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The Global Adoption of Industrialised Building System (IBS): Lessons Learned

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Abstract

Industrialised Building Systems (IBS) is typically used interchangeably with other terms such as prefabrication, offsite manufacturing, offsite construction, and modern method of construction (MMC), industrialised building and industrialised construction. Nevertheless, the term modern method of construction (MMC) has been used to collectively describe both offsite-based construction technologies and innovative onsite technologies in the United Kingdom. It is evident that there exist a wide range of contextual issues which stems from the definition of these terminologies. However, lack of previous research has explored the relationship between these terminologies. Therefore, this paper emphasises the contrasting concepts of IBS and MMC, and concludes that ill-defining the MMC-IBS terms leads to misunderstanding, uncertainty and prejudice of the IBS concept and its benefits besides the adoption of IBS in global, which will be detrimental to efforts promoting the use of IBS in the construction industry.

Keywords: Industrialisation; Modern method of construction (MMC); Industrialised building system (IBS); Global; construction industry.

1. Introduction

As a developing country, the construction industry is seen as contributing to the national economy activity included social development process and supported government revue and Gross Domestic Product (GDP). The growing economic process are required to reinforced to public infrastructure in many regular activities such as services, utilities, commerce and others industries. Previously in between 1997 to 2000, this industry sector has faced a challenging during the ASEAN economic crisis went the majority of the project plan in Malaysian unsatisfactory to achieve the target with only 20% (Abdullah and Egbu, 2009).

Toward to these challenges, under Construction Industry Transformation Program 2016-2020 (CITP), these initiative are taken to enhance the industry to become more productive, sustainable and globally competitive while rising the becoming toward the world-class industry. From this transformation programme, one of the key initiative have been introduced by adopt a new modern methods construction technologies to drive sustainability construction productivity through Industrialised Building System (IBS) (CIDB). This innovative approaches and technology IBS could be save a cost, time, labour, quality and durability (Ismail, 2001). The growing interest in IBS has been noted around the country, for instance there is a good practices and working progress in the UK construction industry (Gibb, 1999; Nadim and Goulding, 2009). The advantages from the implement of this system will support to improve construction process, decreasing cost, wastages and minimizing the effect of risk (Kamar *et al.*, 2009; Nawi *et al.*, 2007).

2. The Concept of Industrialised

Nowadays Industrialization construction become an important trend within construction industry (Čuš-Babič *et al.*, 2014). It contributes to achieve higher productivity levels and better quality of construction product with numerous improvements evolving in the industry (Kamar *et al.*, 2009; Nadim and Goulding, 2009). The advantages industrialised construction partially shifting from construction site to remote location site. Consequently industrialised have a potential for construction industry to become more effective in speed up construction time, cleanliness environment on construction site, proper coordination and management, save space material on construction site and enable reengineering (Čuš-Babič *et al.*, 2014; Nawi *et al.*, 2007).

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From the perspective of construction, industrialisation is part of a wider modernisation process through the development of modern methods of production and technology systems, mainly factory production, where work is centrally organised and production operations are mechanised and focused on mass production (Lessing *et al.*, 2005). Warszawski (1999) highlighted the fact that an industrialisation process is an investment in equipment, facilities and technology with the objective of maximising production output, minimising labour resources, and improving quality (Warszawski, 1999).

Industrialisation has demonstrated a high capacity to reduce the costs, improve the quality and make complex products available to the vast majority of people.

Industrialised construction is a generic process of standardisation and rationalisation of the work processes in the industry to reach cost efficiency, higher productivity and quality (Warszawski, 1999). A more elaborate definition for industrialised construction is a change of thinking and practices to improve the production of construction to produce a high-quality, custom-built environment, through an integrated process, optimising standardisation, organisation, cost, value, mechanisation and automation (Warszawski, 1999). The different term and definition are describe in table 1.

Definition of Industrialised Terms and Their Context

Term	Context
Industrialised Building System (IBS)	Term is coined in Malaysia and define as a construction system where all set of component are manufactured at factories on, or off-site, positioned and interconnected into structures with minimal site work [11]. It may include various procedures (technological and managerial) for the production and assembling of these elements for this purpose [12].
Modern Method of Construction (MMC)	Term adopted in the United Kingdom as a collective description for both offsite-based construction technologies and innovative onsite technologies. This may combining industrialised and non-industrialised innovation method including carpet reinforcement, metal shutters, core jump systems [13].
Prefabrication	Prefabrication as building, at factory, sub-assemblies or full modules which are quite similar to what is produced on a traditional construction site, often using the same processes and the same materials [14].
Offsite Construction (OSC), Offsite Manufacturing (OSM), Offsite Production (OSP)	Widely used in UK and Australia as a part of construction process which is carried out away from the building site, such as in a factory or sometimes in specially created temporary production facilities close to the construction site (or field factories) [15]. While the components are probably assembled onsite and offsite, preassembly literally means to "assemble before" and covers the manufacture and assembly (usually off-site) of buildings or parts of buildings earlier than they would traditionally be constructed onsite [16].

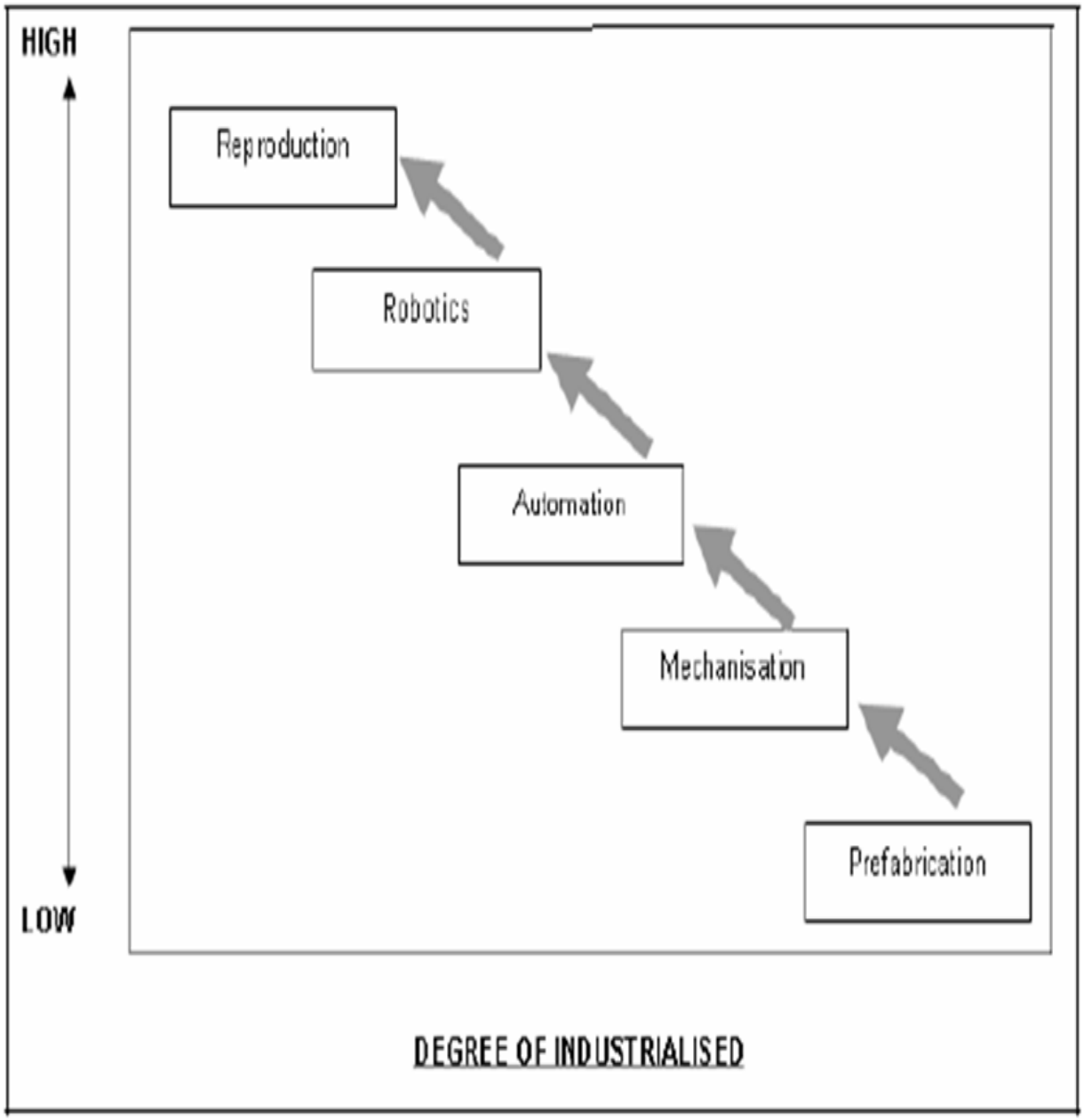
3. Literature Review

In the literature review, IBS is used interchangeably with other terms like offsite construction, prefabrication, offsite manufacturing, Modern Method of Construction (MMC) industrialised building and industrialised construction. Each terminology provides a rich historical account of the development of the concept. So far,

however, there has been little discussion about MMC that has tended to focus on the definition and concept of IBS (such as Abdullah and Egbu (2009), Kamar *et al.* (2009), rather than exploration the relationship between both terminologies. Nonetheless, regardless of the terms, the idea is the same, which is to move some effort away from the construction site to a more controlled environment of the manufacturing floor. According to (Richard, 2005), there are five degrees of industrialisation which are: prefabrication, mechanisation, automation, robotic and reproduction. These are described as follows:

1. Prefabrication is a manufacturing process that generally takes place at a specialised facility, in which various materials are joined to form a component part of the final installation (Richard, 2005).
2. Mechanisation comes in whenever machinery is employed to ease the workload of the labourer.
3. Automation is a situation when the tooling (machine) completely takes over the tasks performed by the labourer.
4. Robotics comprise the ability of the same tooling which has the multi-axis flexibility to perform diversified tasks by itself. This allows the mass customisation concept.
5. Reproduction implies that the research and development of innovative processes are truly capable of simplifying the production process.

Degree of industrialisation (Richard, 2005)



According to Richard, the first four degrees are still more under the influence of the traditional methods of building. Prefabrication aims rather at the location of the production where the next three degrees (mechanisation, automation and robotics) aim at substituting labour with machineries (Richard, 2005). Reproduction, on the other hand, is a concept borrowed from the printing industry and it is an innovation capable of simplifying the multiplier of complex goods and delivering affordable, quality building to the vast majority of people (CIB W086, 2013). More recently, with specific reference to Richard's work, CIB classified industrialised construction into contents and value creation based on the level of complexity and industrialisation (CIB W086, 2013).

4. Global Industrialised Building System (Ibs) Adoption

Modernising the construction processes through industrialisation is a worldwide agenda to improve construction performance. The experiences in developed countries indicate that there is a great potential for IBS to progress, as evidenced by their market share.

The IBS agenda in Malaysia began in the early 1960's when the officers of the Ministry of Housing and Local Government of Malaysia visited a number of European countries and evaluated their housing development programmes (Thanoon *et al.*, 2003). Following their visits and recommendations, the government initiated an IBS or "prefab" (known then) pilot project in 1964 aimed at speeding up the delivery time of quality "low-cost" or affordable housing.

Despite the introduction of the initial form of IBS in Malaysia over 40 years ago, its acceptance is not widespread and the pace of implementation of the system is still below than government target. However, Malaysian government are committed to push the IBS adoption for infrastructure development project by deploy IBS technology for 34 schools in Sabah and Sarawak, project Pan-Borneo Highway, Mass Rapid Transit (MRT) project in the Klang Valley was implement to increase well as the demand for more efficient urban transportation further to expand IBS usage (Hamid *et al.*, 2008).

Hamid *et al.* (2008), reported that there were at least 138 international organisations of various manufacturers and suppliers of IBS in Malaysia (Hamid *et al.*, 2008). Until 2007, the total number of registered IBS contractors in Malaysia was 1,993. This is despite that fact that most locally developed products are based on traditional materials, such as reinforced concrete, and the most innovative materials are based on imported technology (Plan-CIMP, 2005), and there is no mandatory requirement for any certification or accreditation of components, companies or installers in place (Hamid *et al.*, 2008). However, whilst there is no empirical data, some anecdotal evidence suggests that there has been sporadic abandonment of sub-standard foreign products in Malaysia (Thanoon *et al.*, 2003).

4.1. SMEs in IBS Projects in Sarawak

One of the studies conducted a quantitative survey in which the focus group is a big size corporation. The investigator discovered that IBS was still deemed new to most contractors in Sarawak and stated that they still lacked exposure. Meanwhile, another investigator revealed that there is no important distinction between IBS setbacks in rural regions of Sarawak, East Malaysia, and urban regions of West Malaysia. These setbacks are resistance to change, negative stakeholder perceptions of IBS models, costly general building expenses, absence of understanding and exposure to IBS technology, and lack of IBS producers in the industry. (Hadi *et al.*, 2017).

4.2. Experiences and Lessons Learned on Ibs Construction in Malaysia

1. In the past few years, there has been a change in paradigm regarding IBS in Malaysia. In the past, although the benefits of IBS are clear and eminent, the majority of contractors and industry stakeholders have still divided either to use IBS or conventional method.
2. In Malaysia, the IBS promotes open system or hybrid system and encourages complete sector involvement compared to the prefab closed system where only restricted sector businesses can participate. IBS supply chain should consist of modular component-based products that can be produced and interchangeable between any projects, thus promoting mass customization at the end of the customer.
3. The construction industry in Malaysia is very good at changing and adopting IBS technologies captured from overseas practices. Today, many private companies in Malaysia have teamed up with foreign experts to offer solutions to their IBS projects.
4. IBS in Malaysia is seen as a threat to traditional techniques, but in fact many IBS techniques, such as block works, exist in conjunction with standard practices. IBS ' inability to enter the market is due to a misconception that it will ultimately replace the traditional industry, while working strongly together to support best practices in building.
5. One of IBS' main issues is changing the perception of users. Users tend to think that IBS buildings are easy to leak and can't be renovated.
6. Every IBS scheme has its own benefits and constraints. Selecting and implementing the right technology in IBS projects is perhaps the key to IBS success. There is a need to realize that precast concrete IBS is not appropriate for every project. (Mohd Idrus *et al.*).

4.3. Barriers to Ibs Adoption in Malaysia

Currently, IBS incentives are not adequate. Adoption of IBS needs more public pull and push factors. Due to the tiny profit margin, the shift from conventional to IBS was not viable unless there were more appealing incentive systems and advantages that could attract the conventionalist to IBS.

The availability of inexpensive foreign labor that offsets the cost benefit of using IBS is a root cause of slow adoption in the past. As long as it is simple for the sector to find foreign employees, labor levels will stay small and builders will find it unattractive to alter into streamlined alternatives such as IBS. (Mohd Idrus *et al.*).

4.3.1. Pull and Push Factor of IBS Implementation

Several studies researching IBS implantation pull and push factors. The pull variables that encouraged the use of IBS are quality improvement, reduction of defects, decrease of site length, enhancement of housekeeping, decrease of waste, savings in the use of manual labor, incentive from government and cost savings. On the other side, the push

factors that promote adoption are reducing safety & health risk, addressing skill shortages, addressing environmental and sustainability problems, influencing clients, and government policy (Kamar *et al.*).

The following table shows the previous practices of industrialised construction in the others country:

Industrialisation of construction practices in the others country

Country	Practices of Industrialisation
Sweden	In the Swedish construction industry is regarded as the most industrialised and developed in the world, with 90% of single-family houses constructed using IBS [18]. In the mid-1960s, the Swedish government projected a national mission of producing 1 million new houses within 10 years. The objective was achieved through the introduction of IBS [18]. There are about 55 manufacturers offering IBS in Sweden and apart from the local market, Swedish manufacturers export houses to many European countries. Their magnificent achievement in IBS is a result of direct government proactive policies which include substantial grants for research and development [18].
Finland	In Finland, housing made in a factory represents 70% of total building construction. It offers effective and rapid site assembly and improves the quality and productivity of construction [12]. The growth of residential housing using IBS is 20% annually and the predominant form of IBS is small and modular panelised systems [18].
Japan	In Japan, attempts to industrialise the construction industry began in the late 1950s, for the following reasons: shortage of carpenters, oil price hike, rapid economic growth and urbanisation, depletion of timber, quality issues and for better earthquake and fire protection [21] . Most of the prefabricated construction industry concentrated on three major urban markets with consistent population clusters, namely, the Kanto region (Tokyo-Yokohama), the Chubu region (Nagoya) and the Kinki region (Osaka and Hyogo) [22]. Since then, the Japanese housebuilding industry has developed the most advanced manufacturing techniques in construction. Automation and robotics were applied in both manufacturing floor and onsite construction for better quality, minimum onsite duration and better value for customers [22].
Germany	Industrialised construction in the building industry in Germany has improved in quality and provides better value with considerable variety and flexibility in design. It also helps the developers to overcome strict standards of quality control imposed by local authorities in their building industry [23].
Denmark	In Denmark, about 80% of the detachable houses used IBS and most of it was done via a panelised system [18]. The IBS in Denmark is aimed at the domestic market as well as the export market. Their international contractors such as Jespersen & Son and Larsen & Nielson have constructed large projects throughout the world using prefabricated concrete systems[18].
Netherland	The IBS industry in the Netherlands represents 10% of the total market, and the conventional brick wall and masonry construction is still dominant in the market. Nevertheless, IBS has steadily increased in market share. This is due to substantiation by standardised components, a flexible manufacturing process and improved industrialised building techniques [18]. The industrialised housing in the Netherlands is steadily increasing its market share due to potential cost savings of up to 30%. This too is substantiated by standardised components, a flexible manufacturing process and improved industrialised building techniques [18].
Singapore	Singapore, through the Housing Development Board (HDB), has produced advanced prefabricated components and systems for quality housing since the 1980s. It proved successful in terms of the quality and speed of construction. They have started adopting a modulated grid layout concept based on Modular Coordination (MC) as the basic building block for all apartment designs since the early 1970s; its industry-wide pre-fabrication programme started in the early 1980s through technology transfer initiatives with Australian, Japanese and French partners [18]. As a result of continuous effort, the HDB has made a remarkable achievement in the adoption of IBS for the construction of the public housing program. These initiatives are the incorporation of modular co-ordination of its public housing designs, design standardisation and customisation, prefabrication, and the mechanization of site operations. The setting up of HDB Prefabrication Technology Centre (PTC) in 1994 marks another milestone achievement in the application of IBS in Singapore. PTC's main activities are to design, develop and produce prefabricated building products; conduct research and development of advanced and innovative construction materials and systems; manage and supply prefabricated building products; conduct training and license its intellectual property rights.
Thailand	The application of IBS as an innovative construction method in Thailand is gaining higher popularity as compared to the scenario of the construction industry in Thailand way back in the 1970s. According to Buddhi (2004), in 2004, the government of Thailand has a plan to build about 600,000 units within three years for the low to medium income level citizens [24]. Most of these family units are detached houses. Commissioned developers and designers have proposed different housing systems. However, it is important to note that in terms of material, production, construction, etc., the design must be suitable for large scale construction within a limited time and cost. In July 2004, the National Housing Authority (NHA) of Thailand has approved the usage of the "Precast Large Panel Construction". This marks another milestone for the construction industry in Thailand, where several thousand PLP houses will be built within a period of several years. No beam and columns are used except at few locations. In terms of the speed of construction, the total time required is significantly less than the conventional system. According to Buddhi (2004), for a typical 2-3 bedroom two storey house, the time required for casting, lifting, erection and completion of structural system is about 2-4 days once the system is setup [24]. This shows how fast a typical house built based on IBS concept can reach, as compared to conventional construction method.
United Kingdom (UK)	In the UK, both Latham and Egan reports emphasised the advantages of standardisation and preassembly and stressed the importance of modular and industrialised systems to improve construction performance [26],[27]. The UK construction industry has often been described as fragmented, adversarial and inefficient requiring significant improvement. In the impetus of the reports, the Modern Method of Construction (MMC) and offsite construction were introduced to address the under supply, skills shortage and poor build quality of housing [28]–[30]. Promotion of offsite construction has therefore seen as a mechanism for overcoming some of these problems. The Barker Review (2004) suggested that offsite technologies could both improve the quality of construction and address skills constraints in the industry [31]. It has been widely documented that offsite technologies offer potential for reductions in cost, time, defects, health and safety risks and environmental impact and improve predictability, whole life performance and profits.
Manubuild by European Commission	One of the most significant current developments in industrialised construction is the development of the open building manufacturing concept initiated by Manubuild. The Manubuild project is an industry-led collaborative project, part funded by the European Commission. Commencing in April 2005, it involves participation from the industry stakeholders, research institution and universities [25]. The vision of Manubuild is open building manufacturing, a new paradigm for building production and procurement by combining highly efficient manufacturing techniques in factories and on construction sites, and an open system for production of components offers diversity of supply and building component configuration opportunities in the open market [25]. It aims at realising a step change on four different aspects from technology push towards market pull, from mass production to mass customisation, moving towards a combination of offsite production and intelligence onsite production, and from project market towards service-centric market [25].

Currently, offsite and prefabricated construction is a preferred mode of construction of hospitals, military accommodation, hostels and prisons in the UK (Goodier and Gibb, 2007; Pan *et al.*, 2007;2008).

- The following are the Constructing Excellence was established by the Office of the Deputy Prime Minister (ODPM) in response to the reports by Sir Latham (1994) and Sir Egan (1998). Constructing Excellence is a cross sector, cross-supply chain organisation charged with driving the agenda for change in construction including the promotion of MMC through R&D, benchmarking, workshop series and networking.
- The Office of the Deputy Prime Minister (ODPM) has gathered information from 50 leading expert sector practitioners and published a National Audit Office (NAO) report on MMC in 2005. This report is an independent examination to identify how to get the best value by using MMC offsite (Barker, 2004). Barker

33 a cross-industry group was established in 2006 to examine the barriers to greater use of MMC in the provision of new housing and the mechanisms to overcome them (Barker, 2004).

- The Housing Forum has been established as the only housing organisation which provides a network across all housing construction sectors: public, private and social and across their supply chains. The Housing Forum works closely with the Department of Trade (DTI), Housing Corporation, the House Builders Federation and CITB Construction Skills and others as well as its industry partners and sponsors to encourage MMC adoption.
- Buildoffsite is an industry-wide campaigning organisation of clients, designers, constructors, manufacturers, suppliers, government advisors and researchers promoting uptake of offsite construction solutions. This campaign, established in 2005, exclusively and uniquely focused on off-site construction solution facilitation and supporting the government in the implementation process (Buildoffsite, 2008). Buildoffsite engages in two-way communication to promote offsite and MMC through stakeholders' events, workshops, technology showcases and awareness.
- MMC is fully utilised in the public sector by ODPM's Housing Corporation (Social House Regulator for England & Wales) and English Partnership (Urban Regeneration). Large-scale development schemes such as the Thames Gateway and the seven Millennium Community initiatives run by English Partnerships are allowing housing associations to use MMC to promote efficiency in construction (National Audit Office, 2004). In 2004, The Housing Corporation stated that 25% of all new grant aided construction by housing associations should use MMC (5000 homes per year which is equivalent to 3% of total new UK housing) (Buildoffsite, 2008) .
- The government and industry sponsored, Rethinking Construction programme, has encouraged the use of MMC by promoting best practice and providing information. Government research initiative such as the £1.5 million Department of Trade and Industry (DTI) funded 'PROSPA' (Promoting Off-site Production Applications) programme has been aimed at investigating the views of the UK industry concerning offsite MMC. Key events of Modern Method of Construction (MMC) initiatives taken by UK Government.

5. Discussion

This study has given an overview of the IBS implementation in the construction sector worldwide as well as the current status of its implementation in Malaysia. The review shows the several countries across the globe have shown great interest in the direction of IBS implementation and leading the market towards IBS adoption. Even though the implementation of IBS in those countries has evolved in many different pathways, the fundamental issues is that the collaboration of government and private industry support have given a significance impact to the successful of the IBS implementation in the construction sector for each country. The government full support through government entities and its agencies having a mandates to impose the use of IBS for each government project play a very significant role and initiative to help in stimulate IBS technology in Malaysia to be comparable with other developed countries. Further, the need for a standardization of terminology is paramount, to ensure accurate understanding of its advantages as well as to provide certainties with the risk and barriers related to IBS, especially for a developing country such as Malaysia which is just beginning to embrace the IBS techniques to efforts made in its construction industry. Finally, it has been suggested that the successful case of IBS projects should be the focus of the future research papers as part of the strategies for convincing industry especially the private sector towards enhancing IBS implementation in their future projects.

6. Conclusion

This research determined the relationship between the terms of industrialised building system (IBS) and modern method of construction (MMC). It has shown that a different country has their own name or definition of those terminologies due to the research context including UK, Europeand Malaysian construction industry. This situation has generated a lack of clear or uniform definition and uncertainty in the context and boundary that contributed to the prejudices and misunderstanding among the industry and academician. Thus, an establishment and standardisation for those terminologies is needed in order to enrich the application of IBS and MMC in the construction industry around the world.

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References

Abdullah, M. R. and Egbu, C. O., 2009. "Industrialised building system in Malaysia: issues for research in a changing financial and property market." In *Proceedings of the BUHU 9th International Post Graduate Research Conference University of Salford.* pp. 15-25.

Barker, K. (2004). *Barker review of housing supply.* HM Treasury: United Kingdom. www.barkerreview.org

Buildoffsite (2008). *Your guide to specifying modular buildings maximizing value and minimizing risk.* Buildoffsite and BAA: London.

CIB W086 (2013). CIB publication 393. Building pathology. A state-of-the-art report.

Čuš-Babič, N., Rebolj, D., Nekrep-Perc, M. and Podbreznik, P. (2014). Supply-chain transparency within industrialized construction projects. *Computers in Industry,* 65(2): 345-53.

Gibb, A. G. (1999). *Off-site fabrication: prefabrication, pre-assembly and modularisation.* John Wiley and Sons.

Goodier, C. and Gibb, A. (2007). Future opportunities for offsite in the UK. *Construction Management and Economics,* 25(6): 585-95.

Hadi, N. A., Muhamad, W. M. N. W. and Othman, M. K. F. (2017). Critical factors of implementing industrialised building system in sarawak: A research on SMEs. IOP Conf. series. *Earth and Environmental Science,* 67(2017):

Hamid, Z., Kamar, K. A. M., Zain, M., Ghani, K. and Rahim, A. H. A. (2008). Industrialized building system (IBS) in Malaysia: the current state and R and D initiatives. *Malaysia Construction Research Journal,* 2(1): 1-13.

Ismail, E., 2001. "Industrialized building system for housing in Malaysia." In *In 6th Asia Pacific Science and Technology Management Seminar.*

Kamar, K. A. M., Alshawi, M. and Hamid, Z. Industrialised building system the critical success factors. 485-97.

Kamar, K. A. M., Alshawi, M., Hamid, Z. A., Nawi, M. N. N., Haron, A. T. and Abdullah, M. R. (2009). *Industrialized building system (IBS): revisiting the issues on definition, classification and the degree of industrialization.* CIRAIC: Kuala Lumpur.

Lessing, J., Stehn, L. and Ekholm, A., 2005. "Industrialised housing: definition and categorization of the concept." In *In Annual Conference of the International Group for Lean Construction: 18/07/2005-21/07/2005. International Group for Lean Construction.* pp. 471-80.

Mohd Idrus, D., Noraini, B., Mohd Azmi, D., Mohd Rizal, N., Kamarul, A., Mohamad, K. and Zuhairi, A. H. The adoption of industrialised building system (IBS) construction in Malaysia: The history, policies, experiences and lesson learned.

Nadim, W. and Goulding, J. S. (2009). Offsite production in the UK: The construction industry and academia. *Architectural Engineering and Design Management,* 5(3): 136-52.

National Audit Office (2004). *Using modern methods of construction to build homes more quickly and efficiently.* London.

Nawi, M. N. M., Nifa, F. A. A., Abdullah, S. and Yasin, F. M., 2007. "A preliminary survey of the application of IBS in Kedah and Perlis Malaysian Construction industry." In *Proceeding in conference in Sustainable building, Malaysia.*

Pan, W., Gibb, A. G. and Dainty, A. R. (2007). Perspectives of UK housebuilders on the use of offsite modern methods of construction. *Construction management and Economics,* 25(2): 183-94S.

Pan, W., Gibb, A. G. and Dainty, A. R. (2008). Leading UK housebuilders' utilization of offsite construction methods. *Building Research and Information,* 36(1): 56-67.

Plan-CIMP, C. I. M. (2005). *Construction industry development board (CIDB).* Malaysia Kuala Lumpur.

Richard, R. B. (2005). Industrialised building systems: reproduction before automation and robotics. *Automation in construction,* 14(4): 442-51.

Sir Egan, J. (1998). *Rethinking construction, construction task force report for department of the environment, transport and the regions.* Ed: HMSO: London.

Sir Latham, M. (1994). *Constructing the team: Joint review of procurement and contractual arrangements in the UK construction industry.* Department of the Environment, UK.

Thanoon, W. A., Peng, L. W., Kadir, M. R. A., Jaafar, M. S. and Salit, M. S., 2003. "The Experiences of Malaysia and other countries in industrialised building system." In *Proceeding of International Conference on Industrialised Building Systems.* pp. 10-11.

Warszawski, A. (1999). *Industrialized and automated building systems.* E and FN Spoon.