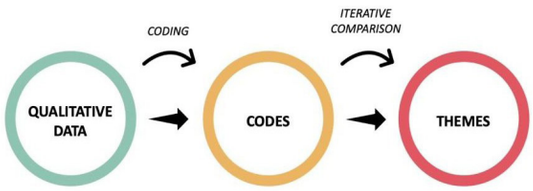

FIGURE 1. Process of thematic analysis

The coding process involved three stages. The first is reviewing raw interview transcripts line-by-line to identify meaningful statements related to financing, policy, awareness, logistics, and technical practices. The second is grouping similar statements into initial codes such as "bank unfamiliarity," "factory-stage work not recognized," and "high upfront capital." The third is clustering the codes into broader themes based on conceptual similarity and relevance to the research objectives. This systematic process ensured that themes were grounded in participant narratives while remaining aligned with the study's theoretical framework (Williams & Moser, 2019).

By combining expert sampling, saturation-based sample determination, and transparent thematic coding, the methodology ensures that findings are both credible and analytically robust. This methodological rigor strengthens the study's ability to generate policy-relevant and financing-focused insights specific to Malaysia's modular construction ecosystem.

FINDINGS

CHALLENGES IN ADOPTING MODULAR CONSTRUCTION SYSTEM IN MALAYSIA

During the interview, the respondents were asked questions regarding the challenges in adopting MCS in Malaysia. From their response, a thematic analysis is conducted where it is coded, and the result uncovered 5 themes to the data. The themes include limited financing options, lack of awareness, dominance of the conventional method, misconceptions and logistical challenges. Table 2 shows the summary of themes for the challenges in MCS in Malaysia.

In addition to identifying operational challenges, the interview protocol was designed to elicit stakeholder perspectives on financing practices, banking interactions, and policy expectations. This enables the study to move beyond descriptive barriers toward generating policy-relevant and finance-oriented insights that can inform the design of modular-specific financing instruments and government intervention strategies suitable for Malaysia's construction ecosystem.

TABLE 2. Challenges in Adopting Modular Construction System in Malaysia

Codes	Themes
C01	Limited Financing Options
C02	Lack of Awareness and Understanding
C03	Dominance of Conventional Construction
C04	Misconceptions about Modular Construction
C05	Logistical Challenges

The identified challenges include limited financing options, lack of awareness, dominance of conventional construction, misconceptions, and logistical constraints. These are not isolated technical issues but institutional and structural in nature. Compared to countries such as the UK and Singapore, where modular financing is supported by government-endorsed valuation and certification systems (Hwang et al. 2017; Thomas & Jayakumar 2017), Malaysia lacks formal recognition of offsite production in lending assessments. This places Malaysian modular developers at a structural disadvantage even when project risks are comparable. Collectively, they point to a misalignment between Malaysia's construction policies, banking practices, and emerging modular production systems. These findings suggest that modular construction cannot be mainstreamed through industry initiative alone but requires coordinated reform across policy, financing, and regulatory institutions.

LIMITED FINANCING OPTIONS

The lack of financing options tailored to MCS is a significant challenge hindering the adoption of this construction method in Malaysia. All respondents agreed that there is a limited number of financing products or loans available that specifically cater to MCS or IBS projects. Respondents mentioned that banks are accustomed to the conventional construction method, where payments are

released based on site progress. However, in MCS a significant portion (85%) of the progress occurs at the fabrication yard, which banks may not recognize or account for in their lending practices. Another response is that there are no specific loans available for modular homes or IBS-like modular construction. Meanwhile based on respondents' insight from the manufacturer's perspective, there is the absence of specific financing for facilitating modular projects.

This finding aligns with the literature review, which highlights that one of the financing challenges in modular construction stems from the limited availability of financing options tailored to suit the unique requirements of this construction method (Silva et al. 2024). Traditional financing models employed in the construction industry are often misaligned with the upfront capital requirements and cash flow patterns associated with modular projects, making it difficult to secure institutional capital.

The absence of tailored financing options aligned with the modular construction workflow poses a significant obstacle for developers and contractors seeking to adopt this method. They are limited to traditional loan products that may not adequately address the unique cash flow requirements and progress milestones of modular projects, potentially hindering their ability to secure sufficient financing (Zhou 2022).

The findings highlight a structural mismatch between Malaysia's conventional progress-payment financing model and the production-driven nature of modular construction. Thus, suggesting the need for a revised financing framework that recognizes factory-stage progress as bankable milestones. Such a model would require regulatory recognition by financial authorities and alignment with valuation and certification procedures. A good practice could potentially be through CIDB-endorsed modular progress certification systems that can be used by banks for loan disbursement verification.

Construction policy could introduce modular-specific certification systems under CIDB that formally recognize offsite manufacturing milestones. Financial innovation could include progress-based modular loans tied to certified factory outputs rather than on-site completion. Such a model would require collaboration between CIDB, Bank Negara Malaysia, and commercial banks to establish valuation and verification standards for modular components.

LACK OF AWARENESS AND UNDERSTANDING

Another significant challenge in adopting MCS in Malaysia is the lack of awareness and understanding among construction stakeholders about the modular method of construction (Arowoiya & Oyefusi 2023). The majority of the respondents agree that the awareness and understanding of this system are still low in Malaysia. More specifically, respondents mentioned that the national bank is currently unfamiliar with budget financing in modular construction. The concept of financing for modular construction is "very new" in the industry and the financial institutions have not seen any modular construction projects fully utilizing a 100% MCS.

In retrospect, multiple literature has discussed the lack of awareness and understanding of modular construction in the construction sector and there needs to be a structured approach to overcome the issue (Wuni & Shen, 2023). Additionally, the lack of successful project track records and case studies in the local context can make it difficult for developers and contractors to demonstrate the viability and benefits of modular projects to potential lenders. Without tangible examples of successful modular projects, financial institutions may be hesitant to provide financing, as they lack the confidence and familiarity with this construction method.

This indicates that financing limitations are not merely financial but institutional and cognitive. Without policy-driven awareness programs targeting financial institutions, modular construction will remain categorized as a high-risk niche. This underscores the need for government-led engagement between government agencies and commercial banks to develop standardized risk assessment guidelines for modular projects. Other important potential is on training programs for financial institutions, similar to professional accreditation systems in construction. Government agencies could facilitate structured dialogues between banks, modular manufacturers, and regulators to co-develop new financing guidelines.

DOMINANCE OF CONVENTIONAL METHOD OF CONSTRUCTION

The dominance of traditional construction methods remains a significant challenge hindering the adoption of modular construction in Malaysia. The conventional construction approach continues to be the dominant method used in the Malaysian construction sector, making it difficult for modular construction to gain traction (Khan et al. 2022).

The interview findings highlight the dominance of conventional construction methods as a major barrier to the widespread adoption of modular construction (Lee et al. 2022). A respondent noted that banks and financial institutions are more familiar with the traditional construction method, as they are accustomed to releasing payments based on site progress (Thurairajah et al. 2023). Similarly, several respondents emphasized that modular

construction is still not widely known in Malaysia, and the conventional method remains the dominant construction approach in the industry.

This sentiment is further echoed by statements such as "there is not much modular construction projects in Malaysia yet," implying that the country still primarily relies on traditional construction methods rather than adopting modular construction (Khan et al. 2023). The literature also supports this finding, indicating that the construction industry in Malaysia has been slow to embrace new technologies and is heavily reliant on conventional construction practices (Salama et al. 2018).

The reluctance to move away from the traditional construction approach poses a significant challenge for the adoption of modular construction in Malaysia. Overcoming this barrier will require a concerted effort to raise awareness, provide education, and demonstrate the benefits of modular construction to industry stakeholders, including developers, contractors, and financial institutions (Salama et al. 2018).

The dominance of conventional construction reflects not only industry habit but policy inertia. Public procurement policies could act as catalysts by mandating modular construction in selected public housing, healthcare, and education projects. Such policy intervention would create demand certainty, which is essential for banks to justify developing modular-specific financing products. Financial innovation is dependent on policy signals that modular construction is no longer experimental but institutionally endorsed.

MISCONCEPTION ABOUT MODULAR CONSTRUCTION

Misconceptions about modular construction are a significant challenge hindering its adoption in Malaysia. The industry remains skeptical about this construction method, which presents a barrier to its widespread implementation. The literature review highlights that one of the major challenges in adopting modular construction is due to the misconceptions of stakeholders (Silwa et al. 2024). While the literature acknowledges the numerous benefits of modular construction, such as shorter schedules, lower costs, higher quality, and improved safety, it also notes that stakeholders, particularly financial institutions, remain skeptical due to the unique risks and uncertainties it presents (Gunasagaran et al. 2022).

The interview findings further support the literature. Respondents pointed out the perceived risks related to the lack of flexibility in the design phase due to the reliance on pre-fabricated components. Another opinion is on the logistical challenges and risks associated with delivery timelines, transportation costs for modules, and the experience levels of local installation crews. The literature review also discusses the uncertainties in offsite logistics, such as module manufacturing, storage, and transportation processes, which can lead to financial implications for suppliers (Generalova et al. 2016).

Interestingly, a response of the interview shed light on a perception issue, specifically stating that "A lot of people don't get that and don't see it that way. Some of them see modular as a temporary building. But it's actually the same as any construction project." This quote indicates that some stakeholders may have the misconception that modular buildings are only temporary, which potentially contributed to the perceived risks and hindered its market acceptance and adoption (Wong 2019).

Overall, the literature review and findings consistently highlighted the perceived high risks and uncertainties as a significant challenge in adopting modular construction. The respondents' perspectives align with the concerns raised in the literature, and these perceived risks and uncertainties contribute to the reluctance of financial institutions to support modular construction projects, hindering the widespread adoption of this construction method.

National construction policy could formally classify modular construction as a permanent and quality-assured building system, supported by standardized design, safety, and durability guidelines. Financial institutions could then align their risk assessment frameworks with these policy standards, reducing uncertainty and enabling the creation of specialized loan products for modular projects.

LOGISTICAL CHALLENGES

Logistical challenges are a significant barrier to the adoption of modular construction in Malaysia. These challenges include high costs, delivery timelines, and the specialized equipment required for transportation and installation.

Respondents highlighted that the delivery timelines of the modules add to the risk in modular construction projects. There are also views that emphasize the cost implications of transporting the modules from the factory to the construction site, which contributes to the logistical challenge. This is supported by other respondents who noted that the modules in modular construction may require specialized equipment to lift, position, and fix them in place, adding to the cost and risk of transportation and installation. Moreover, the need for precise coordination among various teams can further complicate the logistics and increase potential delays (Zhou 2022).

From the manufacturer's perspective, a respondent shed light on the complexity of managing the factory-based production process of the modules, further underscoring the logistical challenges in modular construction. Ensuring consistent quality control and meeting project deadlines had always been a significant addition to the pressure on manufacturers (Jabar et al. 2013). The literature also suggests that transportation issues, including problems related to size and weight limitations, routing limits, and the availability of lifting equipment, can impact construction schedules and increase costs (Nawi et al. 2014).

These logistical challenges can have significant financial implications, which may not be ideal for those who opt for modular construction. Addressing these logistical barriers, through improved planning, coordination, and the development of specialized transportation solutions, is crucial for driving the adoption of modular construction in Malaysia.

Logistical risks suggest a need for infrastructure support. The findings indicate that logistics is not merely an operational issue but a policy and financing concern requiring institutional coordination. Construction policy could create logistics corridors and industrial zoning for modular factories. Financial innovation could involve equipment-leasing schemes, logistics-financing packages, and insurance products tailored to modular transport risks.

STRATEGIES IN ADOPTING MODULAR CONSTRUCTION SYSTEM IN MALAYSIA

After the challenges, the interview transcription on strategies to adopt MCS was analyzed and coded into five themes. Table 3 summarizes these themes, which outline strategies to promote the adoption of the MCS in Malaysia. The strategies identified from the respondents' responses include developing specialized financing products, building expertise in modular construction, improving financial planning and risk management, increasing awareness and education, and enhancing government support and initiatives.

The strategies identified by the respondents include specialized financing products, expertise development, financial planning, awareness, and government support. These indicate that modular construction adoption requires effective collaboration between the government and private-sector. Public–Private Partnerships (PPPs) could play a central role by allowing the government to share early-stage risks, provide demand certainty through public projects, and incentivize banks to develop modular-specific financing instruments. PPP models could include government-backed guarantees for modular projects, joint investment in modular factories, and long-term public procurement contracts that stabilize cash flows for financiers and manufacturers.

TABLE 3. Strategies in Adopting Modular Construction System in Malaysia

Code	Themes
S01	Develop Specialized Financing Products
S02	Develop Expertise in Modular Construction
S03	Improve Financial Planning and Risk Management
S04	Increase Awareness and Education
S05	Government Support and Initiatives

DEVELOP SPECIALIZED FINANCING PRODUCTS

Developing specialized financing products is a crucial strategy to promote the adoption of modular construction in Malaysia. Introducing lending schemes tailored to the high upfront costs of modular construction can help attract stakeholders to implement this construction method.

The survey findings highlight "Develop Specialized Financing Products" as one of the strategies to promote the adoption of modular construction. A respondent emphasized the importance of developing specialized financing products that cater to the distinct characteristics of modular construction projects. The distinct characteristics include unique cash flow requirements and logistics involved in offsite manufacturing and module transportation (Blismas & Wakefield 2009). The literature also supports the need for innovative financing mechanisms to enhance the financing of modular construction in Malaysia. This includes sustainable financing strategies that integrate economic, environmental, and social factors, as well as financial engineering approaches to design new instruments and alternative financing models specific to modular construction (Jailon & Poon 2010).

By developing financing solutions tailored to the modular construction workflow, such as progress-based loans tied to module completions rather than traditional site progress, financial institutions can better align their lending practices with the unique requirements of this construction method. This, in turn, will make it easier for developers and contractors to access funding that meets their needs, rather than trying to fit modular construction into conventional construction loan structures (Ribeiro et al. 2022).

Overall, the findings and the literature emphasize the importance of innovative, modular-specific financing instruments as a strategy to enhance the financing opportunities within this construction method. This may

subsequently increase the chances of widespread adoption of the MCS in the Malaysian construction sector.

Innovative financing products could be institutionalized through collaboration between CIDB, Bank Negara Malaysia, and commercial banks to develop a national modular construction financing framework. According to the respondents, this could include (1) Recognition of factory-stage work as certifiable progress, (2) Modular project valuation guidelines for financial institutions, (3) Hybrid loan structures combining construction and manufacturing finance, and (4) Government-backed risk-sharing mechanisms for early adopters.

DEVELOP EXPERTISE IN MODULAR CONSTRUCTION

Developing expertise in modular construction is crucial for increasing its adoption in Malaysia. The Malaysian construction sector still lacks the technical know-how to fully embrace modular construction in projects. The interview findings highlight "Develop Expertise in Modular Construction" as one of the strategies to enhance the financing of modular construction in Malaysia. Respondents also emphasized that high expertise is needed to pursue IBS or modular ventures in construction, underscoring the need for developing expertise in this field as stated by (Fleisher et al. 2023).

This aligns with the literature, which suggests that the lack of expertise in integrated design, manufacturing, and assembly processes is a significant barrier to the adoption of modular construction in Malaysia (Liu et al. 2022). The limited number of modular projects in the country implies a shortage of technical expertise in this construction method (Hassan Ali et al. 2023). To address this challenge, the industry should focus on training and educating professionals in modular construction techniques. This can be achieved through collaboration between educational institutions, industry associations, and government agencies to develop relevant curricula and training programs. Hands-on experience through pilot projects and internships can also help build a pool of skilled professionals in modular construction (Wuni & Shen 2023).

By investing in the development of expertise, the Malaysian construction industry can overcome the knowledge gap and accelerate the adoption of modular construction, leading to more efficient and sustainable project delivery.

IMPROVE FINANCIAL PLANNING AND RISK MANAGEMENT

Improving financial planning is a crucial strategy for promoting the adoption of modular construction in Malaysia. The financial strength of developers and contractors is vital due to the higher cost implications of adopting the modular system, thus robust financial planning is essential for widespread adoption in the industry. The interview findings highlight the importance of robust financial modeling and forecasting to precisely estimate costs and account for the front-loaded expenditures associated with modular construction. Respondents emphasized the need for precise cost forecasting and accounting for front-loaded expenditures, aligning with the literature's emphasis on effective coordination and understanding of the unique financial requirements of modular construction projects (Feldmann et al. 2022).

From the manufacturer's perspective, respondents emphasized the need for effective management of factory operations, materials, and labor in modular construction projects. This perspective underscores the complexity of financial planning in modular construction from the manufacturer's end, where costs are distributed differently compared to traditional construction methods (Enshassi et al. 2019).

Effective financial planning is essential for the successful implementation of modular construction, as it helps developers and contractors manage the higher upfront costs and ensures that projects are financially viable. This aligns with the literature, which highlights the importance of robust financial planning and risk management in modular construction (Wuni et al. 2023).

INCREASE AWARENESS AND EDUCATION

Promoting awareness and understanding of modular construction is crucial for driving its adoption in the Malaysian construction industry. The interview results highlight the importance of educating stakeholders on the benefits of modular construction (Aziz et al. 2019). The literature review supports this finding, indicating that increasing awareness, creating market acceptance, and engaging with various stakeholders, including the government and financial institutions, are essential for promoting the use of modular construction (Rahim & Qureshi, 2018).

A respondent directly stated that more exposure to modular construction projects is necessary to help enhance financing and encourage banks to participate in these projects (Aziz & Abdullah, 2015). Similarly, others emphasized the role of government awareness in creating

a robust supply chain and attracting more manufacturers. The approach can indirectly contribute to increased demand for modular construction in construction projects (Kho, 2023). These findings suggest that a comprehensive strategy to educate and raise awareness among industry professionals, stakeholders, and the public is crucial for accelerating the adoption of modular construction in Malaysia.

GOVERNMENT SUPPORT AND INITIATIVES

Government support is critical for driving the adoption of modular construction in the industry. Providing incentives for projects that utilize modular construction can help increase demand and spur the development of supply chains (Salman, 2019). The interview results highlight the importance of government initiatives in promoting the use of modular construction. One respondent suggests that the government should take the lead in implementing modular construction in both public and private projects (Kho, 2023). This aligns with the literature, which indicates that governments can support the adoption of modular construction through policies and incentives to attract stakeholder investment.

A respondent also proposed tax reductions as a potential government incentive for products or methods used in modular construction projects (Kho 2023). This recommendation is consistent with the literature, which suggests that rational incentive strategies, such as subsidies, can be effective in boosting the development of construction industrialization, including modular construction (Fleisher et al. 2023).

Beyond generic incentives, Malaysia requires a policy revamp that integrates modular construction into housing delivery, public procurement, and financing regulation. This could include mandating modular quotas in selected public housing schemes, tax incentives for modular factories, and inclusion of modular projects in government-backed housing finance schemes such as PR1MA or Rumah Mampu Milik initiatives.

TOWARDS A MODULAR CONSTRUCTION FINANCING FRAMEWORK FOR MALAYSIA

Synthesizing the findings, a preliminary modular construction financing framework for Malaysia can be conceptualized. This framework would integrate:

1. Policy recognition of factory-stage production as bankable progress,
2. CIDB-certified modular valuation and progress verification,
3. Bank Negara–guided lending standards for modular projects, and
4. PPP-based risk-sharing mechanisms for early adopters.

Such a framework would transform modular construction from a technically viable but financially constrained method into an institutionally supported mainstream construction approach.

CONCLUSION

The study revealed five key challenges in adopting the MCS in Malaysia. These challenges include limited financing options, lack of awareness and understanding of MCS, dominance of conventional construction methods, misconceptions about MCS, and logistical issues. Notably, the lack of financing options and misconceptions about MCS are the most significant challenges, exacerbated by insufficient awareness and understanding of MCS.

Based on the findings, modular construction adoption in Malaysia could be strategically increased from the current estimated level of approximately 10% to at least 25–30% of selected public housing and institutional projects within the next five years, provided that financing and policy constraints are addressed. Furthermore, respondents' experiences suggest that modular construction has the potential to reduce project delivery time by 30–40% and overall lifecycle costs by 10–20% when supported by appropriate financing structures and early-stage planning. These benchmarks provide policy-relevant targets that can guide government agencies and financial institutions in evaluating the success of modular construction initiatives.

The second objective of this research is to determine strategies to promote the adoption of MCS in Malaysia. Most respondents agree that financial strength and good financial management can enhance MCS adoption. Developing specialized financing products tailored specifically for modular construction projects and securing governmental support are also crucial. The government plays a key role in driving the implementation of MCS in Malaysia.

This study contributes uniquely by translating stakeholder experiences into actionable insights for reforming construction financing model in Malaysia. It showed that the primary constraint on MCS adoption is not technical feasibility but institutional misalignment, particularly between banking practices, regulatory frameworks, and modular production workflows. By

identifying the need for factory-stage progress certification, modular-specific loan structures, and government–bank coordination, this study provides an empirical foundation for developing Malaysia-specific modular construction financing models and policy instruments.

While this study achieved its research objectives, some limitations were encountered. There was a lack of response from potential respondents, partly due to heavy work commitments, which extended the data collection timeline. Additionally, the unwillingness of many potential respondents to participate led to a smaller sample size. Future research recommendations include conducting comparative studies across other states or regions in Malaysia to gain a more comprehensive understanding of MCS adoption. Another recommendation is to investigate the potential of public-private partnerships (PPPs) in facilitating the financing and adoption of MCS, exploring the feasibility, challenges, and benefits PPPs may offer in this context. construction (Fleisher et al. 2023).

New research should also develop and test prototype financing models aligned with Malaysia's banking regulations and housing delivery systems. This includes piloting modular-specific loan structures, assessing government-backed risk-sharing mechanisms, and evaluating how public-sector modular procurement can catalyze private financing confidence.

At the policy level, the government should establish modular-specific regulatory and financing frameworks. This includes (1) Introducing CIDB-certified factory-stage progress certification, (2) Mandating modular construction quotas in selected public projects, (3) Providing tax incentives and subsidies for modular factories, and (4) Collaborating with banks and private sectors to develop modular-specific lending guidelines. These interventions would send strong institutional signals that MCS is a national priority rather than an experimental alternative.

At the industry level, the players must adapt their operational and financial practices. Banks should develop modular-specific loan products, developers should incorporate modular planning at early design stages, and manufacturers should standardize module designs to facilitate valuation and financing.

Overall, this study contributes to Malaysia's construction policy discourse by demonstrating that the key constraint on modular construction is institutional rather than technical. By providing empirically grounded insights into financing misalignment, policy gaps, and industry readiness, the study offers a foundation for developing Malaysia-specific modular construction policies and financing models.

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DECLARATION OF COMPETING INTEREST

None.

REFERENCES

Ahmed, S. K. 2024. How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. *Oral Oncology Reports* 12: 100662. https://doi.org/10.1016/j.oor.2024.100662

Ahmed, S. K. 2025. Sample size for saturation in qualitative research: Debates, definitions, and strategies. *Journal of Medicine, Surgery, and Public Health* 5: 100171. https://doi.org/10.1016/j.glmedi.2024.100171

Ambartsumyan, S., Mochalin, D., Avetisyan, R. & Siebeva, J. 2023. Analysis of risks arising at the stages of production, transportation, installation of large-sized modules in the design position. *E3S Web of Conferences* 410: 1–8.

Arowoiya, V. A. & Oyefusi, O. N. 2023. An analysis of the benefits of adopting modular construction: A Nigerian construction industry context. *Journal of Construction in Developing Countries* 28(1): 243–265.

Aziz, N. F. & Abdullah, M. R. 2015. Industrialized building system: A review on trends, advantages and challenges. *Applied Mechanics and Materials* 773–774: 1003–1007.

Aziz, S. & Abdullah, M. R. 2015. Modular construction system in Malaysia: Issues for research in sustaining an affordable home project. *Proceedings of the Postgraduate Conference on Global Green Issues (Go Green)*, 7–8.

Aziz, S., Che Mohd Nasir, S. N., Hatrom, R., Ahmad Bazuli, L. & Abdullah, M. R. 2019. Modular construction system (MCS) in Malaysia: Mass customization through combinatorial. *IOP Conference Series: Earth and Environmental Science* 385(1).

Azman, N. S., Ramli, M. Z., Razman, R., Zawawi, M. H., Ismail, I. N. & Isa, M. R. 2019. Relative importance index (RII) in ranking of quality factors on industrialized building system (IBS) projects in Malaysia. *AIP Conference Proceedings* 2129.

Bello, A. O., Eje, D. O., Idris, A., Semiu, M. A. & Khan, A. A. 2023. Drivers for the implementation of modular construction systems in the AEC industry of developing countries. *Journal of Engineering, Design and Technology*.

Bello, A. O., Khan, A. A., Idris, A. & Awwal, H. M. 2023. Barriers to modular construction systems implementation in developing countries' architecture, engineering and construction industry. *Engineering, Construction and Architectural Management*.

Blismas, N. & Wakefield, R. 2009. Drivers, constraints and the future of off-site manufacturing in Australia. *Construction Innovation* 9(1): 72–83.

DOSM. 2025. Construction statistics, first quarter 2025. https://www.dosm.gov.my/portal-main/release-content/construction-statistics-first-quarter-2025. Tarikh capaian: 14 Januari 2026.

Elghaish, F., Pour, F., Hosseini, M. R., Edwards, D. & Shelbourn, M. 2022. Financial management of construction projects: Hyperledger fabric and chaincode solutions. *Automation in Construction* 137: 104185. https://doi.org/10.1016/j.autcon.2022.104185

Enshassi, M. S. A., Walbridge, S., West, J. S. & Haas, C. T. 2019. Integrated risk management framework for tolerance-based mitigation strategy decision support in modular construction projects. *Journal of Management in Engineering* 35(4): 1–16.

Feldmann, F. G., Birkel, H. & Hartmann, E. 2022. Exploring barriers towards modular construction – a developer perspective using fuzzy DEMATEL. *Journal of Cleaner Production* 367: 133023. https://doi.org/10.1016/j.jclepro.2022.133023

Fleisher, G. 2023. The blueprint for affordable housing: Government support and non-profit synergy in modular construction. *Modular Home Coach*. https://www.perplexity.ai/search/restructure-the-following-writ-Rn80S_6_TJu_UU9krvXRWg. Tarikh capaian: 19 Disember 2023.

Generalova, E. M., Generalov, V. P. & Kuznetsova, A. A. 2016. Modular buildings in modern construction. *Engineering Proceedings* 153: 167–172. http://dx.doi.org/10.1016/j.proeng.2016.08.098

Gunasagaran, S., Yung, L. K., Mohamed, M. R. & Mari, T. 2022. Integrating system thinking in industrialized building system (IBS) in Malaysia. *Journal of Engineering Science and Technology* 17: 222–236.

Hassan Ali, A., Farouk Kineber, A., Jibril Obied Qaralleh, T., Sultan Alaboud, N. & Osama Daoud, A. 2023. Classifying and evaluating enablers influencing modular construction utilization in the construction sector: A fuzzy synthetic evaluation. *Alexandria Engineering Journal* 78: 45–55. https://doi.org/10.1016/j.aej.2023.07.026

Hennink, M. & Kaiser, B. N. 2022. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science and Medicine* 292: 114523. https://doi.org/10.1016/j.socscimed.2021.114523

Hwang, B. G., Shan, M. & Looi, K. Y. 2018. Knowledge-based decision support system for prefabricated prefinished volumetric construction. *Automation in Construction* 94: 168–178. https://doi.org/10.1016/j.autcon.2018.06.016

Hwang, B. G., Zhu, L. & Ming, J. T. T. 2017. Factors affecting productivity in green building construction projects: The case of Singapore. *Journal of Management in Engineering* 33.

Institute, M. B. 2024. Advancing modular construction in government affairs. https://www.modular.org/government-affairs/

Ismail, M. Z., Kamarudin, T. & Halim, N. H. F. A. 2024. Modular construction systems: A focus on developing technical expertise in Malaysia. *Planning Malaysia* 22(3): 104–117. https://doi.org/10.21837/pm.v22i32.1496

Jabar, I. L., Ismail, F. & Mustafa, A. A. 2013. Issues in managing construction phase of IBS projects. *Procedia - Social and Behavioral Sciences* 101: 81–89.

Jaillon, L. & Poon, C. S. 2010. Design issues of using prefabrication in Hong Kong building construction. *Construction Management and Economics* 28(10): 1025–1042.

Khan, A., Yu, R., Liu, T., Guan, H. & Oh, E. 2022. Drivers towards adopting modular integrated construction for affordable sustainable housing: A total interpretive structural modeling (TISM) method. *Buildings* 12(5).

Khan, A. A., Yu, R., Liu, T., Gu, N. & Walsh, J. 2023. Volumetric modular construction risks: A comprehensive review and digital-technology-coupled circular mitigation strategies. *Sustainability* 15(8).

Kho, H. Y. 2023. *Appraising the Opportunities and Challenges of Modular Construction in Malaysia*. Tunku Abdul Rahman University. http://eprints.utar.edu.my/5811/1/1804948_Report_-_HUI_YI_KHO.pdf

Lee, S., Jeong, M., Cho, C. S., Park, J. & Kwon, S. 2022. Deep learning-based PC member crack detection and quality inspection support technology for the precise construction of OSC projects. *Applied Sciences* 12(19).

Liu, S., Liu, Q. & Zhang, M. 2022. Research on modularization of prefabricated affordable housing in Zhengzhou based on the concept of sustainable development. *Advances in Transdisciplinary Engineering* 23: 1012–1023.

Ministry of Works. 2019. *National Construction Policy 2030*. Kuala Lumpur: Ministry of Works.

Mohammad, F. M., Baharin, A. S., Musa, M. F. & Yusof, M. R. 2016. The potential application of IBS modular

system in the construction of housing scheme in Malaysia. *Procedia - Social and Behavioral Sciences* 222: 75–82. http://dx.doi.org/10.1016/j.sbspro.2016.05.189

Motlhatlhedi, I. G. & Nel, H. 2019. Investigation of project delay in construction projects in the South African rail industry. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 600–611.

Nawi, M. N. M., Osman, W. N. & Anuar, H. S. 2014. Improving thermal performance and accessibility of industrialized building system (IBS) implementation in Malaysia. *Journal of Engineering Science and Technology* 9(1): 97–108.

Nguyen, T. D. H. N., Jeong, J., Ahn, Y. & Shin, H. 2023. An innovative approach to temporary educational facilities: A case study of relocatable modular school in South Korea. *Journal of Building Engineering* 76: 107097. https://doi.org/10.1016/j.jobe.2023.107097

Omurtay, I., Soyluk, A. & Unay, A. I. 2024. Use of BIM with modular construction in future construction techniques. *MANAS Journal of Engineering* 12(1): 29–33.

Paliwal, S., Choi, J. O., Bristow, J., Chatfield, H. K. & Lee, S. 2021. Construction stakeholders' perceived benefits and barriers for environment-friendly modular construction in a hospitality centric environment. *International Journal of Industrial Construction* 2(1): 15–29.

Rahim, A. A. & Qureshi, S. 2018. Barriers to the implementation of industrialized building system (IBS) in Malaysia. *International Journal of Built Environment and Sustainability* 5(1): 9–15.

Ramli, M. Z., Abidin, M. Z. Z., Hamid, N. B., Razman, R. & Noh, N. A. M. 2021. Ranking of railway construction project delay factors in Malaysia by using relative importance index (RII). *AIP Conference Proceedings* 2339.

Ribeiro, A. M., Arantes, A. & Cruz, C. O. 2022. Barriers to the adoption of modular construction in Portugal: An interpretive structural modeling approach. *Buildings* 12(10).

Salama, T., Moselhi, O. & Al-Hussein, M. 2018. Modular industry characteristics and barriers to its increased market share. *Modular Offsite Construction Summit Proceedings*, 8–15.

Salman, A. 2019. The critical imperative for government support of modular and prefabricated construction: Insights from global case studies. *LinkedIn*. https://www.linkedin.com/pulse/critical-imperative-government-support-modular-insights-ali-salman-9bmyc?trk=public_post

Silva, P. M., Domingo, N. & Ameer Ali, N. A. N. 2024. Causes of disputes in the construction industry – a systematic literature review. *Journal of Financial Management of Property and Construction* 29(2): 193–210.

Teh, K. T. & Zainal, R. 2021. The study of modular construction system (MCS) application for affordable housing in Malaysia. *Research in Management of Technology and Business* 2(1): 794–811. http://publisher.uthm.edu.my/periodicals/index.php/rmtb

Thomas, B. & Jayakumar, A. 2017. Overseeing quality management in construction industries. *International Journal of Civil Engineering and Technology* 8(4): 792–800.

Thurairajah, N., Rathnasinghe, A., Ali, M. & Shashwat, S. 2023. Unexpected challenges in the modular construction implementation: Are UK contractors ready? *Sustainability* 15(10).

Tungka, N. F. 2020. Combining qualitative and quantitative methods in data analysis. *Sintuwu Maroso Journal of English Teaching*. https://ojs.unsimar.ac.id/index.php/sintuwumarosoJET/article/viewFile/129/114

Williams, M. & Moser, T. 2019. The art of coding and thematic exploration in qualitative research. *International Management Review* 15(1): 45–52.

Wong, H. J. 2019. *The Challenges of Adopting Modular Construction in Malaysian Construction Industry*. Final Year Project, Tunku Abdul Rahman University College.

Wuni, I. Y., Shen, G. Q. P. & Mahmud, A. T. 2022. Critical risk factors in the application of modular integrated construction: A systematic review. *International Journal of Construction Management* 22(2): 133–147. https://doi.org/10.1080/15623599.2019.1613212

Wuni, I. Y. & Shen, G. Q. 2023. Exploring the critical success determinants for supply chain management in modular integrated construction projects. *Smart and Sustainable Built Environment* 12(2): 258–276.

Wuni, I. Y., Shen, G. Q. & Saka, A. B. 2023. Computing the severities of critical onsite assembly risk factors for modular integrated construction projects. *Engineering, Construction and Architectural Management* 30(5): 1864–1882.

Zhou, Z. 2022. The obstacles to promoting the modular building project: A tentative assessment of the literature. *Technology Innovation and Engineering Research* 6: 1–6.