Review of Industrialized Buildings Experience in Malaysia: An Example of a Developing Country

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Abstract. Building industry is currently under pressing need to move towards a sustainable and productive practice. The demand in residential projects keeps on rising, especially in developing countries. The Industrialized Building System (IBS) is deemed to be more sustainable compared to the traditional construction that uses bricks and mortar. However, there is limited uptake for IBS, especially in the housing sector. The lack of incentives and small-scale projects among main factors impede the increase of implementing IBS in residential projects. Around 5 million housing units have been built in Malaysia by both private and public sector since the first IBS housing project is commenced in 1966. Yet, the gap between supply and demand is around 43% (shortage) with small share for IBS in the housing sector. This study Examined IBS projects growth in term of scale, type and classification development in Malaysian context. Then, analysed reasons, impacts and expected results when employing IBS in Malaysia. The findings illustrate the timeline of IBS establishment and development of IBS housing and building projects in Malaysia. This study tracked the development of IBS with greater focus on housing. Moreover, this study reviewed and analysed the way forward to uplift IBS implementation to a higher level. Finally, this study will guide future research and draw the line for other developing countries to follow the path and learn from such experience.

Keywords: Industrialized Building System (IBS), Housing, Modern Methods of Construction (MMC), Malaysia

1. Introduction

The image of the construction industry is reflected by the improvement in the building sector. Building projects play a vital role in countries economy, i.e. through improvement in the gross domestic product (GDP), socio-economic states and employment of the population [1]. The architecture, engineering, construction (AEC) sector is under pressing need to deliver projects faster while retaining the desired quality with minimal impact on the environment; especially for developing countries where more building and infrastructure is needed [2]. The rapid evolution of emerging technology has affected several sectors and industries. Yet, building sector is still suffering from low productivity compared with retail market or info and communication sector [3,4]. As a result, building projects in many developing counties still encounter challenges due to increasing urbanization and high population growth which all exacerbate the low supply of housing projects [5,6].
Globally, a number of scholars have documented a trend of steady increase in industrialized building domain [7]. Western countries have regained an interest in IBS driven by UK, Finland, Sweden among others [8,9]. The implementation of IBS may vary from one country to another. Some markets of developed countries such as the UK, Japan and Sweden continued to demonstrate a steady growth in the use of industrialized construction [8,9]. However, in some developed countries the use of such method of construction is yet to reach a large scale [10]. Nonetheless, Din et al. [11] argued there is a high possibility that IBS would outstrip traditional construction in the near future. The idea of using IBS e.g. precast concrete in Malaysia were mainly to meet the huge need for affordable housing in 1960s [8]. Unfortunately, the outcomes from first prefabrication were unfruitful [4]. Many researchers explained that the outcomes were unfruitful due to the blind adoption of foreign systems without consideration of the Malaysian climate and culture [1,26]. Nonetheless, the same systems in some developed countries had to go for redevelopment process either by renovating or demolishing and rebuilding [12]. With the increased research and development (R&D), IBS systems have been improved extensively.

The Malaysian population is increasing, which caused an increasing need for housing in Malaysia. Around 5 million housing units have been built by both the private and public sector since the first Malaysian plan (1965-1970) until the tenth Malaysian plan (2010-2015) [13,14]. However, the gap of supply-demand (shortage) in housing is 42.8% [13]. This has exaggerated the need for a prompt construction method such as IBS, yet the proportion of IBS in housing is still very limited. Previous research has indicated that the IBS system is still not successful to penetrate to the housing sector which necessitates more research in the housing sector [6,11].

This research aims to give an overview of the development of the industrialized housing construction in Malaysia in a historical development. Moreover, it observes the main elements that motivated the use of industrialized construction in Malaysia. Furthermore, this paper emphasizes on the main elements and factors that will maintain the extensive use of industrialized practices as the way forward for the construction industry. Lastly, the research concludes and gives recommendation from the lessons learned from previous practices of other developing countries.

2. IBS development in Malaysia

The first implementation of IBS, i.e. prefabrication has started long time ago, but the first extensive use of prefab techniques was after World War II in the 1950s and 1960s [15]. Unfortunately, the outcome of the first prefabrication and industrialized construction were unfruitful around the world [4,12]. A number of scholars referred to the poor implementation of prefabrication in Malaysia in the sixties due to imported systems and methods from Western countries without any consideration to the differences in culture and climate in Malaysia. This caused leakage problems, cracks and steel corrode among other issues [1,11,16]. Though this was true, the same systems in Western countries had to undergo a redevelopment process either by renovating or demolishing and rebuilding [12]. Then, in the late 1990s, the second generation of prefabricated components had another surge. It was promoted as a new approach and tailed by sustainability and green construction, focusing on sustainability, productivity and quality as reported in the 2nd IBS roadmap [17,18]. In 1999, the government of Malaysia promoted IBS through the IBS Strategic Plan. Four years later, the IBS Roadmap 2003-2010 was launched followed by the IBS Roadmap 2011-2015.

Subsequently, the Construction Industry Transformation Programme (CITP) 2016-2020 was set to boost productivity, i.e. the main feature of IBS [16]. These roadmaps consist of awareness agendas, training programs, incentives, scoring systems and quality control mechanisms of IBS development process. In 2008, IBS has become a goal for the Malaysian government, when it started to mandate its use of all public projects with a cost of more than RM 10 million, with no less than 70% of IBS system to be employed [11]. This decision has made IBS a strategic choice along with increasing numbers of developers and contractors using IBS gradually [4]. Table (1) gives an extensive summary of the first attempt to use IBS in 1966 to the recent development in IBS, though the emphasis was mainly on housing projects, then more recently the focus shifted on to public projects.
3. IBS classification development in Malaysia

Worldwide, many terms are used to describe the industrialized construction practice including offsite construction (OSC), off-site manufacturing (OSM), modular construction, manufactured buildings and prefabrication. Nonetheless, the definition and classification in Malaysia are wide-ranging including offsite construction and on-site industrialization (OSI) [5,28]. Therefore, IBS can be defined as any system that will provide faster construction and less work on site compared to current practice of using timber formwork, brick, and mortar. Chronologically, IBS classification has gone through a process of

Table 1. IBS historical development

| Dates       | Projects used IBS                          | Description of projects                                                                 | Source |
|-------------|-------------------------------------------|----------------------------------------------------------------------------------------|--------|
| 1966        | Precast Concrete Panels (IBS First Generation) | 3000 units of 17 stories low cost flats in 7 blocks and 40 shops in Kuala Lumpur (large panel system). | [19]   |
| 1966-1968   | Pekeliling flats (Dutch system, Netherland) | 3000 units of 17 stories low cost flats in 7 blocks and 40 shops in Kuala Lumpur (large panel system). | [11,20]|
| 1968        | Rifle Range flats (French System)          | 3699 units of 17 & 18 stories low cost flats in 6 & 3 blocks respectively, using French Estiot System in Penang (large panel system). | [11,20]|
| 1978        | Taman Tun Sardon (UK system)               | 1,200 units of 5 stories flats in Penang designed by British Research Establishment (BRE) (precast component system). | [20,21]|
| 1980        | Quarters at Lumut Naval Base (Japanese system) | 2800 units of houses built by the Ministry of Défense (MOD) used prefabricated panel system. | [11]   |
| 1984        | Dayabumi Complex (Japanese system)         | The 36-storey Dayabumi commercial complex by Takenaka Corporation of Japan (Steel structure). | [17,20]|
| 1981-1993   | PKNS Housing (German system)               | Around 52,000 units of both low cost and high cost housing projects in Selangor using Praton Haus system. | [15,22]|
| 1990-1998   | Commercial and Infrastructure projects      | Projects including: Petronas Twin Tower, Kuala Lumpur International Airport, Railway projects, etc. | [17]   |
| 1998 - upward | Government Strategic Change Toward IBS (Second Generation) | (Note: public projects consist on average 30% and 70% private projects) | [19]   |
| 1998-2008   | Private residential projects               | Private residential projects in Selangor, Putrajaya, Cyberjaya and Johor with focus on higher quality. | [15]   |
| 2003        | SPNB Housing                               | Plan to use IBS to construct 30% of 150,000 units by Syarikat Perumahan Negara Berhad (SPNB). | [22]   |
| 2005        | affordable houses                          | Under budget 2005 government planned to build 100,000 affordable houses using IBS. | [13,23]|
| 2006        | 10% usage of IBS                          | IBS usage is 10% from government projects compared to forecasting usage of 50 %. | [23]   |
| 2008 - up to date | Focus on Government Projects               | Projects including public school, higher learning institutions, hospitals and public offices with cost around RM 9.6 billion. | [24]   |
| 2008-2010   | 331 public projects used IBS               | Projects including public school, higher learning institutions, hospitals and public offices with cost around RM 9.6 billion. | [23]   |
| 2013 & 2016 | 15 & 24 % usage of IBS in public projects  | The CITP 2016-2020 reported only 24 percent of public projects achieved an IBS score of 70%. | [18,25]|
| 2019        | 81 % usage of IBS in big public projects   | IBS usage increased from 24 % in 2016 to 81 % as of 2019 in public projects. | [26,27]|

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development in Malaysia since the system was first practiced in the 60s, in which concrete panels were prevalent around the world at that period. The classification was first based on components size, then it was based on process and lastly the CIDB is classified based on the material and the process. According to Thanoon et al. [8] that Majzub (1977) IBS classification divided into frame, panel and box system either onsite or offsite [8]. After that, Badir et al. [29] categorized all building systems in their Badir-Razali (1998) classification starting with traditional construction which in-situ construction using timber formwork. Then the second is also cast in-situ but using reusable formwork. While the third system, which the classification gave it the name of prefabricated system, consisted of all frames produced off-site, including block work [29]. Then CIDB [21] gave a more detailed classification and separating block work system as it does not belong to prefabricated components such as precast, steel and timber systems. After that ‘innovative system’ has been added in CIDB [17] to cover any system or products that do not fit in any previous classification. Kamar et al. [5] suggested that the future classification of IBS need to be widened to include hybrid and modular constructions [5]. Although IBS development in Malaysia is still at the early stage of industrialization and automation, it is crucial to evolve the implementation process to a more complicated and developed system such as volumetric and modular construction [9]. All the previous classifications are summarized in table (2) below.

Table 2. IBS classification development

| In 60’s Majzub [8] | In 90’s Badir-Razali [29] | In 2003 CIDB [21] | In 2010 & Current CIDB [17] | Future Kamar et al. [5] |
|-------------------|--------------------------|-------------------|---------------------------|------------------------|
| a. Frame System   | a. Prefabricated system: Precast framing | a. Precast framing, Panel & box system | a. Precast systems | a. Frame System |
| b. Panel System   |                          |                   |                          | b. Panelised System    |
| a. Frame System   | a. Prefabricated system: Steel frame | b. Steel framing systems | b. Steel framing systems | a. Frame System |
| a. Frame System   | a. Prefabricated system: timber framing systems | c. Prefabricated timber framing systems | c. Prefabricated timber framing systems | a. Frame System |
| a. Frame System   | a. Prefabricated system: block system | d. Block work systems | d. Block work systems | a. Frame System |
| c. Composition system |                          |                   |                          | a. Frame System |
| b. Panel System   | a. Prefabricated system: Sandwich panel |                             | e. Innovative system: drywall, sandwich panel | b. Panelised System    |
| c. Panel & Box System (on-site) | b. Cast in situ formwork system |                             | f. Formworks systems | e. Onsite fabrication |
|                   |                          |                   |                          | f. Hybrid & Modular System |

4. Driving factors for IBS usage
Improving construction deliverables is getting more crucial than ever. An increasing number of issues has put more pressure on the construction industry to evolve from the wet and risky nature of conventional construction. Most IBS systems employ off-site construction techniques insuring time and cost certainty [9]. Additionally, semi-mechanized method, information and communication technology (ICT) and manufacturing working environment have contributed to a more proactive and productive construction towards achieving the ultimate goal of sustainability [6,30]. In recent years, IBS has gained tremendous increase in research and practice, which prove that emerging advanced technologies with IBS can further enhance construction performance [2,9]. Numerous researchers
have demonstrated the advantages of industrialized construction including, reducing the number of manual labour, minimizing construction duration, guaranteed quality and convenient workplace [7,10]. A lot of research within developed and developing countries likewise described the benefits of IBS including higher productivity, tighter duration, more efficient equipment utilization, and improved safety and quality. Additionally, IBS has addressed the environmental dimension through controlled manufacturing process resulting of waste reduction and provided better and safer working conditions [9,30,31]. Table (3) below explains the prompting reasons that motivated the construction industry for higher usage of IBS.

| Source | Issues why to use IBS | Impact for construction | Solution through IBS |
|--------|----------------------|------------------------|----------------------|
| [1]    | Acute shortage of local labour | Increase reliance on foreign labour | Local sustainable workforce |
| [31]   | Environmental issues | Increased overall waste | Reduce waste and pollution |
| [9]    | Tight schedule needed | Time overrun | Shorten duration |
| [4]    | Inability to increase productivity | Low productivity | Boost productivity |
| [10]   | Low quality outcomes | Unsatisfied quality | Ensured building quality |
| [6]    | Workers safety | Accidents | Safer working environment |

5. The way forward
The use of industrialized building and prefabrication can be encountered with many difficulties; therefore, this section explain the key elements that are needed to overcome these barriers and ensure successful implementation of IBS. A strategic orientation from the government will play a substantial role as well as high investment capacity from the private sector in such technology. Although policymakers in Malaysia has set targets and policies towards higher implementation of industrialized Building System (IBS), they were encountered with several issues that need to be analysed thoroughly. The following describes the factors that will drive IBS implementation to a higher level in Malaysia. These factors are government support and legislation, economies of scale and cooperation amongst supply chain firms.

5.1. Government support and legislation
Governments are major players and deciders on the destination of the construction industry, i.e. implementing several plans and roadmaps to control and guide the industry for a better and a more productive construction [17,25]. Nevertheless, such plans encounter many difficulties, unsatisfied incentives, disagreement among federal, state and local authorities, and poor coordination between authority and construction stakeholders [11]. In 2008, in a way to create a sustained demand for IBS, Malaysian government has mandated the use of IBS for all public projects under the Treasury Circular 7/2008 [32]. However, the government could not follow a strict regulation in implementing IBS, although a regulation to make IBS compulsory for all government projects, so the level of implementation has not achieved the quantity targeted, necessitating an agreement and coordination among different level of authorities and industry players as well [33]. Despite the massive initiatives of the government to push IBS utilization in building projects, polices for mandatory use are not strongly enforced [1]. As a result, IBS implementation still considered low. Additional proposal for compulsory use of IBS has been raised by CIDB, by which the federal government will make IBS adoption a mandatory for all big private projects with total budget of RM 50 million and above starting from 2018. Then it was postponed until 2020 [27]. Arguably, such plans will be implemented with the assistance of local authorities. However, there is a lack of regulatory procedures and fragmentation among federal, state and local authorities. Support from government in a form of supportive polices or tax exemption is crucial to boost IBS implementation, nonetheless, agreement
and cooperation among different levels of authorities is crucial [30]. According to Yunus and Yang [34] there are four areas of action regarding legislation that can be engaged to improve IBS implementation including strong legal mechanism, IBS officer, organizational reviews, and authority consensus.

5.2. Economies of scale
Several studies have reported that higher initial cost could be offset by time saving, labour saving, resource reductions, and above all economies of scale [9,10]. Economies of scale are measured when the cost per unit decline quicker than production costs rise as the number of components being produced increases [35]. In general, the company that can achieve economies of scale will reduces the average cost per unit [36]. It is believed that the construction cost will be reduced starting from the break-even of high production cost that can be gained using standardized production [9]. In order to achieve this in the private sector, the demand for IBS products should be high. Higher demand will encourage more suppliers, and eventually, the prices for the IBS components will be reduced due to the economies of scale [37]. Another major issue highlighted in the literature is the financial problem or cash flow, however, going with partnership with other companies will strengthen the company’s financial ability [2]. Manufacturers in the industry are highly concerned of economies of scale before embarking in the market to secure a constant demand of IBS components is able to reduce cost. Nonetheless, IBS manufacturers must trade off between standardized and flexible design to attain economies of scale and fulfill client needs [35].

5.3. Cooperation among supply chain firms
Implementing IBS could lead to a more integrated business operation or it may result in a fragmented implementation similar to the subcontracting approach used in traditional construction depending on the market structure and maturity of an industrialized construction [23]. A more integrated practice could overcome many obstacles, but that also depends on the capabilities and skills of the main contractors or developers initiating such strategy [4]. The co-located or more integrated IBS has been implemented in several developed countries including Sweden, Japan and US. This allows an integrated relationship and partnership by either limiting the independent number of businesses while promoting innovative thinking or through early involvement and continuous updating of design and assembly using open building process. Nevertheless, the former requires more capital investment and the latter needs close cooperation among parties [5]. If IBS is chosen for a specific project, it is crucial to understand the need for extensive communication and coordination from the early phase of construction process. For instance, coordination of design, transportation, tracking, and installation to ensure successful implementation [11]. Additional to that, adjustments in the work arrangement, standardized drawings, precast elements and other materials management and supply chain scheduling should also be taken into consideration [38].

6. Conclusion
IBS superiority over traditional construction is highly promoted by Malaysian authority. Yet the benefits on the ground are not totally seen or understood by building stakeholders, explaining the low adoption of IBS in the housing projects. However, this review has shown the necessity of using IBS to fill in the shortage of housing supply. Although in the last decade, the use of IBS has been increasing in Malaysia, IBS in housing did not evolve. The repetitive nature of housing makes it more applicable to use standardized construction methods. Supportive polices and measures from governments as well as research and case studies are required to demonstrate the important role of IBS in housing sector. Many developing counties suffer deficient housing supply that may not be cover through traditional construction. Based on availability, necessity and suitability, IBS systems need to be investigated in different context. Developing countries may follow Malaysian path by focusing on government projects to sustain demand, nonetheless, housing projects have higher potential to implement IBS.
systems. More research is needed to explore different products/systems of IBS in each developing country.

References

[1] Amin M A, Abas N H, Shahidan S, Rahmat M H, Suhaini N A, Nagapan S and Abdul Rahim R 2017 A review on the current issues and barriers of Industrialised Building System (IBS) adoption in Malaysia’s construction industry IOP Conference Series: Materials Science and Engineering vol 271 pp 1–8

[2] Akmam Syed Zakaria S, Gajendran T, Rose T and Brewer G 2018 Contextual, structural and behavioural factors influencing the adoption of industrialised building systems: a review Archit. Eng. Des. Manag. 14 3–26

[3] Mohd Fateh M A, Zakariah H and Ema Ezanee S 2020 Improvement for significant clauses in the standard form of contract for industrialized building system construction IOP Conference Series: Materials Science and Engineering vol 713 p 012037

[4] Hamid Z A, Hung F C and Rahim A H A 2017 Retrospective View and Future Initiatives in Industrialised Building Systems (IBS) and Modernisation, Mechanisation and Industrialisation (MMI) Modernisation, Mechanisation and Industrialisation of Concrete Structures pp 424–52

[5] Kamar K A M, Hamid Z A, Azman A and Ahamad M S S 2011 Industrialized Building System (IBS): revisiting issues of definition and classification Int. J. ... 1 120–32

[6] Oleiwi M Q, Mohamed M F, Che-Ani A I and Raman S N 2017 Sustainability of industrialised building system for housing in Malaysia Proceedings of the Institution of Civil Engineers: Engineering Sustainability vol 171 pp 304–13

[7] Hosseini M R, Martek I, Zavadskas E K, Aibinu A A, Arashpour M and Chileshe N 2018 Critical evaluation of off-site construction research: A Scientometric analysis Autom. Constr. 87 235–47

[8] Thanoon W, Peng L W, Kadir M R A, Jaafar M S and Salit M S 2003 the Essential Characteristics of Industrialised Building System International Conference on Industrialised Building Systems pp 10–1

[9] Wuni I Y and Shen G Q 2019 Critical success factors for modular integrated construction projects: a review Build. Res. Inf. 0 1–22

[10] Razkenari M, Fenner A, Shojaei A, Hakim H and Kibert C 2020 Perceptions of offsite construction in the United States: An investigation of current practices J. Build. Eng. 29 101–38

[11] Din M I, Bahri N, Dzulkifly M A, Norman M R, Kamar K A M and Abd Hamid Z 2012 The adoption of industrialised building system (IBS) construction in Malaysia: The history, policies, experiences and lesson learned 2012 Proceedings of the 29th International Symposium of Automation and Robotics in Construction, ISARC 2012 (Eindhoven, The Netherlands) vol 1 pp 26–9

[12] Hoppe T 2012 Adoption of innovative energy systems in social housing: Lessons from eight large-scale renovation projects in The Netherlands Energy Policy 51 791–801

[13] Ebekozien A, Abdul-Aziz A-R and Jaafar M 2019 Moderating effect of government support policy on the relationship between Malaysian LCH leakages, high construction cost and LCH demand-supply: a proposed framework Int. J. Constr. Manag. 0 1–12

[14] Shuid S 2016 The housing provision system in Malaysia Habitat Int. 54 210–23

[15] Azman M, S. Ahamad M and Hilmi N 2012 The perspective view of Malaysian industrialized building system (IBS) under IBS precast manufacturing 4th Int. Eng. Conf. 4 1–13

[16] CIDB 2016 Industrialised Building System: the path to enhanced productivity vol Heights 3 (Malaysia:CIDB)

[17] CIDB 2010 Roadmap for Industrialised Building System in Malaysia (IBS) 2011–2015 (Kuala Lumpur)

[18] Rashidi A and Ibrahim R 2017 Industrialized Construction Chronology: The Disputes and Success Factors for a Resilient Construction Industry in Malaysia Open Constr. Build. Technol.
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