THE ADOPTION OF BUILDING INFORMATION MODELLING IN INDUSTRIALISED BUILDING SYSTEM

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To my family,

I hope that I make my parents and siblings proud.

To the community,

I hope this research could assist in overcoming related problem.

To my supervisor,

I hope all my efforts are meaningful to you.

I thanked you for your guidance and patience.

To myself,

I hope the sleepless nights are worth to sacrifice.

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ABSTRACT

The growing demand of housing has prompted the Malaysian construction practitioners to realize the benefits of Industrialised Building System (IBS). Despite its advantages, IBS in Malaysia is plagued partly due to inefficient adoption strategy and lack of awareness among the practitioners. Hence Building Information Modeling (BIM) is introduced to facilitate the life-cycle of the project by eliminating construction inefficiencies. BIM offers a process of re-engineering to enhance the automation in IBS in terms of quality and productivity performance. The aim of the study is to evaluate the BIM functions in relation to Malaysian IBS work process. In order to achieve the aim, the effectiveness of IBS and BIM implementation in Malaysia were identified. The data is collected through interview sessions with IBS-BIM practitioners. Data from the interview were analyzed using Content Analysis, summative approach. From the analysis, it was found that there are 4 BIM functions (clash detection, visualization, shop drawing, coordination) which able to cope with 3 IBS work process (initial work, component production and installation). Even though BIM are not fully utilized in every work process, it has shown improvement in terms of quality, time and cost. Moreover, an IBS-BIM implementation framework was formulated through framework analysis. The IBS-BIM framework explained BIM integrated functions in relation to IBS work flow. This study is essential to boost the confidence level of IBS practitioners in enhancing its productivity through the BIM implementation. Also, this framework is crucial to help BIM committee and local authorities in determining implementation strategies to integrate BIM in other construction related industry as well.

ABSTRAK

Permintaan rumah yang semakin meningkat telah mendorong industri pembinaan di Malaysia untuk mempraktikkan *Industrialised Building System* (IBS). Walaupun mempunyai banyak manfaat, namun IBS di Malaysia masih kurang dipraktikkan. Hal ini kerana, strategi penggunaan yang kurang cekap dan kurangnya kesedaran di kalangan pengamal pembinaan. Oleh itu, *Building Information Modeling* (BIM) diperkenalkan bagi melancarkan kitaran hayat projek dengan mengurangkan ketidakcekapan dalam pembinaan. BIM menawarkan proses kejuruteraan semula untuk meningkatkan automasi dalam IBS dari segi kualiti dan produktiviti. Tujuan kajian ini adalah untuk menilai fungsi BIM dalam proses kerja IBS Malaysia. Dalam usaha untuk mencapai matlamat kajian, tahap efektif IBS dan BIM di Malaysia akan dikenalpasti. Data yang telah dikumpul melalui sesi temubual dengan pengamal IBS-BIM. Data dari temubual tersebut telah dianalisis dengan menggunakan Analisis Kandungan, pendekatan sumatif. Berdasarkan keputusan analisis, terdapat 4 fungsi BIM yang mampu memebantu melancarkan 3 proses kerja IBS (kerja peringkat awal, pengeluaran komponen dan peringkat pemasangan). Walaupun BIM tidak digunapakai sepenuhnya dalam setiap proses kerja, ia telah menunjukkan peningkatan dari segi kualiti, masa dan kos. Satu rangka kerja pelaksanaan industri IBS-BIM di Malaysia dihasilkan melalui Analisis Kerangka Kerja. Dalam kerangka kerja IBS-BIM, pelaksanaan fungsi BIM dalam proses kerja IBS diterangkan. Kajian ini adalah penting untuk meningkatkan tahap produktiviti memlalui perlaksaaan BIM. Selain itu, rangka kerja ini juga membantu komuniti BIM dan kerajaan tempatan dalam merangka strategi perlaksanaan BIM dalam bidang pembinaan yang lain.

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ABBREVIATIONS		DESCRIPTION
2D	-	Two dimensional
3D	-	Three dimensional
4D	-	Four dimensional
5D	-	Five dimensional
6D	-	Six dimensional
AEC	-	Architecture, Engineering, and Contractors
CIDB	-	Construction Industry Development Board Malaysia
BIM	-	Building Information Modelling
IBS	-	Industrialized Building System
IHT	-	Industrialized House Technology
IT	-	Information Technology
MEP	-	Mechanical Electrical Plumbing
MMC	-	Modern Method of Construction
PWD	-	Director of Public Works
OSM	-	Off- site Manufacturing
OSC	-	Off-site Construction
OSP	-	Off-site Production
CMU	-	Concrete Masonry Units

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In 2020, Malaysia is expected to be a well-developed country with the good economic growth, social stability and good quality of life. In realizing the objectives, the construction sector in Malaysia plays a pivotal role in attaining Malaysia as a developed country status. Construction sector has a great impact on community lifestyle since this sector help in generating income and creating job opportunities. This sector has contributed to the economy relatively compared to the other sector such as service, tourism, and manufacturing sector (Khan *et al.*, 2014).

The construction industry in Malaysia faced challenges with the hiking of demand for houses as well as adopting the sustainable construction practice. The conventional method of construction seems cannot cope with huge demand in a period of time (Kassim and Walid, 2013). As a developing country, Malaysia is moving towards a sustained growth rate according to the Brundtland commission report (Mohamad *et al.,* 2016). Based on the report, developing country should achieve sustained growth rate about 5 to 6 %.

In realizing this vision, the Construction Industry Development Board Malaysia (CIDB), has taking initiative in Malaysian Construction Industry Master Plan 2005-2015 to increase the level of knowledge within the construction community regarding to the sustainability on construction site. However, this approach is still at the early stage and the awareness among the construction players needs to be improved. Therefore, Malaysian Construction Industry Master Plan 2005-2015 is mandatory in order to pursue long term sustainability. Besides, the sustainable development principles improvement may enhance the ability of local construction players to compete in the global market.

The sustainable in construction can be achieved by the industry by minimizing the construction waste and using efficient building material. Industrialised Building System (IBS) seem to be an effective method to achieve these goals (Yunus and Yang, 2011). However, IBS is still not effectively implement even it has been introduced in Malaysia in the early 1960s. The implementation of IBS in Malaysia was lagging behind due to Malaysian construction players are prefer conventional methods rather than prefabrication technology. As a result, government establish (CIDB), to enhance prefabrication technology in the construction industry response with the housing demand (Azman *et al.,* 2012).

One of issues hindering implementation of IBS might be due to the fragmentation of the construction industry and the manufacturing industry itself (Nawi *et al.,* 2011). This practice incurs problem in decision making and project delivery along the construction process. These problems have lead to significant needs of Building Information Modeling (BIM) in IBS project. Information Technology (IT) based tools like BIM have a great potential in providing an effective platform for construction players to make a strategic decision.

Building Information Modeling (BIM) is an innovation platform that facilitates design, digital representation, scheduling of the project and also control the project in term of cost and time (Memon *et al.,* 2014). BIM can promote collaboration between parties that involves in the construction project which can help to increase the effectiveness and efficiency. More importantly, BIM can be a platform to improve the communication between players (Matafi *et al.,* 2012). BIM help to facilitate interaction of different players in the different stages of design, manufactured, delivering, assembling and operational process (Costa and Madrazo, 2015).

BIM implementation in the construction industry has widely explored in numerous studies. Sources by a number of researchers have mentioned that BIM have potential in increasing the efficiency of the construction industry (Rokooei, 2015). During the opening of Infrastructure & Construction Asia's Building Information Modeling and Sustainable Architecture Conference in 2009, BIM has been official introduce by Director of Public Works (PWD) and today Malaysia has now begins to adopting BIM. The seriousness of Malaysia in BIM adoption could be seen in the establishment of BIM Steering Committee in 2013 by CIDB. This committee is collaborating with local bodies in construction industry with aim to facilitate the BIM adoption in Malaysia. Malaysia BIM Roadmap has been developed to formulate strategic plan of BIM implementation by 2020.

1.2   Problem Statement

IBS is a combination of manufacturing industry and construction industry which involving many parties. During prefabrication process until the erection of components on the construction site will be controlled and monitored. Involvement of many parties causing a massive amount of documentation like drawing, bills of quantities and other reports. These documents are expected to be reviewed by others players like engineer, contractor, supplier, manufacturer, fabricator and owner to help them in making a decision and monitor along the process.

IBS practitioners are experiencing conflicts, ambiguities, and uncertainties complexities in communication across the organization with traditional practices which can cause many problems like cost overrun, low-quality product and delay (Khosrowashahi and Ariyaci, 2012). This happened due inaccurate information transfer, poor design information, and wrong deliveries which cause highly fragmented business (Othman, 2011). The fact that construction industry are made up of separate parties from diverse professions and the involvement only in certain stage of the construction phase are attributed to these issues.

Therefore the adoption of BIM in IBS industry raises the concern due to the lack of awareness of BIM capabilities in IBS process can be one of the reason implementation is still at the low level. In addition, there are possibilities of downtime during the transition process. Therefore, an appropriate and effective strategy is needed to raise the awareness the capabilities of BIM and reduce the downtime while implementation process and construction project are on-going at the same time to maintain the productivity of the project.

The complexities in the construction of IBS are worsening by the gap between manufacturing industry and construction industry (Rahim *et al.,* 2012). The fragmentation within the IBS process may cause low productivity and time and cost

overrun. These problems are rooted during the change order, inadequate drawings and specifications, late issuance of construction drawings by consultants and the interrelated problem of coordination between stakeholders (Haron, 2013).

The integration of BIM in the building lifecycle is seen able to integrate the fragmented practices and promote changers in the business process (Aranda-Mena *et al.,* 2009). CIDB has proposed technology tools like BIM to improve the efficiency of the construction process. BIM is capable to generate error-free shop drawings to increase the support for standardization of prefabrication elements (Nath T. *et al.,* 2015).BIM application in construction project helps information collaboration between stakeholders during different phases of the project. In addition, BIM is more systematic even the information comes from different resources simultaneously.

1.3   Aim and Objectives

Complexity in the construction of IBS occurs by the gap between manufacturing industry and construction industry (Rahim *et al.*, 2012). Therefore, appropriate technology like BIM is indeed to close up the gap between these industries. This study is carried out to evaluate the implementation of BIM in IBS industry in Malaysia. These (3) objectives are formulated as follows:

i.   To identify the effectiveness of BIM functions in Malaysian IBS industry.
ii.   To determine the IBS work process in accordance to BIM functions
iii.   To develop IBS-BIM implementation framework in Malaysia.

1.4   Scope of Study

Nowadays, players in the construction industry have been exposed to the benefits of BIM because there are lots of studies focuses on the implementation of BIM in the construction industry. However, these studies need to be more specific since in Malaysia there are a conventional method and IBS method of construction. These two methods of construction have differences in term of material, process and parties involved. Therefore, in order to study the effectiveness of BIM in IBS, the focuses are given according to the work process.

IBS industry can be considered as a manufacturing process as the product is manufactured in a factory and assemble on the construction site. The combination manufacturing and construction industry create a massive documentation. BIM can be the tools to ease the data transferring as well as the communication between stakeholders.

Based on previous study by Latifi *et al* (2013) claimed that by applying BIM, improvement in planning, design and construction can be achieved. This statement is supported by Ismail *et al* (2012), which stated that BIM can contribute to the successful in management factor of IBS project by improvement in planning and scheduling, strategy, good working collaboration and business approach. In addition, a sophisticated tool like BIM can be solutions based on advanced ICT to improve productivity in IBS building maintenance work (Ismail *et al.,* 2015). A few researchers have considered BIM as tools that helping in improving the efficiency of IBS project, nevertheless, BIM need to revise through every stage of IBS process. By focussing on the comprehensive area desired can help in analyzing the level of acceptance of BIM in every stage in IBS process.

This study focuses on the perception of players that involves in IBS project and applying the BIM in their project. By investigating the perception of BIM-IBS practitioner, this study able to reveal the level of BIM acceptance in IBS industry. Interview session will be conducted with the targeted respondents are the four (4) group of architect, engineer, consultant, and contractor. The respondents were asked a certain question regarding the effectiveness of BIM. This study is conducted in peninsular Malaysia and limited to the IBS practitioner. Finally, a framework of to enhance the BIM implementation will be proposed.

1.5   Significance of Study

Malaysia's construction industry has lagged behind in technology aspect. Thus, the problem of productivity, quality and value have arisen (Zahrizan *et al.,* 2013). Construction industry itself is very complex and involving many parties. Immense amount of document and drawing exchange among the parties may create an error which can lead defect to occur in the final product. Adopting BIM in a project can help to facilitate the way of working and improve the data exchange between parties even the data has been changed, the data remains consistent and organized for all stakeholders to view. As a result, faster project approval which can help to save time and money.

Despite the potential of BIM to increase the efficiency, the adoption of BIM in IBS industry raises the concern due to the lack of awareness of BIM capabilities in IBS work process could be one of the reason implementation is still at the low level. Based on the outcome from this study, IBS practitioners able to understand how BIM are implement in every work process. This outcome is essential in order to developing plan of intriguing players in IBS industry to implement BIM in their project, therefore the effectiveness of BIM must be proven.

This study can be evidence of benefits BIM could bring to the organization in achieving their goals after investment in adopting this technology. The success story from IBS-BIM practitioner may harvest interest to others IBS practitioners. This study also can be the performance indicator of implementation of BIM in IBS industry in each the work process. CIDB shall use the information in this study as a guide to help speed up the adoption of BIM in Malaysia. The framework may be used by BIM committee to figure out on how to tackle IBS practitioners to utilize BIM into every work process.

1.6   Research Methodology

These are the sequence of stages involve in the development of study finding.

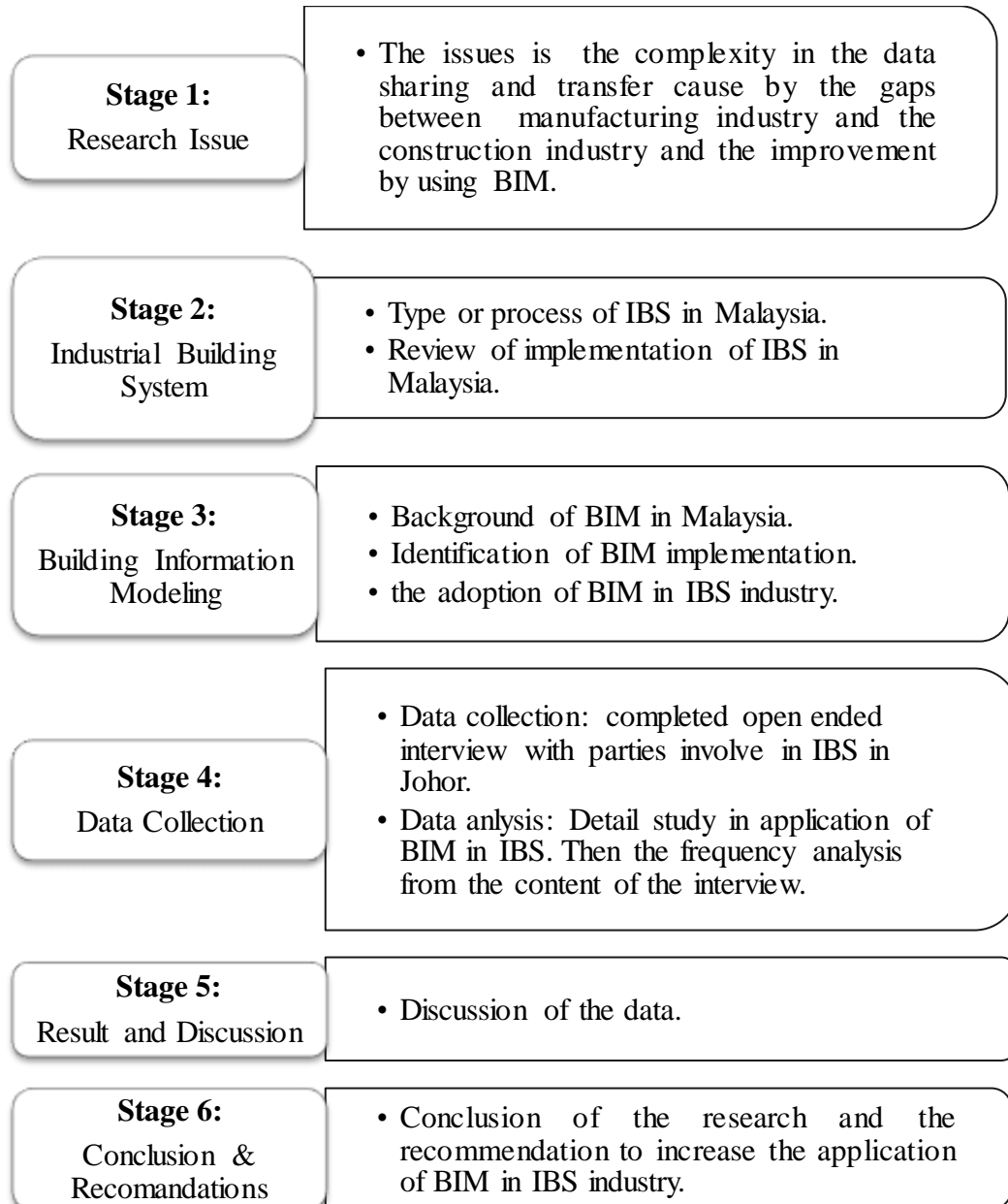| Stage 1: Research Issue	• The issues is the complexity in the data sharing and transfer cause by the gaps between manufacturing industry and the construction industry and the improvement by using BIM.
Stage 2: Industrial Building System	• Type or process of IBS in Malaysia. • Review of implementation of IBS in Malaysia.
Stage 3: Building Information Modeling	• Background of BIM in Malaysia. • Identification of BIM implementation. • the adoption of BIM in IBS industry.
Stage 4: Data Collection	• Data collection: completed open ended interview with parties involve in IBS in Johor. • Data anlysis: Detail study in application of BIM in IBS. Then the frequency analysis from the content of the interview.
Stage 5: Result and Discussion	• Discussion of the data.
Stage 6: Conclusion & Recomandations	• Conclusion of the research and the recommendation to increase the application of BIM in IBS industry.

Figure 1.1: Sequence stage of study

Stage 1: Identify the Research Issue

Research usually starts by identifying the issues raised. There are a few approaches to identify the issues such as based on experienced, discussion with the supervisor, reading articles regarding the current issues in the industry and find the research gap from the previous study. Resources on the topic can be accessed through online e-database from UTM's library website. In this stage, the objectives of the study are identified.

Stage 2: Literature 1 (Industrial Building System)

In this stage, all the information that need to this study like the background of IBS in Malaysia is collected in order to help the process of achieving the study objectives. Information is collected from various resources such as by reading material, journals and article. Besides that, Construction Industry Development Board (CIDB) website also provides vital information like a list of IBS Company in the area of the case study.

Stage 3: Literature 2 (Building Information Modeling)

Documentation regarding the BIM characteristic and application in Malaysia is important to achieve objectives of the study. Data is collected from journals, articles, convention paper, seminar paper and the internet. The concern of this chapter is to get information about BIM in Malaysia in order to get an accurate picture of the study area.

Stage 4: Data Collection

Background study in literature writing helps in determining the method of data collection. After the method of research is discovered, interview session will be conducted regarding the application of BIM to know the validity and reliability. Data is collected from 4 parties involve in IBS industry in Johor. By using content analysis, the result is measured.

Stage 5: Result and Discussion

From the data analysis, it is possible to know if the objective of this study is achieved. Every objective has a different method of analysis will be carried out. Analyzing method like content analysis, frequency analysis, and independent T-test, will be used in this study. For a better understanding, the result of the data analysis will be present in a graphical form such table, pie chart, and graph.

Stage 6: Conclusion and Recommendations

In this stage, the judgment of the study finding will be made to sum up whether the objective is achieved. Besides presenting the study finding, recommendation, limitation and suggestion of ideas for further this study is made.

1.7   Organization of the Project

This project contains seven (7) chapters. The following the outline of each chapter:

Chapter 1 is the introduction of the project. This chapter presents the background of the problem, objectives of the study, scope and limitation, significant of study, research design and the organization of the study.

Chapter 2 is the literature review focus on the Industrialised Building System. This chapter demonstrates discussion about IBS industry in Malaysia support by achievement, limitation, and reviews of the previous study.

Chapter 3 is literature review on Building Information Modeling which focuses on the issues that related to the BIM in Malaysia. In this literature study, review on BIM is made based on the previous study to support the background and rationale of the study.

Chapter 4 is on research methodology. This chapter focuses on the outline in collecting data for each objective. Every objective has a different way to collect data. This chapter also explains tests that need to be run in the process obtaining the result.

Chapter 5 is deal with result and analysis. In this chapter, the data that obtained from the interview sessions will be analyzed. Then, the result of the analysis is shown in graphical form such table, pie chart or bar chart.

Chapter 6 focuses on discussion of the result obtained. Extended review and discussion about the application of BIM in IBS will be made by asking why should apply this study in industry, who will get the benefits by this study, what is the

benefit of this study, where the study can be applied and when the study can be applied in the industry. These questions will be addressed in order to get a comprehensive discussion.

Chapter 7 is the conclusion of this study. In this topic, the summary for this study is made by state whether the objective is achieved or not. Next, the recommendation to improve this study is made for a further explores in future.

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