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KNOWLEDGE STRATEGIES ON THE IMPLEMENTATION OF MODULAR BUILDING SYSTEM (MBS) FOR CONSTRUCTION PROJECT

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ABSTRACT

The Malaysian construction sector is underway a shift from an industry using conventional methods to a more standardized and mechanized system utilizing the latest modern technology, the Industrialized Building System (IBS). Plus, with the aid of a Modular Building System (MBS) under the classification of IBS, the urbanization process of Malaysia could be boosted by a fair amount. Therefore, the objective of this paper is to suggest knowledge strategies for the implementation of MBS for construction players. For this study, the quantitative approach was employed to collect data from respondents who were construction industry professionals with experience working on industrialised or modular building system projects. The questionnaire survey was used to gather feedback on respondents' perceptions of the effects of the industrialised and modular building system projects.The data gathered from the questionnaire will be analysed statistically using the average index and methods. The study's findings indicate that the respondents concur that there are some major obstacles, such as a shortage of experienced labourers and a high initial capital cost, that are preventing them from establishing this new, innovative way as the standard. To normalise this new type of MBS, knowledge techniques for its application for construction players are essential. The study's importance lies in its ability to assist construction industry participants in honing their MBS abilities.

Keywords: *Knowledge strategies, Modular Building System, Construction, Modern technology, IBS construction.*

INTRODUCTION

The worldwide construction sector has changed, particularly in terms of game-changing technologies (Ahmadi-Karvigh et al., 2019). Instead of using traditional building methods, the construction industry has found that the modular construction system is one of the most effective solutions to address the issue of sustainable design (Teh & Zainal, 2021). This is because, in comparison to the conventional building approach, it offers shorter construction times, a secure environment, and superior quality control (Argyrou G., 2018). Prefabrication construction is a relatively recent method of building in which the building materials are produced at a factory and then brought to the project site for installation. Adoption of alternative construction methods knowns as modular construction had different terms according to the country for instance, modular integrated construction (MiC) in Hong Kong, permanent modular construction (PMC) in the United States, and prefabricated prefinished volumetric building (PPVC) in Singapore. A step up from the previous industrialised Building System version, the Modular Innovative Industrialized Building System (MIBS) is a contemporary method of construction that emphasises innovation and a "green" component (IBS).

Modular Building System (MBS) is one of the technologies categorized as an old technology in developed countries, but it is considered a new technology in developing countries like Asian regions including Malaysia. The first known use of modular building dates back to the 1830s, when a London carpenter by the name of John Manning built a prefabricated house for his son. Before being erected in Australia, this house was built in pieces and sent there from England. The "Crystal Palace" for Britain's Great Exhibition of 1851 was built using this famous construction technique, which also gained favour during World War Two and while homes were being quickly rebuilt after the war. It was also popular during the American 1840s California Gold Rush. The Modular Building Institute was established as a result of modular construction's growing popularity in the United States.

On the other hand, Malaysia pioneered the usage of modular building in the 1940s. Modular construction has evolved and endured significant modifications since that time. Modular construction is a cutting-edge approach to building construction that draws on the concept of mass-producing industrialized systems (Musa et al., 2018). The building phase is exceptional because to the MBS utilization, novel materials, strict quality control in the factory, and sophisticated technology. Mohamad Kamar et al., (2009) had defined IBS as the mass manufacture of (on or off-site) building components in accordance with specifications and standards before being transported and put together at construction sites. Simply said, MBS is the idea of mass-producing high-quality buildings in a factory and then transporting them to the construction site. It has its advantages that the traditional system lacks such as faster and safer manufacturing, increased quality control, and lower environmental impacts,

resulting in material efficiency, reduced onsite waste up to 90%, and improved working conditions (Thai et al., 2020). In hoping that it will provide a solution to the affordable housing crisis by means of providing housing supply quickly with affordable price. Airports, ports, roadways, and rail transportation were among the infrastructure projects included in the Eleven Malaysia Plan (Economic Planning Unit, 2015). As a remedy, the MBS encourages adaptability and interchangeability to meet shifting requirements for built infrastructure reconstruction. The use of MBS in infrastructure projects and its potential to enhance infrastructure redevelopment must thus be further investigated by the construction sector.

MBS implementation, nevertheless, has challenges in Malaysia's building sector. Among these include a lack of expertise and skills, significant capital expenses, and transportation problems. According to Nawi et al., (2014), The procedure and elements of MBS are unknown to and poorly understood by the client and contractors. The MBS process and components must thus be understood by both the contractor and the client. In Malaysia, MBS is not extensively used which contributes its lack of use of the advantages and are also accompanied by restrictions and obstacles. The most frequent issues with IBS systems are faulty component assembly, which typically involves the beam-to-column and column–to–base connections (Ahmad, B. A. R., & Wahid, 2006). This is because of the need for a high precision of connections method among the construction. In addition, there is still not much expertise in this kind of building system. For example, consultant firms and contractors are still not familiar with this type of building system in Malaysian construction industry. Other than that, the difficulties identified from applying MBS are mostly monetary in nature. Financial and legal concerns proved to be crucial difficulties for the principal contractors and the customer (Mohammad et al., 2014). Many of them think MBS concept is considerably less expensive than conventional construction. The results of Haron's (2005) case study, however, demonstrated the opposite. Capital usually has a high initial cost. This now includes all expenses associated with constructing factories, casting beds, and purchasing support machinery, all of which are often rather affordable. In certain MBS there is also a considerable need for export labor. Consequently, additional expenses are incurred for the training of unskilled or semi-qualified workers.

While uptake in Malaysia is slowly growing, MBS has seen widespread adoption in other parts of the world. Rapid urbanization in Malaysia is leading this to becoming an increasingly important, and affordable, solution throughout the Asia Pacific region too.

Other than that, the implementation of an Industrialized Building System (IBS) construction faces challenges related to inadequate skills and knowledge, according to Mohamad Kamar et al., (2009), He claimed that because of this lack of knowledge and awareness, local authorities frequently misinterpret the current building guidelines for the IBS, which causes further delays in approval. The adoption of the IBS system was further hampered by civil engineers' and construction professionals'

lack of expertise in structural analysis and design of prefabricated components. According to IBS Workshop (2011), a lot of local authorities are not completely familiar with the modular coordinating and standardization idea linked to IBS design and assembling operations.

Moreover the most frequent issues in Industrialized Building System (IBS) construction were faulty component assembly, which often involves the beam-to-column and column-to-base connections. These issues occur because the building parties undervalue how crucial accuracy is when determining the alignment and levelling of the bases. One of the difficulties with this building approach is the difficulty in transporting and organizing IBS construction. This is in line with the claim made by Enshassi et al., (2019), that the obstacles have been the size and weight constraints, route restrictions, permitting, and the availability of lifting equipment. Additionally, when the components arrive at the building site, extra lift planning is necessary. Furthermore, as IBS use grows, the intricacy of lifting often rises as well. Therefore, the construction plans, the site's development, the cost of the crane, and the accessibility of the plan itself will be impacted by transportation concerns. Thus, the objective of this paper is to suggest the strategies of knowledge in understanding modular building systems implementation for construction projects.

Issues Highlighted In Modular Building System

The Modular Building System (MBS) has been suggested as a new innovative method in the Industrialized Building Systems (IBS) classification. It was anticipated that this would help the building sector achieve greater productivity and quality goals. Thus, it appeared to accomplish and satisfy the housing industry's sustainability concerns. This prefabricated building technology served as an alternative to the conventional, labor- and time-intensive approaches. Developed countries have accomplished great implementation in this area since its inception. In Malaysia, wealth and strong demand have led to a high level of demand in the building industry. Master Builders Association Malaysia (MBAM) president Tan Sri Sufri Mhd Zin notes that the industry’s response to modular construction systems has been pretty much neutral before and during the pandemic (Racheal Lee, 2022). However, there have been many challenges in implementing the modular building system.

For example, problems with leakage and sealant are now common problems and are to blame for the negative reputation of the industrialized building method. According to (CIDB, 2016) Malaysia has 32 million people and its population is expected to grow by 2 million people every five years. This growing number has led to more construction activities that could be improved by the Modular Building System. Prefabrication has generally replaced conventional building processes in developed countries' construction industry.

Most of the IBS design process, through the notion of design for preassembly and pre-fabrication, is focused on offsite manufacturing. Numerous prior studies have found that one of Modular IBS's flaws is its laborious connections and jointing methods, which can lead to mistakes and sloppy work (Mohammad et al., 2016). Hence, experienced and expert construction players is needed in order to carry out the industrialized Building System Modular System (IBSMS) construction works. However, to enhance and modernize the Malaysian construction industry, the Malaysian government introduced the IBS Roadmap and Construction Industry Master Plan (CIMP) 2006-2015, which emphasizes the use of green, recycled, recyclable materials in the Malaysian construction sector in order to achieve sustainability. The significance of this study is to promote the construction players and consumers and at a time boost the knowledge and familiarity of modular building system. It also encourages sustainability in infrastructure building since, before this alternative construction method is widely adopted, its potential to increase sustainability must be better understood.

Overview of Modular Building System implementation

Definition of Modular Building System

Table 3.1 illustrate the definition of MBS from 3 different country, Malaysia, United states and United Kingdom. Some developed nations define the Modular Construction System (MCS) as an Offsite Fabrication (OF) or Modern Method of Construction (MMC) (OSF). The term "modular construction" refers to a method of building that involves mass-producing modular units or modules off-site in a manufacturing facility. Planning and integration are used to properly coordinate the logistical and assembly aspects of it (Musa et al., 2014). The phrase "modular construction" refers to prefabricated, room-sized volumetric pieces that are installed as load-bearing "building blocks" on-site and are typically fully outfitted in the factory (Lawson et al., 2012). According to Setiani, (2009), The modular building system (MBS) is a construction process in which the building's structural components are made in a factory off-site, transported, and put together with little additional effort on the job site.

However, Malaysia's construction industry has not often used the modular building approach. Mohammad et al., (2016) agree that modular construction is a building procedure that involves creating building modules or components with the same design and standard in a manufacturing facility, then having them shipped and assembled to create a building. An MCS that has been utilized for public projects in Malaysia is reportedly managed by top-tier Malaysian developers. In addition, Musa

et al., (2018) also said that The term "modular construction" refers to a method of building that involves mass-producing modular units or modules off-site in a manufacturing facility.

Table 1: Definitions of Modular Building System

COUNTRIES	DEFINITION OF MODULAR	AUTHOR
Malaysia	Standalone components or combined (fully constructed 3D modules), by joining on-site to create a modular structure made up of numerous linked and stacked modules with the proper cladding features. Based on module construction, volumetric modules may be stacked several stories high and require additional structural elements, etc.	Rohana Mahbub (2015)
United States	Modular building operations, which generate buildings in modules off-site, use materials identical to those used in conventional construction and are constructed to the same codes and standards, but they complete their work in about half the time. When assembled on location, building modules resemble traditional built facilities.	Modular Building Institute (2013)
UNITED KINGDOM	Prefabricated room-size volumetric units (load bearing; building blocks) that are fully outfitted in a manufacturing plant will be installed there.	Lawson (2010), Goodier and Gib (2004)

In addition, it has been established that a 3D module that is produced, manufactured, and assembled in a factory qualifies as an MCS. As for the MCS module's construction, it requires a variety of equipment and tools, and the MCS has good construction quality (Aziz et al., 2019). This is supported by (Ahmad, B. A. R., & Wahid, 2006) and (Jabar & Ismail, 2018) that described Modular building system is an assembly of pre-fabricated parts used in construction. Machines, formworks, and other mechanical equipment are used to produce the components in a methodical manner. The parts are made off-site and delivered to construction sites for assembly and erection after they are finished. Based on the table above, the concept of modular construction, which involves the use of standalone components or pre-constructed 3D modules that can be combined on-site to create a modular structure. These modules are linked and stacked together, with appropriate cladding features, to form a complete building.

Overview of Modular Building System

Given its economic importance and contribution to the nation's Gross Domestic Product, the construction sector is crucial for every country's development (GDP). interms of politics, environment, and society. Through its multiplier effects, the construction sector significantly supports other industries (Mohamad Kamar et al.,

2009). Malaysia's construction industry is currently out of step with the country's projected future growth (CIDB,2016). The construction industry in Malaysia has been afflicted by a number of challenges, thus the government of Malaysia devised the IBS Roadmap and the Construction Sector Master Plan (CIMP) 2006-2015 in order to enhance and modernise the Malaysian construction industry

This makes way for another option which is IBS Modular to solve the problems in the construction industry.According to a government plan (8th Malaysia Plan, 2001–2005), 600,000–800,000 housing units were expected to be constructed. The high demand for housing in Malaysia as well as the rise of IBS has an impact on this. The demand could not be addressed by the conventional construction process (Abdul Kadir et al., 2005). Al Aghbari (2004) estimated that 709,400 of the homes required to be built between 2005 and 2010. The demand for residential buildings in Malaysia increased to 8,850,554 units between 1995 and 2020, including 4,964,560 new dwelling units (Aziz & Abdullah, 2015).

The use of IBS in Malaysia has two primary goals: first, to lessen the country's reliance on imported labour; and second, to stem the flow of lost foreign currency (Mohamad Kamar et al., 2009). The actors in the construction industry now have the potential to present a new image of the industry as being on par with manufacturing-based industries thanks to the International Building Show (IBS). Additionally, the implementation of IBS holds the prospect of elevating the entire construction business to a new level and image of professionalism (CIDB, 2007). Not only will the application of sustainable modular IBS in the Malaysian construction industry result in a better and more improved building, but it will also lead to an improvement in the quality of life of the people who occupy the building.

The introduction of Industrialized House Technologies (IHT) in Malaysia in October 2013 as part of the PR1MA initiatives by the Prime Minister of Malaysia shares the same vision and will pave the way for the adoption of Modular Integrated Building Systems (IBS) in Malaysia and to produce more houses in future in limited time (Nawi et al., 2014). Malaysia housing department focused on various segments of society and on boosting socioeconomical status, built environment, safety and comfortable (10th Malaysian Plan). PR1MA housing was an example of affordable home that is supposed to use the modular construction in Malaysia as planned by the government. There are some critical issues on IBS construction in Malaysia which mostly IBS project use the traditional approach in construction (Nawi et al., 2014). This prefabricated system has improved as Malaysia's GDP grew by 10.1% in the first quarter of 2010. The two main industries that saw growth were manufacturing and construction, which grew by 16.9% and 8.7%, respectively (MITI, 2010). In 2003, 2005, and 2008, the CIDB conducted three IBS surveys with respondents who were contractors and architects (Majid et al., 2010). The survey captured recent changes in IBS component usage, and it revealed an increase in the number of respondents who gave positive responses for utilizing IBS, which was demonstrated by the success of IBS usage in Malaysian building construction.

Knowledge Strategies on the Implementation of Modular Building System for Construction Project.

Knowledge is the main key component before initiating any type of building system construction. Therefore, increasing the knowledge of construction players on Modular Building System is quite vital for it to be successful. According to M. H. Zack, (1999), New knowledge is merged with existing knowledge to develop unique insights and build even more valuable knowledge. Organizations should therefore pursue areas of learning and experimentation that can potentially add value to their existing knowledge via synergistic combination. In addition, Innovative knowledge is that knowledge that enables a firm to lead its industry and competitors and to significantly make the innovative viable.

Next is, emphasizing the new syllabus on Modular Building System among construction players and students. For example, new syllabus or content needs to be introduced in our educational system, especially in higher education to familiarize the students on the new innovative method. According to Tomé & Gromova (2021), the syllabus, programs, teaching techniques, and evaluation must alter. It has to be altered correspond to the government Roadmap for IBS 2020 and further. This automatically brings up the up roaring about cost benefits from implementing Modular Building System.

Students should be brought to visit ongoing project sites, especially on site that implements Modular Building System, for them to witness and learn about this method. However, before each site visit, the location was examined, and the responsible parties (guides) were informed of the students' present knowledge, any misconceptions they may have, and the objectives of the visit. This gave the tour guides time to prepare the topics they wanted to cover during the visit and made them feel more at ease speaking with post-secondary students (Muscat & Pace, 2013). Furthermore, Government intervention helps by removing budget limitations with Government providing subsidies to those who implement Modular Building System. Plus, such government intervention promotes the commercialization of scientific information (Mazzucato, 2013). Government involvement can also influence the motivations and capabilities needed for entrepreneurs to capitalise on the state of the art in scientific knowledge (Muscat & Pace, 2013). The government can actively support the development and commercialization of scientific knowledge with a long-term strategic aim and commitment, which is why the role of the government in scientific knowledge is crucial (Lee & Yoon, 2015).

RESEARCH METHODOLOGY

For this research, it used the quantitative method to get the valid and reliable result from the respondents which are the construction players who involved and

experienced in the Modular or Industrialised Building System projects. The questionnaire survey was adopted in order to get reviews on the opinions of respondents on the impact of the Modular and Industrialised Building System Projects. The sampling strategy employed for this study is a particular kind of purposive sampling strategy. Purposive sampling is a method used in research to carefully select participants or cases based on specific criteria and gain valuable insights for the specific group being studied. Instead of randomly choosing people, researchers deliberately choose individuals who can provide valuable information or represent certain characteristics related to their study. This approach helps researchers gather targeted and relevant data for their research questions.

The research is focusing on the adoption of Modular Building System projects in Malaysia. The scope of respondent targeted for this research are the contractors who are involved and experienced in Modular Building System projects and/or IBS projects. However, as of now, there are a total of 549 IBS contractor from G5 to G7 who had registered with CIDB. Among the total, the highest amount of IBS contractor registered with CIDB is in Central zone which includes Selangor and Kuala Lumpur as shown in Figure 3.2 above. With this, the location of this study will be among these two regions in Malaysia. Population size for contractor obtain from CIDB Malaysia on registration contractor G5 to G7. The population size is 594 contractors. The sample size was calculated using a Raosoft sample size calculator with a margin error 5%, confidence level of 90% and a 50% response distribution. As a result, the total number of respondents in that selected for this study is 147 respondents. The data gathered from the questionnaire will be analysed statistically using the average index and methods.

Reliability Statistics

Cronbach's Alpha	N of Items
.923	22

Figure 1: questionnaires Cronbach Alpha

Based on the figure 1, shows that the questionnaires Cronbach Alpha has achieved 0.923 with 22 items. Thus, it reaches the acceptable level which is minimum 0.70 based on (Ghazizadeh et al., 2019).

Demographic analysis

In this section, the respondents are asked about their particular background. Table 2 shows the demographic analysis of the needs analysis questionnaire respondents.As reported in Table 4.1, the majority of the respondents (56.2 %, n=86) are male while 43.8 % (n=67) are female. This is because of the construction industry, especially in the contractor's part, usually there are more males than females.

However, on the consultant's part there might be more balanced in terms of gender. Since the modular building system is quite unfamiliar in Malaysia's construction industry, almost all of them are (52.3%, n=80) 20 – 29 years old and (40.5%, n=62) 30 – 59 years old. Only 5.2% (n=8) of the respondents are 60 years old and above, and (2.0%, n=3) age below 19 years old. In terms of the working sector, majority are Private sector with (72.5% n=111), followed by 27.5% (n=42). As for contractor's class, majority of the respondents are G7 IBS contractor (38.6%, n= 59) as the most distributed groups are contractors that are distributed through Facebook groups. Then it is followed by G6 IBS contractor (36.6%, n=56) and G5 contractor (18.3%, n=28). Lastly, most Modular Building System or IBS experience are 1-5 years (69.3%, n=106), followed by 6-15 years (28.8%,n=44) and lastly More than 15 years (2.0%,n=3).

Table 2: Demographic analysis of the respondents

		Frequencies	Percentage
Gender (1M, 2F)	Male	86	56.2 %
	Female	67	43.8 %
Age	Below 19 years old	3	2.0%
	20 – 29 years old	80	52.3%
	30 – 59 years old	62	40.5%
	60 years old and above	8	5.2%
Working Sector	Private Sector	111	72.5%
	Public Sector	42	27.5%
Contractor class	G7	56	36.6%
	G6	59	38.6%
	G5	28	18.3%
Modular Experience	1-5 years	106	69.3%
	6-15 years	44	28.8%
	More than 15 years	3	2.0%

FINDINGS OF THE QUESTIONNAIRE

Table 3 summarizes the results of a descriptive analysis used to analyse the strategies of knowledge for construction players in implementing modular building systems.

Table 3: Descriptive analysis on the strategies of knowledge for construction players in implementing modular building systems

	No	Mean	Std. Dev	Rank
Increasing the knowledge of Modular Building System among construction players	153	4.35	.632	1
Government providing subsidies to those who implement Modular Building Systems	153	4.35	.683	1
Students should be brought to visit ongoing project site, especially on site that implements Modular Building System for them to witness and learn this method	153	4.21	.713	2
Emphasizing the syllabus on Modular Building System among construction players and students	153	4.12	.691	3
Government intervention (campaign)	153	4.12	.789	3
Up roaring about cost benefits from implementing Modular Building System	153	4.06	.588	4
4.21	.459			

The results obtained from the analysis revealed that most of the respondents voted for Increasing the knowledge of Modular Building System among construction players and the Government providing subsidies to those who implement Modular

Building Systems with the distribution mean of 4.35.After that, the second rank is the strategies that Students should be brought to visit ongoing project site, especially on site that implements Modular Building System for them to witness and learn this method at the same time cultivate interest in themselves in this respective building system.

Meanwhile, there are two (2) elements ranked third which both share the same mean score of 4.12 which are emphasizing the syllabus on Modular Building System among construction players and Government intervention (campaign). Next, with the mean distribution of 4.06, up roaring cost benefits from implementing Modular Building System has been ranked forth. The majority of the respondents showed positive feedback on the question of this element and agreed that this is one of the main strategies of knowledge for construction players in implementing modular building systems. Lastly, most of the respondents has agreed that these are all the strategies that could be implemented for knowledge for construction players in implementing modular building systems as the total mean of this section D is 4.2 which is agree.

DISCUSSION

Based on the analysis of mean distribution, the most significant strategies of knowledge for construction players in implementing modular building systems for IBS projects are increasing the knowledge of Modular Building System among construction players along with Government subsidies with the mean of 4.35. This correlates with (Nawi et al., 2014) that stated the participants must have the necessary training, expertise, and knowledge for the field, such as at least five years of professional experience with a number of successfully completed local IBS projects. Second in rank is students should be brought to visit ongoing project sites, especially on site that implements Modular Building System for them to witness and learn this method. This corresponds with (Chua et al., 2018) that stated the company primarily uses past experience and site visits to successful projects to demonstrate accessibility, maintainability and feasibility of modular designs.

Next, emphasizing the syllabus on Modular Building System among construction players and students together with Government intervention ranked third with 4.12 mean. This correlates with (Ahmadi-Karvigh et al., 2019) that stated new syllabus on Modular Building System on students can boost the understanding for the construction industry. After that, the fourth rank are up roaring about cost benefits from implementing Modular Building System with 4.06 mean. This automatically gives free marketing for this type of building system.

CONCLUSION

Conclusively, this study reveals the positive views of the IBS construction players regarding the adoption of Modular Building System in IBS projects. Also, it highlighted the major challenges and barriers faced by IBS construction players which made them refuse to implement and not to comply with Modular Building System in their projects. Other than that, the impacts of the adoption of Modular Building System to IBS projects have been identified and discussed in detail. As a conclusion, this research has achieved the objectives had been set.

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