Available Online at www.e-iph.co.uk

ASLI QoL 2017

E-B
Environment - Behaviour
Proceedings Journal

AicQoL2017Bangkok

5th AMER International Conference on Quality of Life
Nouvo City Hotel, Bangkok, Thailand, 25-27 February 2017

e-IPH
e-International
Publishing House Ltd.,
United Kingdom

The Industrialised Building System Modular System (IBSMS) Framework

Muhamad Faiz Musa [*1 2], Mohd Reeza Yusof [1], Noor Sahidah Samsudin [1], Faridah Muhamad Halil [2]

[1] *Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Cawangan Perak, Kampus Seri Iskandar, Seri Iskandar, 32610, Perak, Malaysia*
[2] *Construction Economics and Procurement Research Group, Centre of Studies for Quantity Surveying, Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia*

Abstract
The enhancement of quality and to promote sustainability in the construction or built environment can be achieved through the adoption of offsite manufacturing (OSM). The adoption OSM through modular construction is already being adopted all over the world but to be considered as new technology and innovation in Malaysia. This paper will discuss the development of a framework for modular construction that embraced the Malaysian IBS approach. The framework is developed from the existing framework, literature review and the findings of the case studies. The established framework hopes to increase the understanding and awareness of modular construction in Malaysia.

Keywords: Industrialised Building System (IBS); modular construction; Industrialised Building System Modular System (IBSMS); offsite manufacturing (OSM)

1.0 Introduction

The history of modular construction started in 1958 in the United State (US) where a housing manufacturer produces a two sections house or two modular unit structure that complied with the existing building code. Back then, most of the modular buildings constructed using modular construction are rectangular consists of two to four modular unit structure. Nowadays, modular construction can compete with conventional or traditional construction through the factory technology and advancement of computer design. Due to its advantages, modular construction is adopted in developed countries which include US, UK, Japan and Australia (Musa et al., 2014; Musa et al., 2016).

Malaysia has begun to use Industrialised Building System (IBS) in the early 1960's. IBS is the term used in Malaysia to represent prefabrication concept in the built and construction environment. IBS is a construction process that uses standardised building components mass produces in a factory or onsite then transported and assembled using appropriate machinery and equipment with minimal workers with proper planning and integration (Kamaruddin et al.,2013; Mohammad et al., 2013; Musa et al., 2015). Industrialised Building System Modular System (IBSMS) is the terminology for modular construction that embraces the Malaysian IBS approach. Since the term IBS is already established in Malaysia; therefore it is necessary for the modular construction to adapt to the IBS approach (Ismail et al., 2013; Jabar et al., 2014; Musa et al., 2014; Musa et al., 2016). According to Construction Industry Development Board (CIDB), there are six classifications of IBS which are (CIDB, 2003):

- IBS Precast concrete system
- IBS Reusable formwork system
- IBS Steel framing system
- IBS Blockwork system

* Corresponding author. Tel.:
E-mail address: faeezzz@yahoo.com

ISSN: 2398-4287© 2017. The Authors. Published for AMER ABRA by e-International Publishing House, Ltd., UK. This is an open access article under the CC BYNC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). Peer–review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers), ABRA (Association of Behavioural Researchers on Asians) and cE-Bs (Centre for Environment-Behaviour Studies), Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.
DOI: http://dx.doi.org/10.21834/e-bpj.v2i5.713

- IBS Prefabricated timber framing system
- IBS Innovative system

The current classification of Malaysian IBS by CIDB does not include modular construction. The introduction of modular construction in the Malaysian construction industry is to be expected since modular construction has the potential to eliminate IBS's limitation. Therefore, before modular construction is officially introduced in Malaysia, a study on the fundamentals of modular construction that suit the IBS approach needs to be carried out.

2.0 Offsite Manufacturing (OSM), modular construction and degree of industrialisation

Offsite Manufacturing (OSM) begun in 1837 and is not a new concept in the construction industry (Musa et al., 2016). OSM is a process where the manufacturing of a whole or components of the building will take place in a factory environment and the installation of the building structure using the prefabricated components at designated site (Mohammad et al., 2016). For conventional or traditional construction method the building structure will be constructed on the site. OSM concept allows the manufacturing stage to be added in the construction project process. For OSM, the manufacturing of the building components will be concurrent with the construction work on site as shown in figure 1. OSM spectrum includes whole building solution knows as modular building, volumetric unit (toilet pods) and non-volumetric unit (wall panels and building components such as beam). OSM approach offered several benefits over conventional construction approach that includes better build quality of end products, promote sustainability, faster speed of delivery, improve health and safety, enhance energy in use, lower whole-life carbon footprint and reduced transport pollution in the built environment (CIB, 2013).

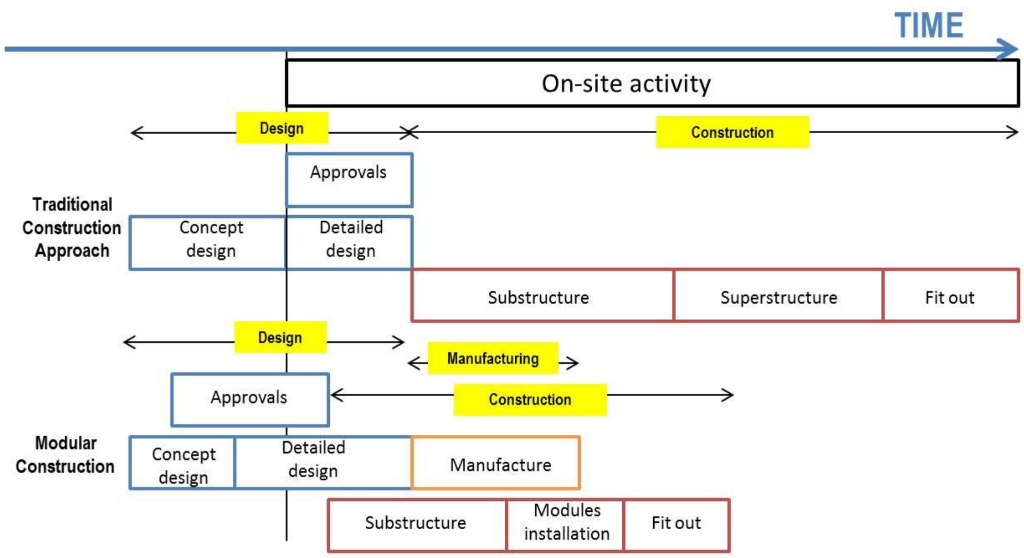

Fig. 1: The main stages comparison between conventional construction and modular construction (Source: NHBCF, 2006)

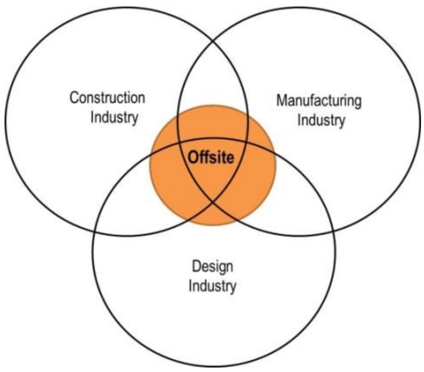

Fig. 2: Design, Manufacturing, and Construction: Offsite Interrelationships (Source: CIB, 2013)

The concept of OSM involved three well-established industries that include design, manufacturing, and construction. Based on research carried out by the International Council for Research and Innovation in Building and Construction (2013), the findings indicate that the design, manufacturing and construction industry in many respects are interrelated and integrated. The overlapping central core between all the three industries is OSM or offsite as shown in figure 2. Furthermore, for a construction project that adopts any OSM and prefabrication concept, the design, manufacturing and construction element or stage will be incorporated into the construction project timeline and process as shown in figure 1 (NHBCF, 2006).

IBS in Malaysia is the combination of OSM and on-site prefabrication. It is due to the six types of IBS. For example, the Malaysian IBS precast concrete system is divided into two types which are the on-site casting of the precast concrete components (mobile yard) and offsite prefabrication of the precast concrete components (factory).

Modular construction is categorised as offsite manufacturing (OSM). Modular construction is a method to construct a building using three-dimensional (3D) modular units or modules, which are assembled and produced in a factory. Modular construction includes the logistic and assembly aspect of it, done in proper coordination through planning and integration (Musa et al., 2015; Musa et al., 2014; Musa et al., 2016). According to Musa (2015; 2014), the characteristic of modular construction are:

- High quality and identical three-dimensional modular units or modules
- Ensure faster speed delivery in a project
- Promotes sustainability in the built environment
- Require logistics and storage assessment
- Require planning, coordination, and communication amongst project members

One of the most significant studies on industrialisation concepts in construction was the work of Roger-Bruno Richard. In his research, the degree of industrialisation should be an indicator to measure the level of industrialisation adoption in construction. The level of industrialisation discussed in Richard's research is in Figure 3 (Kamaruddin et al.,2013; Musa et al., 2014; Richard, 2005). Offsite Manufacturing (OSM) begun in 1837 and is not a new concept in the construction industry (Musa et al., 2016). OSM is a process. There are five degrees of Industrialisation. The first four are prefabrication, mechanisation, automation, and robotics. They duplicate the conventional process in construction, merely transferring the task from human workers to the machine. The fifth degree, reproduction, implies research and development of innovative processes truly capable of simplifying the production.

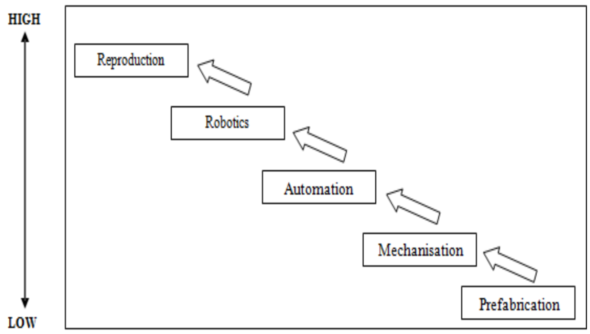

Fig. 3: Degree of Industrialisation (Source: Richard, 2005)

3.0 Methodology

The aim of this research is to develop a framework for modular construction that suited the Malaysian construction industry. For the aim of the study to be achieved, two objectives were established. The first objective is to investigate the adoption of modular construction in Malaysia and the second objective is to develop and validate the framework. Modular construction is new in Malaysia; therefore, a study on the adoption of modular construction is required to clarify the scenario of modular construction in Malaysia further. An extensive literature review was carried out to obtain the information about modular construction, IBS, and OSM in the construction environment. The literature review involved a comprehensive review of secondary data that include journal articles, books, conference proceedings, research reports and guidelines. Three important variables for modular construction are identified from the literature review that includes design, manufacturing, and construction. The identified variables are used for the data collection and the framework development.

For the first objective, to investigate the adoption of modular construction in Malaysia, case studies are being used for the data collection for in-depth knowledge about modular construction in Malaysia. According to Zainal (2007), case study method allows the researcher to examine and explore the data closely within a specific content. Since modular construction is new in Malaysia and comprehensive data is required. Therefore, case study method is the suitable data collection method for the first objective. An explanatory case study is being used for the first objective. The explanatory case study examines the data in surface and depth to explain the phenomena in the data (Zainal, 2007). Three case studies are carried out for the first objective. The collected data becomes useful after analysis where the analysed data can provide descriptions and relationships that will be used in addressing the research objective. Content analysis and cognitive mapping techniques will be used for data analysis of the case study supported by the Nvivo software. Findings from the first objective are used to complete the second objective of the research. Furthermore, other frameworks that are related to the research are being reviewed as a reference for the development of the framework.

3.1 Case Study

Three case studies had been carried out for the research. The case studies emphasis on the design, manufacturing and construction stages of the project. Moreover, the case studies will be focusing on the overall process of the projects that adopt modular construction. The limitation of this research's case study is a lack of modular unit or modular building manufacturer. To date, there are only three register modular building manufacturers in Malaysia. Furthermore, projects that adopt modular construction in Malaysia are low.

3.1.1 Case Study A

Case study A is an office building consists of 72 lecturer office rooms that adopt modular construction using refurbished shipping containers. Shipping container suits the key feature of modular construction which is the 3D modular units and modules feature. The shipping container is found to be the most suitable solution or material to be used for modular construction. According to Musa et al., (2016), the shipping container is mainly a solution or material to be used in modular construction because it fulfils the main criteria of modular construction that is a 3D modular unit with value added factors on strength and durability.

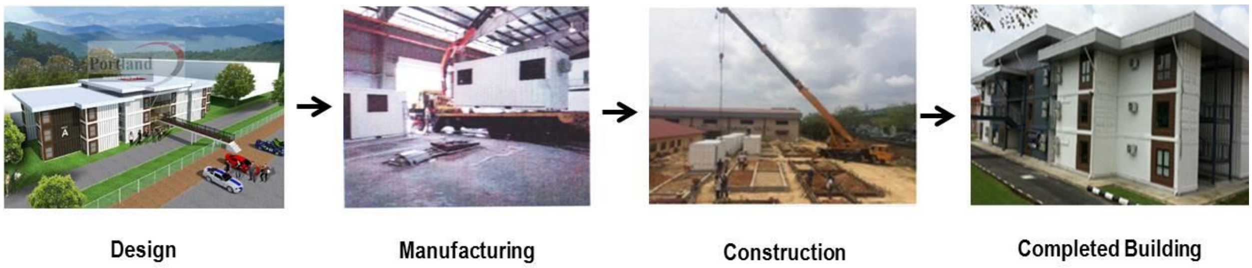

Fig. 4: The design, manufacturing and construction stages for case study A

The project process of Case Study A is different compared to a conventional construction approach with the addition of manufacturing stage. Furthermore, the requirements for every stage are not the same as conventional construction approach. For Case Study A's design development, a new process is introduced where the project team consists of the contractor, manufacturer and consultants need to coordinate and finalised the design at the early stage. AutoCAD is used to ease the design process. Shop drawings for mechanical and electrical (M&E) are being produced at the early project process since the refurbishment and fitting out of the shipping containers is done offsite.

Manufacturing and prefabrication are not new in the Malaysian construction industry. However, for Case Study A, the usages of large 3D units for building structure are new in Malaysia. The process of refurbishing and fitting out the shipping containers are carried out in a warehouse. The shop drawing for every shipping containers needs to be produced at the beginning of the project so that it will affect the refurbishing work and fitting out of the finishes, fixtures, M&E and services of the shipping containers. The cutting and welding works of the shipping containers require skill welders. The manufacturing level for case study A is prefabrication. According to Richard (2005), prefabrication is the lowest level of industrialisation in the degree of industrialisation.

For the construction stage of Case Study A, the construction method is new and not the same as a conventional construction method. The refurbished shipping containers are transported from the warehouse to the designated site. Once, arrive the refurbished shipping containers are lifted from the lorry and install into place. The construction method of Case Study A used a mobile crane to lift the shipping containers and newly train installers to assemble the shipping containers as a building. It is called as the 'LEGO concept', where once the shipping containers are placed on the foundation for the ground floor, the 1st-floor containers will be stack on top of the ground floor containers.

3.1.2 Case Study B

Case Study B is a single storey bungalow modular prefabricated house that is prefabricated in a factory using hot deep galvanised lightweight steel as structure. The modular prefabricated house is completed in the factory and transferred to the site which represents 80% of the project timeline. Another 20% of the project timeline of the modular prefabricated house is the roofing installation and foundation construction on-site. The build up for the modular prefabricated house for case study B is 800 square feet consists of two modular units (40' x 10' each).

The project process for Case Study B is same with the modular construction process as shown in figure 1. Once the final design is approved, the modular building manufacturer will manufacture the 3D modular units. Once the 3D modular units are complete, it will be store at the factory temporarily. The 3D modular units will be transported to the site when the foundation is built. Once the 3D modular units are assembled, the roofing will be installed. The organisation in charge of Case Study B is the designer, manufacturer, and contractor for the project. Therefore, for Case Study B, there is no issue of insufficient coordination, improper planning and lack of communication since the teams involved work together to ensure a holistic planning process for efficient execution of a project. Case study B adopt 'Design and Build' concept.

Fig. 5: The design, manufacturing and construction stages for case study B

For Case Study B's design development, the design team will finalise the design and get it to be approved by the client. Once approved, the design team will produce the shop drawings and to be hand to the manufacturing team. For Case Study B, the designer adopted Design for Manufacturing and Assembly (DfMA) concept in their design and Building Information Modelling (BIM) using Revit software. The designers are BIM competent personal using Revit software.

The manufacturing level for Case Study B is very high where, the manufacturer has adopted robotic, the second highest level of industrialisation in the degree of industrialisation. Semi-Automated Mason (SAM) is used for welding works to weld the joints between structural elements of the 3D modular units on the assembly line. Furthermore, Case Study B's factory adopted prefabrication, mechanisation, automation and robotic. Workers are being trained to operate the machinery and automated machine. Despite the used of SAM for welding works, skill welders are still required since the cost of SAM is expensive.

Once the 3D modular units are manufactured, and the site is ready, the 3D modular units will be transported to the site. For Case Study B, the 'Pick and Drop' concept is used. The lorry used to transport the 3D modular units has a crane mounted at the rear of the lorry that is used to lift the modular units at the factory. At the site, the mobile crane is used because of site constraint. The lorry cannot park next to the foundation and lift the 3D modular units down because there are no spaces to park and due to the neighbouring houses and site condition.

3.1.3 Case Study C

Case Study C is a double storey bungalow modular prefabricated house that is prefabricated in a factory using galvanised steel as structure. The modular prefabricated house is completed in the factory and transferred to the site. For the 3D modular units on the 1st floor, the roof elements that include roof trusses and metal deck have installed the construction work on-site required is the construction of the foundation. The build up for the modular prefabricated house for Case Study C is 1,765.12 square feet consists of four modular units (12m x .3.4m for every unit).

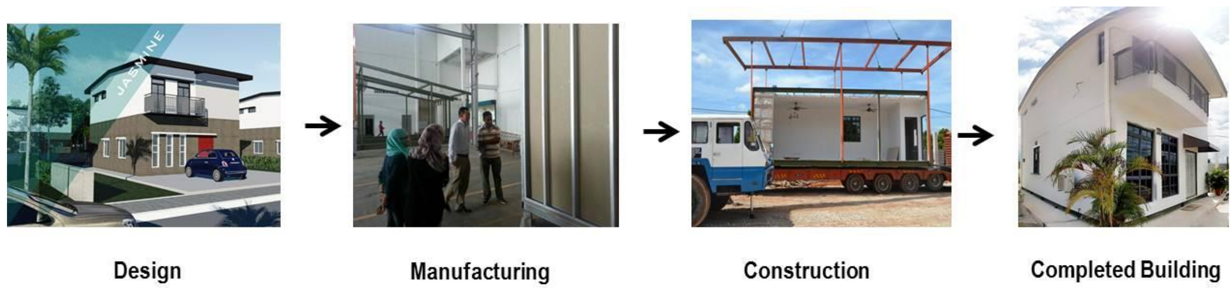

Fig. 6: The design, manufacturing and construction stages for case study C

Case Study C has the same project process like Case Study B as shown in figure 1. Once the final design is approved, the modular building manufacturer will manufacture the 3D modular units. Once the 3D modular units are complete, it will be transported to the site when the foundation is completed. The organisation in charge of Case Study C has the same organisation roles in Case Study B whereby; they are the designer, manufacturer, and contractor for the project. Therefore, for Case Study C, there is no issue of insufficient coordination, lack of collaboration, improper planning and lack of communication since the teams involved work together to ensure a holistic planning process for efficient execution of a project.

The manufacturing level for Case Study C is low where since the manufacturer adopted mechanisation and prefabrication. Machine operator to operate the machinery and skill welders for the welding works are needed. The 3D modular units are manufactured at the factory and will be transported to the site. At the site, a mobile crane is used to lift the 3D modular units. The 3D modular units for Case Study C's length is longer compare to the 3D modular units for Case Study B. Therefore, long truck and lorry are used to transport the 3D modular units.

4.0 Data analyses and findings

Content analysis and cognitive mapping techniques are used to analyse qualitative data collected from case studies supported by the Nvivo software. Nvivo helps the researcher in establishing coding rules in a large number of texts and transparently enhance the reliability and validity of the data analysis (Mohammad et al., 2014; Shukor et al., 2016). The contents of the case studies were coded in Nvivo 9 software and allow the nodes be displayed accordingly and help the researcher manage data. Based on the conceptual content analysis, the coded concept was analysed based on quantification. Furthermore, the themes and sub-themes had been linked that created through a cognitive mapping that characterised by the arrow format in the Nvivo 9 software. The cognitive mapping has been done to display the data and to understand the relationship between ideas.

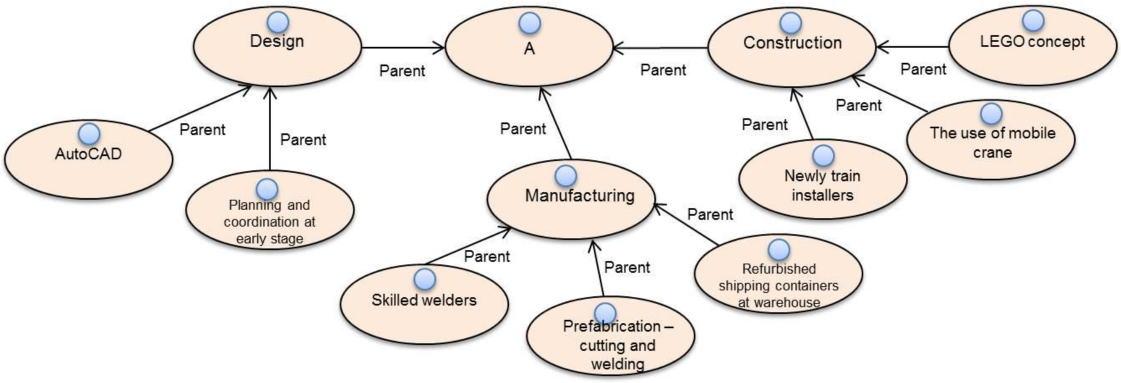

Fig. 7: Cognitive mapping of the variables of modular construction in case study A

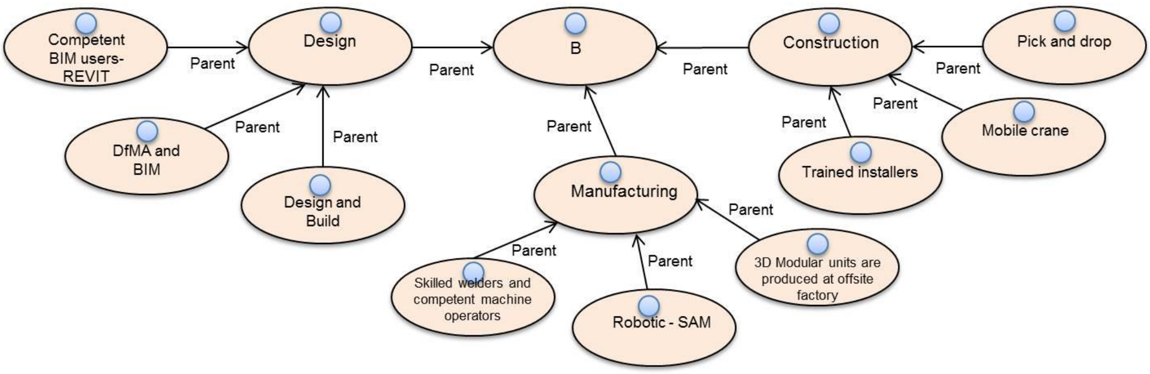

Fig. 8: Cognitive mapping of the variables of modular construction in case study B

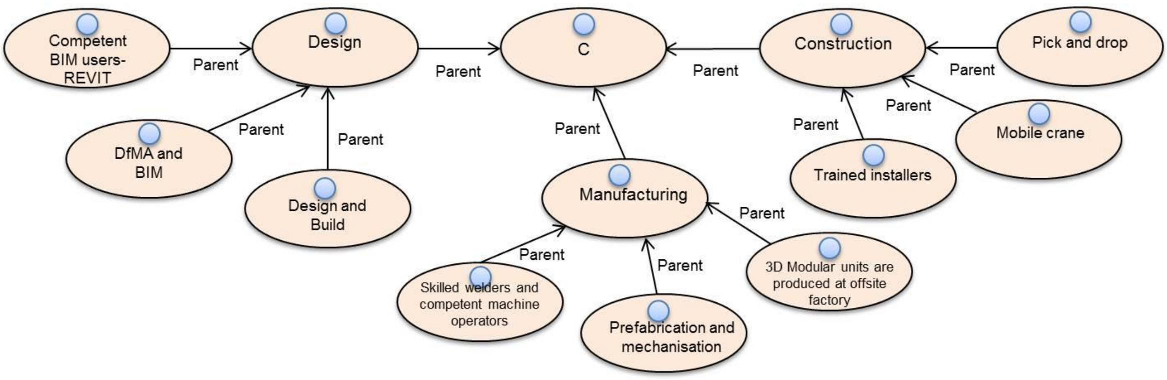

Fig. 9: Cognitive mapping of the variables of modular construction in case study C

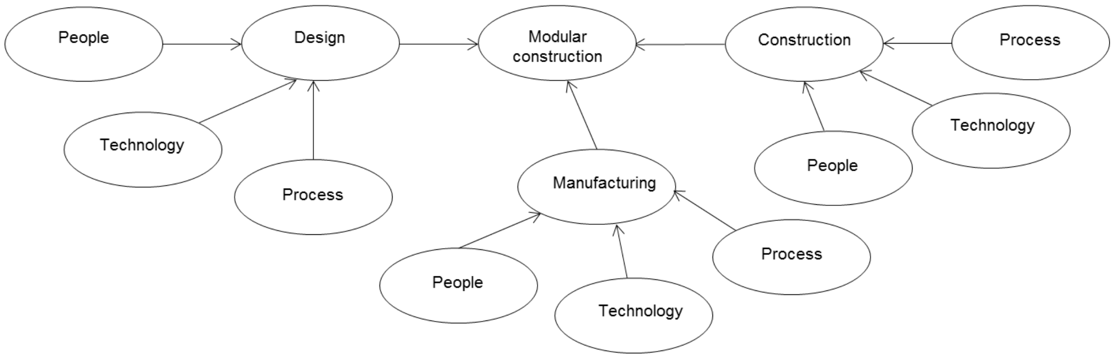

Fig. 10: The summary of the findings

The findings of the study show that for modular construction and OSM concept, there are three main elements or factors which are design, manufacturing, and construction. All three elements are interrelated and integrated for modular construction and OSM. For every element, for example, design, there will be another three sub-factors that can be considered as requirements for every element, which are process, people, and technology. From the finding of every case study, for every design, manufacturing and construction elements, the people, technology and process factors are required. The finding is supported by Davenport (1992), where Davenport indicates that any innovation in most sectors is mostly diffused through three central themes of People, Process and Technology.

Table 1. The summary and comparison of the case studies

	Case Study A	Case Study B	Case Study C
Application	Office	Residential/ House	Residential/ House
Year constructed	2014	2015	2016
Project period	Five months	Two weeks (including the manufacturing of the modular units)	A month (including the manufacturing of the modular units)
Cost of project	RM 3.5 million (including internal M&E works, air-conditioning and furniture)	RM 75,000 (including transportation and foundation construction)	RM 260,000 (including transportation not exceeding 50 km from factory)
No. of 3D modular units	-15 units (40' length shipping containers) -39 units (20' length shipping containers)	2 units	4 units
Types of 3D modular units	Four-Sided Three-Dimensional Units (Shipping container)	Partially Open-Sided Three-Dimensional Units	Partially Open-Sided Three-Dimensional Units
Additional structural framework	-Steel framing to provide staircases, floor joists, and walkways -Shipping containers are stack on top of another -Only used pad footings and ground beams for substructure	None (Only needs a raft foundation or tilt with pad footing)	None (Only needs a raft foundation)
Benefits of adopting modular construction/ building	-Fast speed of construction -Environment friendly -High-quality end product	-Fast speed of construction -Suitable for disaster aid -Movable/ transferable -Environment friendly -High-quality end product & productive	-Fast speed of construction -Environment friendly -High-quality end product

5.0 Industrialised Building System Modular System (IBSMS) Framework

IBSMS is the rebranding of modular construction to suit and adapt to the IBS approach in the Malaysian construction industry. Based on the extensive literature review and the findings from the 1st objective of the study; to investigate the adoption of modular construction in Malaysia, IBSMS is defined as "to construct a building using 3D modular units or modules; mass produces offsite in a manufacturing facility. The 3D modular units are mass produced using the same materials and design to the same standards that increase the speed of construction. It includes the assembly and logistic aspect of it done in proper coordination through detailed planning and integration of design, manufacturing and construction elements in the process". The aim of the IBSMS framework is to outline the essential elements and variables including necessary enablers for IBSMS. Thus, increase the understanding and awareness of modular construction in Malaysia. From the literature review and findings from the case studies, the IBSMS framework is developed as shown in figure 11.

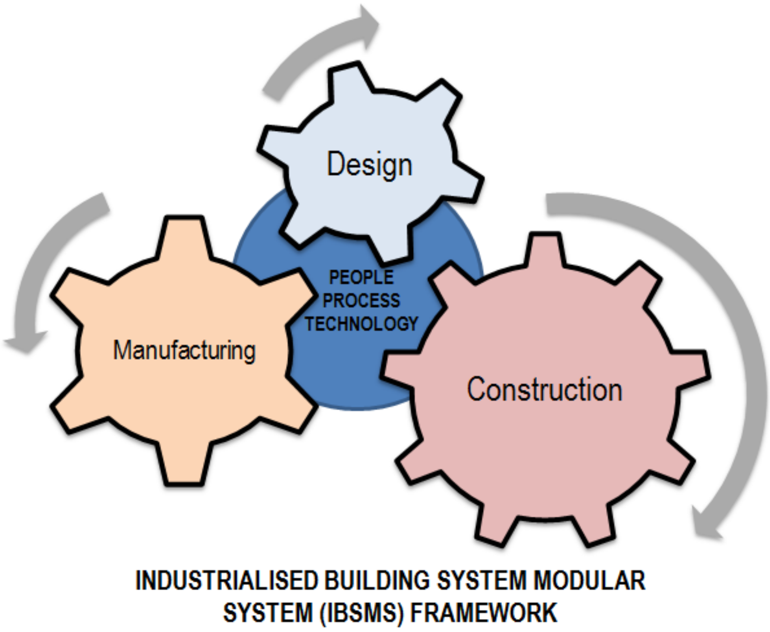

Fig. 11: The Industrialised Building System Modular System (IBSMS) Framework

The gear concept for the IBSMS framework is to show the integration between design, manufacturing, and construction. All these elements or variables are essential for modular construction, and these three core elements are interrelated with one another. Based on the findings of the case studies, modular construction requires a holistic planning and integration of design, manufacturing and construction elements in the process for efficient execution of a project.

On the other hand, people, process, and technology are the three sub factors and essential for the three main elements of design, manufacturing, and construction. To show that the people, process and technology factors are required for three main elements of design, manufacturing, and construction, the people, process and technology factors are placed in the centre and overlapping with the design, manufacturing and construction elements.

For the validation of the IBSMS framework, the framework is presented to a panel of experts in the field of IBS, prefabrication, and OSM in the Malaysian construction industry. This validation method using expert panel is selected due to lack of related research and framework that can be validated using structural equation modelling (SEM). The framework cannot be validated through testing since the framework is a descriptive framework outlining the essential variables for modular construction.

The panel of experts is representatives from Ministry of Urban Wellbeing, Housing and Local Government (KPKT), Ministry of Works (MOW), Jabatan Kerja Raya (JKR), Construction Industry Development Board (CIDB), Universiti Teknologi MARA (UiTM) and the modular building manufacturers. To ensure the panel of experts to validate the framework is reliable and experience in IBS and OSM, table 2 will display the information of the panel members.

Table 2. The information of the panel members to validate the IBSMS framework

Organisation	Position held	Experience in IBS and OSM
CIDB	General Manager	20 years
CIDB	Senior Manager	15 years
CIDB	Manager	6 years
KPKT	Head Of Consultant	10 years
MOW	Engineer	6 years
JKR	Engineer	8 years
UiTM	Senior Lecturer	15 years
UiTM	Senior Lecturer	12 years
Modular building manufacturer	Director	10 years
Modular building manufacturer	General Manager	11 years

The validation process was conducted by a panel of ten experts experienced in the subject matter. The framework is presented to the experts, and the experts need to give verbal response after the presentation. The verbal response from the experts are recorded and transcript for the study. From the outcome of the validation process, the panel of experts agreed with the content of the framework but with minor changes to the IBSMS framework and no need for the second session for the validation process.

6.0 Conclusion

There is the need for the Malaysian construction industry to opt for a new and improved construction method, to shift from the conventional construction method to the adoption of OSM, modern method of construction and sustainable construction concept. The established IBSMS framework hopes to encourage and create awareness about modular construction and IBSMS in the Malaysian construction industry, therefore increase the adoption of modular construction in Malaysia. Due to the advantages and potential of modular construction, it is hoped that the adoption modular construction can contribute to the improvement in the quality of built and construction environment in Malaysia. The novelty of this research is the development of a framework, particular for modular construction that suits the Malaysian IBS approach.

Acknowledgements

The Authors wish to thank the Universiti Teknologi MARA Cawangan Perak, Kampus Seri Iskandar, Construction Industry Development Board (CIDB) and a remark of indebtedness to the Acculturation Grant Scheme (RAGS), No: 600-RMI/RAGS 5/3 (134/2014) by the Ministry of Education, Malaysia for its grant award.

References

CIB. (2013). Offsite Production and Manufacturing - Research Roadmap Report. In J. Goulding & M. Arif (Eds.), CIB Publication 372 (pp. 43): International Council for Research and Innovation in Building and Construction.

CIDB. (2003). IBS Roadmap 2003-2010. Kuala Lumpur.

Ismail, F., Baharudin, H. E. A., & Marhani, M. A. (2013). Factors towards Site Management Improvement for Industrialised Building System (IBS) Construction. Procedia - Social and Behavioral Sciences, 85, 43-50.

Jabar, I. L., Ismail, F., & Aziz, A. R. A. (2014). Public Participation: Enhancing Public Perception towards IBS Implementation. Procedia - Social and Behavioral Sciences, 168, 61-69.

Kamaruddin, S. S., Mohammad, M. F., & Mahbub, R. (2013). Enhancing the Quality of Life by Adopting IBS: An Economic Perspective on Mechanisation and Automation. Procedia - Social and Behavioral Sciences, 101, 71-80. doi: 10.1016/j.sbspro.2013.07.180

Kamaruddin, S. S., Mohammad, M. F., Mahbub, R., & Ahmad, K. (2013). Mechanisation and Automation of the IBS Construction Approach: A Malaysian Experience. Procedia - Social and Behavioral Sciences, 105, 106-114.

Mohammad, M. F. (2013). Construction Environment: Adopting IBS Construction Approach Towards Achieving Sustainable Development. Procedia - Social and Behavioral Sciences, 85, 8-15. doi: 10.1016/j.sbspro.2013.08.332

Mohammad, M. F., Baharin, A. S., Musa, M. F., & Yusof, M. R. (2016). The Potential Application of IBS Modular System in the Construction of Housing Scheme in Malaysia. Procedia - Social and Behavioral Sciences, 222, 75 – 82.

Mohammad, M. F., Shukor, A. S. A., Mahbub, R., & Halil, F. M. (2014). Challenges in the Integration of Supply Chains in IBS Project Environment in Malaysia. Procedia - Social and Behavioral Sciences, 153, 44-54.

Musa, M. F., & Mohammad, M. F. (2015). Adopting Modular Construction through IBS Approach: LAP LAMBERT Academic Publishing.

Musa, M. F., Mohammad, M. F., Mahbub, R., & Yusof, M. R. (2014). Enhancing the Quality of Life by Adopting Sustainable Modular Industrialised Building System (IBS) in the Malaysian Construction Industry. Procedia - Social and Behavioral Sciences, 153, 79-89. doi: 10.1016/j.sbspro.2014.10.043

Musa, M. F., Mohammad, M. F., Yusof, M. R., & Ahmad, R. (2016). Industrialised Building System Modular System (IBSMS) Organisational Readiness Framework. Procedia - Social and Behavioral Sciences, 222, 83-92.

Musa, M. F., Mohammad, M. F., Yusof, M. R., & Mahbub, R. (2015). The Way Forward for Industrialised Building System (IBS) in Malaysia. In gajalakshmis@sps.co.in (Ed.), InCIEC 2014 (pp. 163-175): Springer Singapore.

Musa, M. F., Yusof, M. R., Mohammad, M. F., & Mahbub, R. (2014). Characteristics of Modular Construction: Meeting the Needs of Sustainability and Innovation. Paper presented at the Colloquium on Humanities, Science and Engineering 2014 (CHUSER 2014), Penang.

Musa, M. F., Yusof, M. R., Mohammad, M. F., & Samsudin, N. S. (2016). Towards the adoption of modular construction and prefabrication in the construction environment: A case study in Malaysia. Journal of Engineering and Applied Sciences, 11(13), 8122-8131.

NHBCF. (2006). A guide to modern methods of construction. In K. Ross, P. Cartwright & O. Novakovic (Eds.): NHBC Foundation.

Richard, R.-B. (2005). Industrialised building systems: reproduction before automation and robotics. Automation in Construction, 14(4), 442-451. doi: 10.1016/j.autcon.2004.09.009

Shukor, A. S. A., Mohammad, M. F., Mahbub, R., & Halil, F. M. (2016). Towards Improving Integration of Supply Chain in IBS Construction Project Environment. Procedia - Social and Behavioral Sciences, 222, 36 – 45.

Zainal, Z. (2007). Case study as a research method. Jurnal Kemanusiaan, 9.