PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 22 ISSUE 2 (2024), Page 45 – 57

INDUSTRIALISED BUILDING SYSTEM MODULAR SYSTEM (IBSMS): ADDRESSING MERITS AND CHALLENGES FOR SUSTAINABLE DEVELOPMENT SUCCESS

Norhafizah Yusop[1], Shahira Irdina Muhammad Nizam[2], Wan Norizan Wan Ismail[3], Siti Sarah Mat Isa[4], Norsyazwana Jenuwa[5]

[1,2,3,4,5] *Department of Built Environment Studies and Technology, College of Built Environment,*
UNIVERSITI TEKNOLOGI MARA, PERAK BRANCH, MALAYSIA

Abstract

In response to the current demand for an innovative construction design that offers shorter construction periods and cost-saving benefits, Malaysians are increasingly seeking alternative solutions for sustainable development. The Industrialised Building System Modular System (IBSMS) emerges as a promising sustainable approach for home design and has developed as a transformative approach in the construction industry, holding massive potential for sustainable development. Nevertheless, certain merits and challenges must be addressed to promote the widespread adoption and implementation of sustainable development within the Malaysian construction industry. To provides a complete analysis of the merits and challenges associated with IBSMS, a questionnaire survey was conducted with the aim of shedding light on its role in fostering the success of sustainable development. The survey targeted G7 contractor companies in Selangor, resulting in 77 valid responses. The data obtained from the survey underwent descriptive analysis. The survey findings revealed that the most significant challenges hindering IBSMS adoption were the shortage of construction professionals experienced in working with modular systems, logistical complexities, cost implications, complex compliance implementation procedures, and resistance to change. Addressing the complex balance between these merits and challenges is crucial for policymakers, construction professionals, and researchers in unlocking the full potential of IBSMS in sustainable development and advancing construction in Malaysia.

Keywords: Sustainable Development, Industrialised Building System Modular System, Merits, Challenges

[1] Corresponding Author Email: norha158@uitm.edu.my

INTRODUCTION

In an era marked by rapid development, resource scarcity, and environmental concerns, the construction industry faces an urgent need to embrace innovative approaches aligned with the principles of sustainability. In recent years, IBSMS has gained attention as a construction method that holds the potential for improving efficiency and quality in the Malaysian construction industry. Unlike the traditional construction paradigm, characterised by on-site assembly of buildings using labour-intensive and often wasteful methods, IBSMS, with its emphasis on off-site fabrication, assembly line production, and modular components, presents a compelling alternative that offers various advantages for the construction industry and broader societal goals. However, despite its promising advantages, the widespread adoption of IBSMS in Malaysia faces significant challenges. These challenges hinder the effective implementation of the system and limit its progress in comparison to other countries.

This research aims to investigate the merits and challenges associated with IBSMS in the context of sustainable development within the state of Selangor, Malaysia. Therefore, it is essential to conduct a questionnaire survey among registered contractor companies in Selangor to identify and understand the merits and challenges associated with IBSMS. The primary purpose is to provide insights that will guide its successful integration into sustainable construction practices in the Malaysian construction industry. By gaining insights into these benefits and challenges, appropriate measures and strategies can be developed to overcome them, ultimately enhancing the implementation of IBSMS, and leading to improved innovative construction practices and outcomes in Malaysia.

LITERATURE REVIEW

Industrialised Building System Modular System (IBSMS)

Construction industry is a significant contributor to the economy of developed countries, including Malaysia. Unfortunately, the Malaysian construction industry has recently faced challenges related to productivity, wastage, performance, and an over-reliance on foreign labour (Rahman et al., 2012). Since Industrialised Building System (IBS) is already established in the Malaysian construction industry, it is vital to adapt IBSMS to the IBS approach. The IBSMS has been improved to address current and future demands challenges. In addition, it holds a great potential to eliminate the current IBS limitations and drive the industry towards improved views, rapid progress, and sustainability. 14% of experts agreed that IBSMS is suitable for future construction planning in Malaysia (Aziz et al., 2019).

The adoption of IBSMS in the construction industry has become increasingly prevalent. Nevertheless, this adoption process is not without its challenges. Successful implementation of IBSMS in construction projects requires addressing key obstacles, including additional transportation and logistics considerations, extensive coordination and organisational requirements, a lack of experience and skills among construction professionals, public and expert perception issues, complex inspection, and code compliance requirements, as well as higher financial risks. These obstacles significantly impact the integration and effectiveness of IBSMS in construction practices.

To comprehensively understand and address these challenges, conducting a literature review is essential. This review based on existing research and scholarly works, aims to provide an in-depth exploration and understanding of the obstacles associated with IBSMS adoption in construction practices (Wuni, Shen, & Mahmud, 2022). The insights gained from this review will contribute to the advancement of research and practice in the construction field, facilitating the successful integration of IBSMS in the Malaysian construction industry.

Transportation & Logistics Considerations

One particular challenge in adopting IBSMS in construction practices is the transportation of modular units. This process typically involves the use of large trucks and trailers, necessitating careful logistics coordination. Modular units come in various specifications, with widths ranging from 8 ft to 14 ft, lengths reaching up to 70 ft, and heights between 11 ft and 13 ft. Smooth transportation and logistics require the implementation of specific control measures, such as staging areas, traffic officer control, and parking restrictions. Ensuring the timely and efficient transportation of oversized components to distant locations is vital to prevent delays, mitigate additional costs, and avoid adding complexity to the project schedule. Moreover, the transportation of modular units is subject to the regulations set by a country's road department (Musa et al., 2016).

Coordination & Organisational Requirements

Subsequently, effective communication is essential for successfully delivering construction projects, especially with the growing housing demands in the industry (Mohd Fateh et al., 2023). Besides, the fragmented nature of IBSMS presents a considerable challenge in coordinating and ensuring a continuous transition between various work processes. This complexity can result in potential cost overruns and technical difficulties. Therefore, the need for extensive coordination and organisation is also crucial to mitigate these challenges and ensure the successful implementation of IBSMS. To achieve efficiency in project scheduling and cost-effectiveness (Lim et al., 2022), proper coordination among different stakeholders involved, effective planning, and

well-defined processes are necessary. This emphasises the importance of maintaining clear and effective communication channels throughout the project's execution (Al-Mayahi et al., 2018), as it plays a pivotal role in facilitating collaboration and overcoming challenges posed by the modular system's complexities.

Construction Professionals Experience & Skills

Another significant challenge in adopting IBSMS is the lack of experience and skills among stakeholders and construction professionals in Malaysia. They seem to lack familiarity with IBSMS, which may result in knowledge gaps and potential complications. This lack of familiarity is partly attributed to a limited understanding of the design, applicability, and accomplishment of building practitioners (Navaratnam et al., 2019). Consequently, this issue hinders the proper implementation of the system, leading to improper work procedures and unattained benefits. Additionally, a shortage of modular expertise and skills within the construction industry has also been noted (Aziz et al., 2019). The substandard quality of modular construction in Malaysian projects arises from issues like improper manufacturing, unskilled labour, and inadequacies among architects, engineers, and contractors.

Public & Construction Expert Perception

Furthermore, the adoption of IBSMS also faces substantial challenges due to negative perceptions from the public and even construction experts (Rahman, 2014). Generally, these unfavourable views often reduce public demand for this construction method, driven by concerns and doubts about its quality and performance. Stereotypes that associate the modular system with cheapness and limited construction options further hinder its widespread acceptance. Despite being recognised as one of the modern methods of construction, the development and adoption of modular construction remain limited to a few developed countries, with a generally low adoption rate in the construction industry (Lim et al., 2022).

Building Codes, Standards & Regulations

In Malaysia, the construction of modular buildings is regulated by guidelines and regulations established by the Malaysian Construction Industry Development Board (CIDB) and other relevant authorities. These guidelines cover various aspects, including design, construction methods, materials, and quality control measures, tailored to the specific requirements of the Malaysian context (CIDB, 2019). While Malaysian standards and regulations for modular construction may differ from those in other countries, such as the HUD-Code used in the United States, the primary objective remains consistent: ensuring that modular

construction adheres to the necessary implementation procedures standards for structural integrity, safety, and functionality (Said et al., 2014).

One notable challenge encountered when adopting IBSMS in Malaysia is the complexity of the inspection process for modular buildings. Due to the unique characteristics of modular construction, such as non-conventional connections and different procedures, a comprehensive and meticulous inspection of every aspect of the building is required. This complexity, combined with challenges related to building regulations and planning permission procedures, can hinder the process of obtaining building-occupancy approval (Hyams et al., 2018).

Finance Risks

In addition to the challenges mentioned earlier, another significant obstacle in adopting IBSMS in construction practices is the higher risk to finance. While the system offers cost savings through reduced on-site activity, there are substantial upfront costs associated with automation, including the establishment of fabrication plants, allocation of machinery, equipment, formwork, and transportation fees. Experts argue that the design and engineering aspects of IBSMS can contribute to overall cost increases (Navaratnam et al., 2019). Additional expenses arise from the need for additional design and engineering hours, approximately 10% more than conventional methods, and the use of extra materials, requiring about 30% more structural steel for module transportation (Egege, 2018). These costs can add up to approximately 0.5% of the total construction cost. As a result of these financial considerations, lenders may perceive funding IBS modular projects as risky. The potential bankruptcy of module manufacturers poses a concern for lenders, who may face the risk of losing their investment (Abdelmageed, Abdelkhalek, & Zayed, 2020). Therefore, the higher risk to finance further compounds the challenges encountered in the adoption of IBSMS in the Malaysian construction industry.

RESEARCH METHODOLOGY

The study adopts a quantitative analysis approach, employing a carefully designed structured questionnaire as the primary tool for data collection. The questionnaires underwent meticulous design, incorporating insights from an extensive literature review that included sources such as journals, reports, and seminar papers from Malaysia and other countries. Validation of the questionnaire by experts in the construction field ensured its clarity, relevance, and appropriateness, guaranteeing its quality and applicability.

Selangor was chosen as the research location due to its top rank in project awards for 2021 and 2022, as reported by the CIDB (2022). Additionally,

Selangor is a rapidly developing region in Malaysia with a wealth of building and infrastructure projects, providing ample opportunities for future well-planned and extensive construction endeavours. The study focused on G7 contractors selected based on their eligibility, investment capabilities, experience, and advanced technology, which positioned them as leaders in the IBS market. These contractors' companies, operating in the selected area, are approved, and licensed by the Malaysian CIDB, enabling their engagement with professionals and specialists for larger civil engineering and housing construction projects.

To create an accurate sampling frame, a comprehensive list of potential participants was compiled from diverse sources, including construction industry associations, governmental databases, and academic institutions, primarily within the regions of Gombak, Kuala Langat, and Sepang. The research employed a simple random sampling method to select respondents from the target population, with a primary focus on individuals who are construction experts knowledgeable about IBSMS and its implications. Out of the 4,669 companies registered under CIDB in Selangor, the study specifically targeted the Gombak (29.9%), Kuala Langat (37.7%), and Sepang (32.5%) areas, comprising approximately 95 companies. Using the sampling approach outlined by Krejcie and Morgan (1970), the research selected 77 respondents from registered contractor companies.

ANALYSIS AND DISCUSSION

The research questionnaires were distributed to the respondents via Google Forms, resulting in a 100% response rate, indicating a reliable dataset for further analysis. The collected data was analysed using SPSS version 28 software. In this study, the majority of respondents fell into the age group of 31 to 35 years (28.6%), followed by those aged 36 years and above (26%), 26 to 30 years (24.7%), and 18 to 25 years (20.8%). The majority of respondents were from Kuala Langat (37.7%), while others were from Sepang (32.5%) and Gombak (29.9%). Regarding their job positions, the primary role was Quantity Surveyor (28.6%), followed by other positions, such as Site Manager, Contractor, Project Manager, Project Coordinator, and Safety Officer (23.4%). Architects accounted for 16.9% of respondents, Administration Personnel constituted 16.9%, and Engineers represented 14.3%. Majority of the respondents had 6 to 10 years of experience (36.4%). Respondents with 1 to 5 years and 11 to 15 years of experience each made up 20.8%, while those with 16 to 20 years of experience comprised 16.9%. Only 5.2% of respondents had over 20 years of experience.

Implementation of IBSMS

The findings of this study indicate that a significant proportion of survey respondents, specifically, 41.6%, have worked on at least five modular projects

over their careers, indicating limited exposure to modular construction. Besides, 39% of respondents reported handling 6 to 10 modular projects throughout their professional experience, suggesting a moderate level of involvement in IBSMS implementation. Furthermore, the findings demonstrate that only a small percentage of respondents (16.8%) handled 11 to 15 modular projects, and an even smaller portion (2.6%) managed more than 15 projects, indicating limited involvement in IBSMS projects. Based on the findings, it can be inferred that IBSMS projects are increasingly being adopted in the industry. Within the last 12 months, most respondents (68.8%) had not participated in any modular projects, but over the last five years, a significant portion of the respondents (68.8%) had been involved in modular projects, indicating a growing interest in and adoption of the IBSMS construction methods.

Merits in Implementing IBSMS

Essentially, the summary of the literature review highlights the cruciality in addressing the merits to promote IBSMS projects in future development. As shown in Table 1, merits incorporate a range of factors, from increased construction efficiency and quality to minimised waste and reduced environmental impact.

Table 1: Merits to promote IBSMS.

Author	Findings	Benefits
Aziz et al., 2019; Boafo et al., 2016	80% of construction activity will be done in factory	Faster
Kamali & Hewage, 2016; Lawson et al., 2012	The number of visits by delivery vehicles to the site reduced by 70% and the bulk of transport activity has been shifted to the factory	Minimise site disruption and traffic
Musa et al., 2016; Navaratnam et al., 2019	Modular building can be movable, dismantled, refurbished, and relocated for use in another location and for new purposes	Flexible
CIDB, 2019; Said et al., 2014	Reducing the environmental and human health concerns associated with demolition, such as dust production and noise	Environmentally friendly
Abdelmageed et al., 2020; Musa et al., 2016	The programme consists of strict quality control combined with testing protocol and independent inspection that promote superior quality of construction	High quality
Lawson et al., 2012; Peñaloza et al., 2017	IBSMS reduces on-site accidents by 80%	Significantly safer with enhanced security

By identifying the benefits, the industry can facilitate the widespread implementation of modular construction methods, leading to improved efficiency and effectiveness in the construction process. Table 2 presents the analysis of mean scores and rankings obtained from the 77 respondents.

Table 2: Merits of implementation of IBSMS in Malaysia's construction industry.

Category	Mean	Rank
High quality	4.18	1
Faster	3.96	2
Environmentally friendly	3.75	3
Significantly safer with enhanced security	3.73	4
Minimise site disruption and traffic	3.60	5
Flexible	3.57	6

Evidently, the results show that a significant number of respondents emphasised the high quality achievable in the modular system, ranking it first with a mean score of 4.18. They also recognised the faster procedure of modular construction, ranking it second with a mean score of 3.96. Subsequently, environmentally friendly, and significantly safer with enhanced security were ranked third and fourth, with mean scores of 3.75 and 3.73, respectively. On the contrary, the results reveal that site disruption and traffic minimisation, as well as flexibility of the modular system, were ranked fifth and sixth, with mean scores of 3.60, and 3.57. Apparently, the results suggests that the respondents highly value the quality and speed advantages of the modular system, while the perception of its flexibility and potential for minimising site disruption and traffic is relatively lower. This suggests a need to address perceived challenges and better promote the benefits of modular construction in Malaysia's construction industry. The lower ranking and mean scores in this aspect could be due to a lack of exposure to successful implementations or a need for more evidence and case studies to showcase these advantages. Consequently, the findings emphasise the need for addressing the perceived challenges associated with modular construction. These challenges could include misconceptions about its limitations, concerns about integration with existing construction practices, or the need for clear guidelines and standards for modular projects.

Challenges in Implementing IBSMS

The final section of the questionnaires aims to assess the obstacles related to IBSMS, as identified by previous researchers. Table 3 highlights significant challenges, including a lack of construction professionals experienced with modular systems, logistics complexities, cost implications, complex compliance

implementation requirements, and resistance to change. These challenges require strategies for the successful integration of IBSMS in Malaysia.

Table 3: Significant challenges of IBSMS implementation.

Author	Description	Challenges
Musa et al., 2016; Rahman, 2014; Xu et al., 2020	Modular units need to be transported by large trucks and trailers and imposed with additional overhead of logistics coordination	Transportation and logistics consideration
Rahman, 2014; Xu et al., 2020	Coordination and transition challenges	Extensive coordination and organisation
Aziz et al., 2019; Navaratnam et al., 2019	Lack of modular expertise and skills in the construction industry	Lack of experience and skills
Paliwal, 2019; Rahman, 2014; Subramanya et al., 2020	The concept of IBS modular system is viewed negatively by public and even to some experts in the construction industry	Negative public and expert perception
Xu et al., 2020	The complex structure of the system involving non-conventional connections, indeed demands more inspection effort	Complex inspection and code compliances
Abdelmageed et al., 2020; Egege, 2018; Navaratnam et al., 2019	Some experts believed that the design and engineering of IBS modular system can add up to the overall cost	Higher risk to finance

Table 4 presents the findings on the critical challenges encountered when implementing the IBSMS in the Malaysian construction industry.

Table 4: Challenges in adopting IBSMS in Malaysia's construction industry.

Category	Mean	Rank
Lack of experience and skills	4.23	1
Additional transportation and logistics consideration	3.99	2
Higher risk to finance	3.96	3
Complex inspection and code compliance	3.86	4
Extensive coordination and organisation	3.36	5
Undesirable public and expert perception	2.97	6

Likewise, the present analysis has identified the top six challenges, as deemed by industry professionals, in adopting IBSMS as the most challenging. Among these challenges, the lack of experience and skills among construction professionals emerged as the highest-ranked concern, with a mean score of 4.23. The respondents strongly agreed that this aspect poses the most significant challenge in adopting IBSMS in Malaysia. Following closely, additional

transportation and logistics considerations were ranked second, with a mean score of 3.99. The respondents identified this as another critical challenge impacting the adoption of IBSMS. The third and fourth ranks were assigned to the challenges of higher risk to finance and complex inspection and code compliance, with mean scores of 3.96 and 3.86, respectively. These challenges were recognised as important factors that need to be addressed for the successful implementation of IBSMS in the Malaysian construction industry. On the other hand, extensive coordination, and organisation, as well as undesirable public and expert perception, were rated as the least challenging aspects in adopting IBSMS. These factors obtained the fifth and sixth ranks, with mean scores of 3.36 and 2.97, respectively. Although they were perceived as less challenging, they still warrant attention to ensure the smooth adoption and integration of IBSMS in the Malaysian construction industry.

CONCLUSION

This research has revealed that IBSMS holds significant promise for advancing sustainable development in the construction industry. Through a comprehensive literature review exploration and a structured questionnaire survey of merits and challenges, drawing upon the experiences and perceptions of construction professionals and stakeholders in Gombak, Kuala Langat, and Sepang, within the state of Selangor, Malaysia, it has highlighted the potential benefits of IBSMS, including a range of factors, from increased construction efficiency, quality to minimise material waste and reduced environmental impact by energy efficiency, and enhanced occupational safety. These merits not only align with the principles of sustainable development but also point out the potential of IBSMS to transform the construction industry, making it eco-friendlier and more efficient. At the same time, however, this study also pinpointed significant challenges, such as initial cost considerations and resistance to change, that require strategic planning and policy support to facilitate the widespread adoption of IBSMS. Addressing these barriers could encourage more extensive engagement with IBSMS projects and pave the way for greater efficiency and cost-effectiveness in the construction industry. Among the challenges identified in this research, lack of experience and skills among construction professionals emerged as the most significant obstacle. This finding emphasises the importance of investing in training and capacity-building programmes to equip construction professionals with the necessary expertise to implement modular construction practices effectively.

In conclusion, addressing these challenges is crucial to unlocking the full potential of the modular system and promoting the successful integration of IBSMS in the Malaysian construction industry. While the significance of undesirable public and expert perceptions was relatively low, stakeholders should

still make efforts to enhance awareness and understanding of the benefits and capabilities of the modular system. Active engagement with stakeholders, encompassing the public and industry experts, enables the dispelling of misconceptions, thus paving the way for increased acceptance and adoption of modular construction methods. To mitigate these challenges, it is imperative for construction professionals and stakeholders to take proactive measures such as promoting collaboration and knowledge sharing among industry professionals, encouraging innovative approaches to modular construction, and fostering a supportive regulatory environment that facilitates the adoption of modular techniques. By addressing these challenges head-on and leveraging the benefits offered by the modular system, the construction industry in Malaysia can experience significant advancements. The successful implementation of the modular system can yield a range of advantages, including improved efficiency, reduced construction timelines, enhanced sustainability, and increased cost-effectiveness.

In summary, this study has illuminated the challenges impeding the adoption of the modular system in the Malaysian construction industry. By recognising these challenges and implementing appropriate strategies, stakeholders can overcome barriers and capitalise on the extensive potential of modular construction. The findings will not only benefit individual projects but also contribute to the overall growth and sustainability development of the construction industry in Malaysia.

REFERENCES

Abdelmageed, S., Abdelkhalek, S., & Zayed, T. (2020). Benefits and challenges of modular integrated construction in Hong Kong: A literature review. 8th International Conference on Construction Engineering and Project Management (ICCEPM2020), 7-8. https://www.researchgate.net/publication/349965988

Al-Mayahi, H. T., Ismail, S., Wahab, M. H., Rani, W. N. M. W. M., & Amat, R. C. (2018). Architectural practices of project communication management in Iraq. *Planning Malaysia*, *16*(1), 1–14. https://doi.org/10.21837/pmjournal.v16.i5.406

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). https://Doi.Org/10.1088/1755-1315/385/1/012030

Boafo, F. E., Kim, J. H., & Kim, J. T. (2016). Performance of modular prefabricated architecture: Case study-based review and future pathways. *Sustainability (Switzerland)*, *8*(6), 1–16. https://doi.org/10.3390/su8060558

Construction Industry Development Board Malaysia, CIDB. (2019). *Guideline for volumetric module house: Manufacturing design and construction for Malaysia*. Kuala Lumpur: CIDB Malaysia. https://www.cidb.gov.my/wp-content/uphttps://www.cidb.gov.my/wp-content/uploads/2022/07/187-Guideline-

for-Volumetric-Module-House-Manufacturing-Design-Construction-min.pdfloads/2022/07/187-Guideline-for-Volumetric-Module-House-Manufacturing-Design-Construction-min.pdf

Construction Industry Development Board Malaysia, CIDB. (2022). *Construction domestic projects.* Kuala Lumpur: CIDB Malaysia. https://convince.cidb.gov.my/(S(5hu51we1l5u22udmcat2wu5x))/CMS/Page/1

Egege, C. O. (2018). Off-site modular construction as a method of improving construction quality and safety. *International Journal of Structural and Civil Engineering Research*, *7*(3), 259–268. https://Doi.Org/10.18178/Ijscer.7.3.259-268

Hyams, A., Mccann, E., & Ferguson, H. (2018). Construction methods: Modular. *Building Magazine*, 46–50. https://www.building.co.uk/data/construction-methods-modular/5094760.article

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

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(3), 607-610. https://doi.org/10.1177/001316447003000308

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

Lim, Y. W., Ling, P. C., Tan, C. S., Chong, H. Y., & Thurairajah, A. (2022). Planning and coordination of modular construction. *Automation in Construction*, *141*, 104455. https://Doi.org/10.1016/j.autcon.2022.104455

Mohd Fateh, M. A., Arshad, R. A., Ahmad Marzuki, S. M., & Yusof, M. R. (2023). Improvements of the communication between consultants and contractors during the construction phase in Malaysia. *Planning Malaysia. 21*(26). https://doi.org/10.21837/pm.v21i26.1261

Musa, M. F., Yusof, M. R., Mohammad, M. F., & Samsudin, N. S. (2016). Towards the adoption of modular construction and prefabrication in the construction environment: A case study in Malaysia. *ARPN Journal of Engineering and Applied Sciences*, *11*(13), 8122–8131. https://www.researchgate.net/publication/305550264

Navaratnam, S., Ngo, T., Gunawardena, T., & Henderson, D. (2019). Performance review of prefabricated building systems and future research in Australia. *Buildings*, *9*(2). https://Doi.Org/10.3390/Buildings9020038

Peñaloza, G. A., Formoso, C. T., & Saurin, T. A. (2017). Resilience skills used by front-line workers to assemble precast concrete structures: An exploratory study. *Ambiente Construído*, *17*(4), 25–43. https://doi.org/10.1590/s1678-86212017000400183

Rahman, I. A., Memon, A. H., Nagapan, S., Latif, Q. B. A. I., & Azis, A. A. A. (2012, December). Time and cost performance of construction projects in southern and central regions of Peninsular Malaysia. In *2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER)* (pp. 52-57). Kota Kinabalu, Malaysia. https://Doi.Org/10.1109/CHUSER.2012.6504280

Rahman, M. M. (2014). Barriers of implementing modern methods of construction. *Journal of Management in Engineering, 30*(1), 69–77. https://Doi.Org/10.1061/(Asce)Me.1943-5479.0000173

Said, H., Ali, A. R., & Alshehri, M. (2014, May). Analysis of the growth dynamics and structure of the modular building construction industry. In *Construction Research Congress 2014: Construction in a Global Network* (pp. 1977-1986). https://Doi.Org/10.1061/9780784413517.202

Subramanya, K., Kermanshachi, S., & Rouhanizadeh, B. (2020, July). Modular construction vs. traditional construction: Advantages and limitations: A comparative study. In *Creative Construction e-Conference 2020* (pp. 11-19). Budapest University of Technology and Economics. https://Doi.Org/10.3311/Ccc2020-012

Wuni, I. Y., Shen, G. Q., & 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

Xu, Z., Zayed, T., & Niu, Y. (2020). Comparative analysis of modular construction practices in mainland China, Hong Kong, and Singapore. *Journal of Cleaner Production*, *245*, 118861. https://doi.org/10.1016/j.jclepro.2019.118861

Received: 29th Feb 2024. Accepted: 8th May 2024