Critical Driving Factors Influencing Awareness and Application of Industrialized Building System (IBS) Technology Among the Building Contractors in Sri Lanka

Sasangi Chandrasena[1], Harshini Mallawaarachchi[2]
[1]Department of Quantity Surveying, Sri Lanka Institute of Information Technology Malabe, Sri Lanka
[2]Department of Facilities Management, University of Moratuwa, Sri Lanka
qs20785406@my.sliit.lk, harshinim@uom.lk

ABSTRACT

As the commonly applied approach in building construction, conventional construction approach is linked to low quality and productivity, higher danger to employee safety, high reliance on labour and cost and time overruns. Hence, Industrialised Building System (IBS) has been emerged as an alternative for conventional construction by overcoming its shortfalls. Previous studies identified the lack of awareness and application can be taken as most critical factor influencing the application of IBS. Also, there are some of other critical factors which directly influence for this regard. Since a few studies has been focused on evaluating the significance of such driving factors, the purpose of this research was to assess the criticality of driving factors influencing awareness and application of IBS technology among the building contractors in Sri Lanka.

In order to fulfil aim and objectives of the research, deductive approach under quantitative phenomenon was used. The Survey strategy was adopted as the most ideal research strategy as this research focused on evaluating the criticality of driving factors. Questionnaire survey was used as the primary data collection technique. Accordingly, the questionnaire was distributed to 50 randomly selected practitioners from the building contracting organisations, such as Architects, Quantity Surveyors and Engineers to collect the data. Data were analyzed by using Weighted Mean Average (WMA) and Relative Importance Index (RII) techniques.

As derived through analysis, 13 factors affecting the level of awareness and application of IBS, which were identified through literature review were assessed to determine the significant factors. Results revealed that cost of construction is the most significant factor while small contractors' involvement is the least significant factor. As the main implication this research provides a basis to further improve the use of IBS technology in Sri Lanka and introduce different methods to reduce the initial cost of the construction.

KEYWORDS: *Application, awareness, building construction industry, building contractors, industrialised building system, Sri Lanka*

1 INTRODUCTION

Buildings and construction industry plays a vital role in improving the population's quality of life. It is always trying to meet the requirements and needs of the society (Al-Sanad, 2015).

Construction of buildings comes before other types of infrastructure. The commonly employed conventional construction approach, which entails all work being done on-site, is unsustainable since it is linked to low quality and productivity, a significant risk to worker safety, a large reliance on labour, cost and time overruns, and poor project performance (Rahim and Qureshi, 2018). As a result, construction experts began to focus on more potent construction methods. According to a study conducted by Thanoon et al (2003), Industrialised Building System (IBS) technology has been established as an alternative solution for the problems of conventional construction method.

This can be taken as a new construction technology, which use in the construction industry. According to the study conducted by Rahim and Qureshi (2018) IBS is a construction method that involves creating components off-site in a factory-controlled environment before having them moved and quickly installed there. Additionally, it can be deduced from that study that IBS is employed as a

https://doi.org/10.54389/JMEH9873

sustainable strategy because to its short duration and higher quality with fewer on-site operations. When looking at the history of IBS, this method is the Malaysian term for prefabricated construction and was begun in the 1960's Malaysia and become popular in 1998 and used as a solution to improve construction image and performance (Kamar et al, 2009). As the first pilot project, it was built on 22.7 acres of land along Jalan Pekeliling and consisted of the building of 7 blocks of 17-story apartments, 4 blocks of 4-storey apartments, and 40-story shop lots, totalling roughly 3,000 low-cost apartments. (Thanoon et al, 2003).

Thus, this IBS technology, which started in Malaysia, has spread in many other countries in the world today. Thus, the developed and developing countries such as Japan, Argentina, Singapore, Thailand, United Kingdom (UK), Australia, Germany, Netherlands, United States of America (U.S.A), Canada, Denmark, Sweden and Finland have resorted to using this method grants for their own construction (Thanoon et al,2003). The study conducted by Nduka et al (2019) shows as a developing country Nigeria also use this IBS technology in their industry. Rahim and Qureshi (2018) identified faster project completion, waste reduction, improve the quality of the building, reduction of labour and safety, foreign labour workforce and payment reduction, efficient construction process and higher productivity, adverse weatherproof construction, optimal usage of materials and make cleaner and safer environment, decrease whole life cycle cost and space-saving as advantages and lack of involvement from small contractors, ignorance of the technology, higher capital investment, use of heavy equipment and machineries and lack of experience with the technology are mentioned as barriers of using IBS technology.

Despite the disadvantages, it is clear that IBS method is very much beneficial for both clients and contractors than the conventional method. But to use this technology, level of awareness is much needed. When consider IBS technology, research studies conducted by Algumaei and Sarpin (2022), Ali et al (2018), Rozaimi A Samad et al (2020) and Thomas Tarang et al (2022) pointed out lack of awareness as a main barrier of using this IBS technology. Although the awareness and knowledge about the technology is crucial for the implementation to succeed of IBS technology. However, depending on the previous studies, it is clear the assessment and studies that have examined the awareness level of construction specialists mainly construction contractors are at a very low level. Through the studies conducted by Malaysia, Nigeria they clearly identified lack of awareness among the building contractors mainly influences and impact on the application of IBS technology in the construction industry. Although this technology is currently being used in Sri Lanka, the number of studies done in this regard is very minimal. The study conducted by Qi et al (2021) often focused on IBS adoption of structural basis and have not fully experienced the advantages of emerging technologies and it is only limited for the concrete-framed structures. Therefore, awareness of IBS technology among the construction practitioners is at a minimum level. With that importance, this research aimed at assessing and identifying the critical driving factors influencing awareness and application of IBS technology among the building contractors in Sri Lanka.

2 LITERATURE REVIEW

2.1 Importance of IBS for Building Construction

According to the study conducted by Rahim and Qureshi (2018) IBS is a method of building that involves producing components off-site in a factory-controlled setting, transporting, and assembling them into a structure with limited work on the construction site. According to that study as an alternative solution for the problems of conventional construction method, IBS technology was established. The study conducted by Qi et al (2021) stated that a practice of manufacturing and pre-assembling a particular number of building components, modules, and parts before shipping and installing them on the construction site is referred to as off-site construction. Normally IBS construction method is used to assemble building components after they have been manufactured on-site or off-site under controlled conditions and also known by prefabricated construction, off-site construction, and modular construction (Saad et al ,2022). In other way according to the study conducted by Hon et al (2022) mentioned IBS, or innovative building system, is a construction technique developed in Malaysia that uses prefabricated or pre-cast components through off-site construction or modularization. Accordingly, the technology of IBS was defined in this research as "an on or offsite construction method,

manufacturing building components in a controlled environment and transported and assembled in to a structure".

As a construction technology the use of IBS technology in building construction gives much more benefits than the conventional method. In IBS, buildings are constructed quickly, more effectively with minimal on-site activities, and sustainably. According to the study conducted by Rahim and Qureshi (2018) time saving, quality improvement, labour, wastage and cost reduction, reduction of payments by foreign labour, efficient construction process and higher productivity, flexible design, and adverse weatherproof construction can be taken as importance of using IBS technology. In 2022, Algumaei and Sarpin identified time reduction, quality improvement, decrease overall costs, environment friendly and flexibility of designing IBS product as some benefits of using IBS through their study. Reduced project implementation costs, short project completion period, improved level of hygiene and safety at the construction site, reduced requirement on foreign workers and use of quality components identified as advantages of using IBS (Samad et al, 2020). The study conducted by Hon et al, (2022) speed up on-site construction activities, reduce waste, reduce energy consumption, produce better construction quality, reduce life-cycle cost (LCC) and reduce construction cost can be taken as importance of using IBS technology.

2.2 Different Applications of IBS Technology in Building Construction Industry

Most of the developed and developing countries use IBS as a convenient technology, for their construction work. A study conducted by Mohamad et al (2009) clearly described the involvement of Malaysian construction society with the IBS technology. Further to the authors, strong awareness of government encouragement among companies makes good opportunity to going with this technology in Malaysia. As a developing country Nigeria is also use this method for their construction works. The study conducted by Nduka et al (2019) mainly investigated the Critical Success Factors (CSFs) contribution to the implementation of IBS in Nigeria. Mostly this IBS technology is use in Malaysian construction industry and according to the study conducted by Rahim and Qureshi (2018) it clearly mentioned in 1999, Malaysia realized that the oversupply of unskilled imported labor and the lack of skilled local workforce could only be overcome through the use of IBS and "according to the Construction Industry Development Board (CIDB), 2016 the first IBS strategic plan was announced followed by two IBS 'Roadmaps' (2003-2010 and 2011-2015)".

According to a study conducted by Thanoon et al (2003) Japan, Singapore, Thailand, U.K., U.S.A, Australia, Argentina, Germany, Netherlands, Canada, Denmark, Sweden and Finland are identified as experienced countries in IBS technology. Further to the authors identified "majority of the IBS are originated from United States, Germany and Australia and as developed countries Japan, Germany and U.K. indicate that there is a great potential for IBS to progress as evidenced by their growing market share". According to the study conducted by Rahman and Omar (2006) 'Brickfileds Secondary School in Kuala Lumpur' used 75% of pre-fabricated components to construct. In addition to that 'Jaya Jusco', 'Tebrau', 'Johor Bahru', 'Subang Square', 'Subang Jaya', 'Millennium Hall', 'Seberang Prai' also can get as examples for the usage of IBS in Malaysian construction industry. In construction of 'Senawang Police Quarter', 'teachers' quarters in Kuala Kangsar' and government quarters in Putra Jaya, load bearing wall system are used. And steel structured Kuala Lampur City Center (KLCC) convention center in the prestigious is also constructed according to the IBS technology.

Rozaimi A Samad et al (2020) did their study to found about the successful development of IBS using additional school buildings as examples in Malaysia and Kamar et al (2009) discussed through their study "IBS technology were used as a hybrid construction technique to build national landmarks such as 'Bukit Jalil Sport Complex', KLCC, Lightweight Railway Train (LRT) and 'Petronas Twin Towers' in Malaysia" and this approach "is begun since early 1960's in a low-cost housing scheme and today IBS has evolved and used in hybrid construction to build national landmark". Through this study it also mentioned IBS promote as a sustainable and green construction in UK. The study conducted by Mohamad et al (2009) mentioned "all government projects are essential to use IBS at least 70% of completed project and have a really indicate government encouragement to implement IBS in Malaysian construction industry".

According to the study conducted by Nduka et al (2019) it recommended a public-private cooperation with favorable monetary policies will help IBS talented contractors. The study conducted

by Thomas Tarang et al (2022) identified "67% of the study agreed that IBS contractors are prone to the risk in their business venture as an unstable political climate may cause policy changes and the less stable political climate will be causing a higher risk business and eventually lead to a lesser interest in implementing IBS as the rules and policies keep changing. The changes in political stands will affect the rules, regulations, and policies, making IBS business too risky".

2.3 Driving Factors Influencing Awareness and Application of IBS Technology in Building Construction

Mohamad et al (2009) identified the vast majority of partitioners are unaware of the range of IBS references and short courses that CIDB provides to aid with IBS implementation in Malaysia. Because of this, their level of awareness of IBS in management and technical activities was quite poor. This study identified IBS knowledge as one of the most important requirements for them to advance and receive greater recognition in the Malaysian construction sector over the short term. The study conducted by Qi et al (2021) discussed some businesses or employees could be reluctant to accept new technologies because they think that doing so will complicate and interrupt their workflow.

Many of research are identified limitations and influences which are mainly impact for the application of IBS construction. Skills shortage, Higher Cost, Lack of small contractors' involvement, Lack of Awareness are identified as the main limitations which involved the use of IBS through the study conducted by Rahim and Qureshi (2018). The study conducted by Algumaei and Sarpin (2022) identified the biggest issue with IBS adoption in Yemen was a lack of knowledge in terms of the absence of educational programs that address it. The studies conducted by Ali et al (2018) Samad et al (2020) and Thomas Tarang et al. (2022) also identified lack of knowledge and lack of experience among the workers as main barriers to the implementation of IBS construction. Also, the lack of awareness can be taken as internal challenge that IBS contractors have to face.

The study conducted by Hon et al (2022) lack of experience, insufficient knowledge, lack of codes and standard of application, poor cooperation and communication between stakeholders and lack of special equipment or technology are identified. Unavailability of research and educational courses on IBS, unfamiliarity, lack of technology reference, Insufficient IBS manufacturer and inadequate educational course for IBS as well also can be taken as driving factors which impact to the awareness and application of IBS technology (Zakari et al , 2017). In Industrialized and System (2016) clearly mentioned limited understanding is the main barrier for the implementation of IBS construction. The study conducted by Ali et al (2018) it is evident that the primary barriers to the adoption of IBS in Malaysia are a lack of information, awareness, and skilled labor. In addition to that Jaffar and Lee (2020) identified cost of construction, experience and expertise in IBS projects, training, communication, government policies, resource integration, and software use as other key determinants .

In summary 13 driving factors were identified, namely cost of construction, availability of technology, level of cooperation and communication, knowledge and experience, availability of special equipment, involvement of skilled workers, government policies, integration of resources and utilization of software, knowledge level of codes and standard of application, familiarity of technology, availability of research and educational courses on IBS, level of awareness and small contractors' involvement which were used in subsequent analysis.

2.4 Application of IBS Technology in Building Construction in Sri Lanka

When going with the building construction, there are some building technologies which normally used in the construction industry to achieve better quality and effectivity of the construction. IBS also can take as highly recommended building technology which used in the industry. To going with those technologies level of awareness is much needed. Consider about IBS technology, many research studies pointed out lack of awareness and application as one of major influence. Although the awareness and knowledge about the application of technology is very important for the success of IBS technology. But the assessment and studies that have examined the level of awareness and application among the construction specialists mainly construction contractors are very low. Although this technology is currently being used in Sri Lanka, the number of studies done in this regard is very minimal. Considering the last 10,15 years the studies done in Sri Lanka regarding the knowledge level of contractors about

IBS technology is very fewer. Therefore, the knowledge of IBS technology among the construction practitioners is at a minimum level.

3 RESEARCH METHODOLOGY

A combination of literature review and questionnaire survey instrument was employed in this study. The research design was chosen to examine the research objectives by eliciting their expertise as experts (Rajakaruna, De silva and Bandara ,2008). Deductive approach under quantitative phenomenon was used in this study to gather data on critical driving factors influencing awareness and application of IBS technology among the building contractors in Sri Lanka.

Quantitative research focuses on analysing and quantifying data to summarize the results (Apuke, 2017). In this research theory testing was happened. Here mainly identified certain factors and assessed criticality of driving factors influencing awareness and application of IBS technology. The factors were recognized through literature review in order to assess level of awareness and application of IBS. Since this research intended to assess the criticality of driving factors influencing awareness and application of IBS technology, had intended quantitative outcome and not done any in-depth investigation, quantitative approach was selected.

This research focusing on assessing and identifying the critical driving factors influencing awareness and application of IBS technology among the building contractors in Sri Lanka.

So as the research strategy Survey strategy was adopted. The study conducted by OGOLO in 2019 cited (Yomere, 1999: 159) mentioned survey is "the systematic study of a small or large population in order to understand and be able to predict some characteristics or behavior of the population"

3.1 Method of Data Collection

Reviewing the concept of ‘industrialised building system (IBS) and its different applications in building construction and identifying the factors influencing application of industrialised building system technology in building construction were identified under first two objectives through literature reviews.

To establish third objective, data was gathered through survey study. To collect the primary data in response to the research questions, questionnaire survey was used as a data collection technique for determining the respondents' perception on criticality of driving factors which influencing to the level of awareness and application of the IBS among the building contractors in Sri Lankan construction industry. Questionnaire was conducted among 50 randomly selected professional and experienced practitioners from the building contracting organisations such as Architects, Quantity Surveyors and Engineers to assess criticality of driving factors influencing awareness and application of IBS technology in Sri Lanka (refer Table 1). All participants were selected from grade CS2-C4, private companies, government and semi-government organisations. Random convenience sampling method was used. The questionnaire was considered the nature of the data required for this study. Quantifiable data was found to highlight the criticality of driving factors which influencing for the level of awareness and application of IBS technology.

Table 1. Profile of Respondents

Criteria	No. of participants	Percentage (%)
Designation		
Quantity surveyor	15	45.5
Architect	4	15.1
Engineer	13	39.4
Highest academic qualification		
Diploma	-	-
Higher National Diploma	2	6.1
Bachelor’s Degree	28	84.8
Master’s Degree	3	9.1
Doctoral Degree	-	-
Years of experience		
0 – 5	23	69.7
5 – 10	7	21.2

10 – 20	1	3.0
More than 20 years	2	6.1
Grade / type of organisation		
CS2	7	21.2
CS1	1	3.0
C1	6	18.2
C2	1	3.0
C3	1	3.0
C4	2	6.1
Private companies	6	18.2
Government organisations	6	18.2
Semi-government organisations	3	9.1

13 key factors which affecting the level of awareness and application of IBS were identified through literature review. Those key factors were given to the participants through the questionnaire to categories as very low, low, normal, high and very high.

3.2 Method of Data Analysis

The collected data was analyzed by using statistical analysis in tools in weighted mean average and RII method. Microsoft Excel spreadsheet was used as a data analysis tool.

13 factors were examined, and their mean values and RII values were ranked from highest to lowest. According to Algumaei and Sarpin (2022) state that the study analysis's mean was calculated using the provided formula and ordered from highest to lowest.

$$\text{Mean} = \frac{\sum_{i=1}^{5} \text{Weight of ranked position}(1) \text{ x Frequency of respons (i)}}{\sum_{i=1}^{5} \text{Frequency of respons(i)}} \quad (1)$$

RII = ∑W / (A*N)
W = Weighting given to each factor by the respondents
A = Highest Weight
N = Total number of respondents

4 DATA ANALYSIS AND FINDINGS

4.1 Current Awareness and Application of IBS in Construction Industry in Sri Lanka

According to the responses provided by the participants it clearly shows most of the contractors generally know about the IBS technology. It says 60.6% participants aware about this technology. But 39.4% of the participants have not any idea (Figure 1) Here the most of them acquired knowledge through the internet. The people who gained knowledge through working experience are very few. In addition, there is a small number of people who have gained knowledge through the awareness programs (Figure 2) Although many people have knowledge about IBS technology, the percentage involved in related projects is very low (Figure 3).

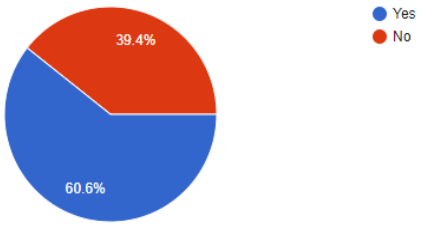

Figure 1. General awareness about IBS technology

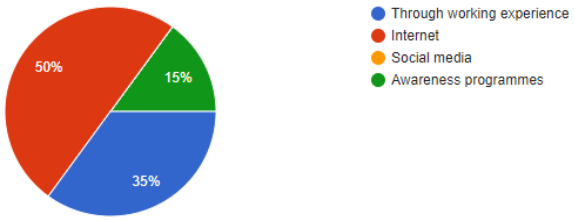

Figure 2. Sources of knowledge about IBS technology

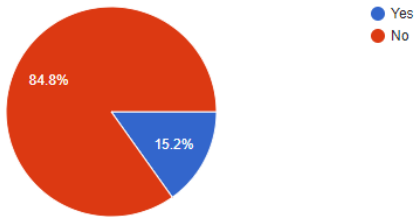

Figure 3. Involvement in IBS construction project

IBS technology is currently being used in Sri Lanka under the name of prefabrication. Through the questionnaire survey, it gives better understanding of the projects that the participants have been involved in so far. Accordingly Middle-income people housing project, Aitken Spence Printing Factory-steel prefabricated project, Kurunegala water supply project, Residence with prefabricated concrete walls and Temporary Industrial Building at Horana can take as examples for applications of IBS.

4.2 Driving Factors Influencing Awareness and Application of IBS Technology in Construction in Sri Lanka

According to the responses, driving factors which influencing awareness and application of IBS technology in Sri Lanka was ranked according to their mean and RII values (refer Table 2)

Table 2. Calculated Mean Scores, RII Values and Ranking of Driving Factors Which Affect to the Awareness and Application of IBS Technology

Driving Factors	Mean score	RII	Rank
Cost of construction	3.333	0.667	1
Availability of technology	2.848	0.570	2
Level of cooperation and communication	2.758	0.552	3
Knowledge and experience	2.758	0.552	3
Availability of special equipment	2.727	0.545	5
Involvement of skilled workers	2.697	0.539	6
Government policies	2.667	0.533	7
Integration of resources and utilization of software	2.667	0.533	7
Knowledge level of codes and standard of application	2.606	0.521	9
Familiarity of technology	2.545	0.509	10
Availability of research and educational courses on IBS	2.485	0.497	11
Level of awareness	2.424	0.485	12
Small contractors' involvement	2.152	0.430	13

According to data analysis, cost of construction was identified as the most critical driving factor (WMA=3.333) (RII=0.667) which affect to the awareness and application of IBS technology. Then availability of technology (WMA=2.848) (RII=0.570) as the second and both knowledge and experience and level of cooperation and communication (WMA=2.758) (RII=0.552) as third highest factors can be pointed out which influence for the IBS technology. Accordingly, availability of special equipment (WMA=2.727) (RII=0.545), involvement of skilled workers (WMA=2.697) (RII=0.539), both integration of resources and utilization of software and government policies (WMA=2.667) (RII=0.533), knowledge level of cords and standard of application (WMA=2.606) (RII=0.521), familiarity with technology (WMA=2.545) (RII=0.509), availability of research and educational courses on IBS (WMA=2.485) (RII=0.497) and level of awareness (WMA=2.424) (RII=0.485) were ranked from higher to lower according to their mean and RII value. As a least critical factor (WMA=2.152) (RII=0.430), small contractors' involvement was identified through the survey study.

When compared with previous studies, it was revealed that the final results obtained from the survey study were completely different. Accordingly, it can be pointed out that the cost of the construction, rather than the lack of awareness, mostly affects the awareness and application of IBS construction in the Sri Lankan construction industry.

In addition to the driving factors which recognized through literature review, the participants of the survey had indicated that the "attitude of the people" also affect to the IBS construction as another factor.

5 CONCLUSIONS AND RECOMMENDATIONS

This paper investigates about the criticality of driving factors which influencing awareness and application of IBS technology among the building contractors in Sri Lanka. Through the literature review 13 common critical factors which influence on awareness and application of IBS were identified. The influence of those factors in the Sri Lankan construction industry was assessed through this study. As results this article reviled cost of the construction as the most critical factor affecting the use of IBS technology in Sri Lanka. Then availability of technology was identified as the second most critical factor and both level of cooperation and communication and knowledge and experience thirdly identified. According to the study, it was concluded that the small contractor involvement has the least impact on IBS technology in Sri Lanka. In addition to that the study was pointed out that between the most critical factor and least critical factor, knowledge and experience, availability of special equipment, involvement of skilled workers, government policies, integration of resources and utilization of software, knowledge level of codes and standard of application, familiarity of technology and availability of research and educational courses on IBS have influence on IBS technology. Then the study recommends that the strategies should be introduced to further improve the use of this technology in Sri Lanka and introduce different methods to reduce the initial cost of the construction.

6 ACKNOWLEDGEMENT

The authors wish to express the gratitude to all the professionals who contributed as respondents during data collection to success of this research. Authors also thanked to Department of Quantity Surveying, Sri Lanka Institute of Information Technology, for the assistance provided. Because this project would not have been possible without them.

REFERENCES

Algumaei, M. S., & Sarpin, N. (2022). Critical success factors of industrialized building system (IBS) implementation for construction industry in Yemen. Research in Management of Technology and Business, 3(1), 522-536.

Ali, M. M., Abas, N. H., Affandi, H. M., & Abas, N. A. (2018). Factors impeding the industrialized building system (IBS) implementation of building construction in Malaysia. International Journal of Engineering and Technology (UAE), 7(4), 2209-2212.

AlSanad, S. (2015). Awareness, drivers, actions, and barriers of sustainable construction in Kuwait. Procedia engineering, 118, 969-983.

Apuke, O. D. (2017). Quantitative Research Methods: A Synopsis Approach. Kuwait Chapter of Arabian Journal of Business and Management Review, 6 (11), 40–47.

De Silva, N., Rajakaruna, R. W. D. W. C. A. B., & Bandara, K. A. T. N. (2008). Challenges faced by the construction industry in Sri Lanka: perspective of clients and contractors. Building Resilience, 158.

Industrialized, O.F. and System, B., (2016) Jurnal Teknologi L Egislative Challenge to Sustainable Application. 5, Pp.45–55.

Ismail, S., Hon, C. K., Crowther, P., Skitmore, M., & Lamari, F. (2022). The drivers and challenges of adopting the Malaysia industrialised building system for sustainable infrastructure development. Construction Innovation, (ahead-of-print).

Jaffar, Y., & Lee, C. K. (2020). Factors Influencing Industrialized Building System (IBS) Project Performance: A Systematic Review. Journal of Governance and Integrity, 3(2).

Kamar, K. M., Alshawi, M., & Hamid, Z. (2009, January). Barriers to industrialized building system (IBS): The case of Malaysia. In Proceedings of the BuHu 9th international postgraduate research conference (IPGRC), Salford, UK (Vol. 30).

Mohamad, M. I., Zawawi, M., & Nekooie, M. N. M. (2009). Implementing industrialised building system (IBS) in Malaysia: Acceptance and awareness level, problems and strategies. Malaysian Journal of Civil Engineering, 21(2).

Nduka, D. O., Fagbenle, O. I., Ogunde, A., & Afolabi, A. (2019, November). Critical success factors (CSFs) influencing the implementation of industrialized building Systems (IBS) in Nigeria. In IOP Conference Series: Materials Science and Engineering (Vol. 640, No. 1, p. 012012). IOP Publishing.

Qi, B., Razkenari, M., Costin, A., Kibert, C., & Fu, M. (2021). A systematic review of emerging technologies in industrialized construction. Journal of building engineering, 39, 102265.

Rahim, A. A., & Qureshi, S. L. (2018). A review of IBS implementation in Malaysia and Singapore. Planning Malaysia, 16.

Rahman, A. B. A., & Omar, W. (2006, September). Issues and challenges in the implementation of industrialised building systems in Malaysia. In Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006) (pp. 5-6).

Saad, S., Alaloul, W. S., Ammad, S., Altaf, M., & Qureshi, A. H. (2022). Identification of critical success factors for the adoption of Industrialized Building System (IBS) in Malaysian construction industry. Ain Shams Engineering Journal, 13(2), 101547.

Samad, R. A., Usman, I. M. S., & Raman, S. N. A (2020) review on construction of additional building school using Industrialized Building System (IBS) in Sarawak, Malaysia.

Thanoon, W. A., Peng, L. W., Kadir, M. R. A., Jaafar, M. S., & Salit, M. S. (2003, September). The Experiences of Malaysia and other countries in industrialised building system. In Proceeding of International Conference on Industrialised Building Systems (Vol. 10, pp. 255-261).

Thomas Tarang, V. A., Mohammad, M. F., Nizam Akbar, A. R., & Mohamed, M. R. (2022). Pertinent internal and external issues in industrialised building system (IBS) construction business in Malaysia. Built Environment Journal, 19(1), 32-41.

Zakari, I., Awal, A. A., Zakaria, R., Abdullah, A. H., & Hossain, M. Z. (2017). application of industrialized building system: A case study in Kano State, Nigeria. GEOMATE Journal, 13(39), 80-86.