Potential Opportunities and Strategy of Building Information Modelling (BIM) in Malaysian Infrastructure Construction

Asmawan Mohd Sarman[1,2], Lim Chung Han[1,2#], Allan Lumberio Lim[1], Elis Mardzianah Mazlan[3], Muhammad Muizzuddin Mukhtar[1]

1 Faculty of Engineering, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, MALAYSIA.
2 Green Materials and Advanced Construction Technology (GMACT) Research Unit, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, MALAYSIA.
3 Development and Maintenance Department, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, MALAYSIA.
#Corresponding author. E-Mail: andrew.lim@ums.edu.my; Tel: +6088-320000; Fax: +6088-320348.

ABSTRACT This study mainly identifies the potential, opportunities and strategy of Building Information Modelling (BIM) in Malaysian infrastructure construction. The main objective of this study is to identify the barriers and strategies to overcome the implementation of BIM in the Malaysian construction industry, Sabah to be specific. The industry personnel have conducted an online survey through Google Forms. SPSS identified barriers, and correlation analysis was carried out. Besides, a bridge representing the infrastructure component is modelled to determine the interoperability of the available software in the market. Throughout the survey, it is evident that several issues that stall the implementation of BIM in the Malaysian construction industry are required to be addressed. While for the modelling part, software interoperability from different developers arises during the modelling process, which could also be a barrier in this topic.

KEYWORDS: Opportunities; Barriers; Strategy; Building Information Modelling; Civil Information Modelling
Received 12 March 2022 **Accepted** 12 April 2022 **Online** 15 September 2022

Original Article

INTRODUCTION

Malaysia is a developing country in which the construction industry is currently booming. The construction industry is seen as one of the main pillars of the country's economy. The construction industry is vital because it contributes approximately 3 to 5 per cent of the Gross Domestic Product (GDP) annually (Ali *et al.*, 2014). As the day goes by and the projects get more prominent, the industry seems to be a step behind the developed country regarding productivity, quality, and value. This slow progress is due to the construction industry in Malaysia being seen as the most problematic industry, such as cost overruns, delays, the production of low-quality products, intensive labour, and the use of outdated technology. These problems are due to the project's complexity as many parties are involved in the construction, hence arise the conflict in communication.

Information exchanged among them mainly involves a lot of documents and drawings. This practice creates errors because of the large number of documents and drawings as they are primarily in the paper-based format that is not adequately managed, resulting in miscommunication among them (Wikforss & Lofgren, 2007). Misinformation and miscommunication could stall the project's progress as it is time-consuming to revise the design.

Therefore, information management must be adequately managed to ensure every project section gets the correct information. The utilization of Building Information Modelling (BIM) is one of the platforms to achieve this objective. BIM is used to manage the knowledge of a building and has been mainly adopted for large-scale and commercial buildings (Sarman *et al.*, 2021). On 27 August 2007, the Malaysian government established the Public Works Department (PWD) committee to establish BIM and choose the right BIM platform to ensure interoperability (Latiffi, *et al.*, 2015). This study

was carried out to identify and be an exploratory study of the extent of BIM/CIM implantation in the Malaysian construction industry through literature review and interviewing industry personnel.

PROBLEM STATEMENT

When the geotechnical engineering projects started to be implemented as the development progressed in Malaysia, the construction industry hugely contributed to growth. As the days pass by, the Malaysian construction industry is falling behind in terms of technology development applied in the construction industry. The significant problems in the Malaysian construction industry are delayed construction period, design discrepancy, inefficient time management and cost overrun. One of the current technological advancements in the construction industry that could improve is Building Information Modelling (BIM). However, BIM Is widely applied in the construction industry in developed countries such as the United States of America, England and Singapore, whereby Malaysia's adoption of BIM is progressing at a slow pace. Singapore has its own national guideline to ease the implementation of BIM in the country (Zakaria *et al.*, 2013).

OBJECTIVES

The objectives of this research are:

a. To identify the barriers, opportunities of BIM application in Malaysian construction industry.
b. To identify the advantages of utilization between the current method and application of BIM.
c. To identify the applicability of BIM in infrastructure works specifically bridge construction.

SCOPE OF WORK

The main scope of this study is divided into two parts. The first part is to identify BIM's potential, opportunities, and strategies to infiltrate the Malaysian construction industry. Questionnaires were distributed among industry personnel. The questionnaires consist mainly of the current status of BIM/CIM utilization in the Malaysian construction industry and their understanding of BIM. While for the second part, it consists of project modelling. The project chosen for modelling in this study is a bridge. The bridge modelling will be conducted using Autodesk Revit. Data and information will be extracted from the model to be compared with the current design method. The comparison between conventional and CIM modelling is carried out to determine the project feasibility using CIM and other features of Autodesk Revit 3D, 4D and 7D.

METHODOLOGY

The data collection method will be discussed in this chapter. Data for this paper are obtained by literature review, circulation of questionnaires along with semi-structured interviews. Both approaches have collected information about BIM implementation in Malaysian construction projects.

The data collection for this study is divided into two methods, desk study in and out of Malaysia and industry-based survey analysis. The desk study has been carried out from the source, mainly journals and books regarding BIM. A comprehensive literature review has been conducted on the current status of BIM implementation in the construction industry in Malaysia to understand and identify the research requirements for this study. Besides that, a literature review was carried out to

collect information about the definitions, history, applications, current implementation status in the Malaysian construction industry, potential, opportunities, and benefits of BIM.

While for the industry-based survey analysis, a set of questionnaires regarding BIM will be distributed among industry personnel, mainly government officials (development unit) and engineering consultant firms. The interview will also be conducted among the industry personnel to understand the ground-level status of BIM implementation better.

RESULT AND DISCUSSION

Questionnaire Analysis

The questionnaire is divided into five parts, in which the first part consists of questions regarding the participants' background qualifications and experience. For the second part, the questions consist of matters regarding the participant's general knowledge of Building Information Modelling (BIM) / Civil Information Modelling (CIM).

For the third part, the questions are regarding the benefit and barriers of BIM implementation in Sabah's construction industry. While for the fourth part, the questions are regarding possible suggestions for improving the outreach of BIM implementation in Sabah's construction industry. The fifth part consists of questions regarding the BIM infrastructure construction industry.

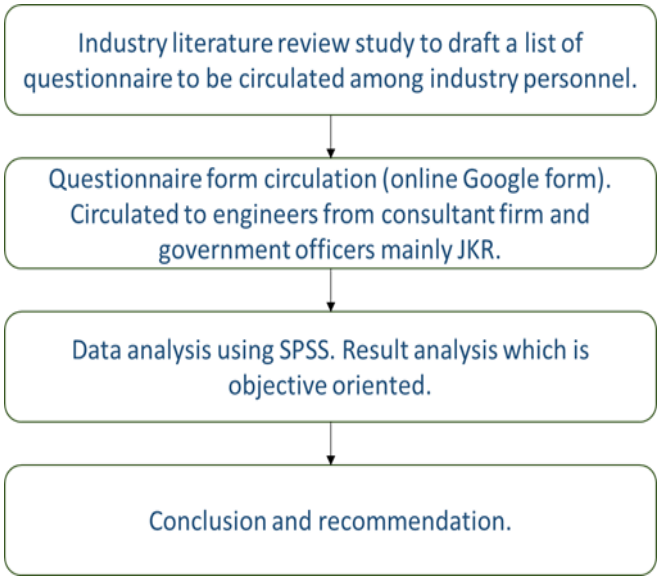

Figure 1. Questionnaire and survey analysis workflow

Analysis of Correspondent Industry Sector Against Familiarity with BIM

Table 1 shows a tabulated correlation between familiarity with BIM and the corresponding industry sector. Out of 51 correspondents, those who perceived themselves with a fair amount of knowledge regarding BIM is ten out of fifty-one, which is 19.61%. While those who have minimal knowledge about BIM are 64.70%, and those who never heard of BIM are 15.69%.

This correlation between these two variables indicated industry personnel's depth of knowledge and understanding of the topic. According to the data, the outreach of BIM among industry players seems to be very slow. The Public Work Department (PWD) has been assigned a committee since 2007 in charge of handling matters related to BIM (Jabatan Ukur dan Pemetaan Malaysia, 2022).

Even with PWD's inception of the committee, the expansion and outreach of BIM seem to be slow. Factors contributing to the slow development will be analysed later on.

Table 1. Cross tabulation of correspondent industry sector and familiarity with BIM Using SPSS

Industry_Sector * Familiar_with_BIM Crosstabulation

		Familiar_with_BIM			
		I have fair knowledge about BIM	I have minimal knowledge about BIM	Never heard of BIM	Total
Industry Sector	Consultant	2	16	2	20
	Contractor	5	11	5	21
	Developer	1	1	1	3
	Government	2	5	0	7
Total		10	33	8	51
Percentage		19.61	64.70	15.69	100

Analysis of Correspondent Industry Sector Against Knowledge and Understanding of BIM

Table 2. Cross tabulation of correspondent industry sector and knowledge and understanding of BIM

Industry_Sector * Knowledge_and_understanding_of_BIM Crosstabulation

Count

		Knowledge and understanding of BIM					
		1	2	3	4	5	Total
Industry Sector	Consultant	5	5	10	0	0	20
	Contractor	4	5	7	4	1	21
	Developer	0	1	1	0	1	3
	Government	3	1	1	2	0	7
Total		12	12	19	6	2	51
Percentage		23.53	23.53	37.25	11.76	3.93	100

Analysis Tabulation between Industry Sector and Willingness to use BIM in the Future

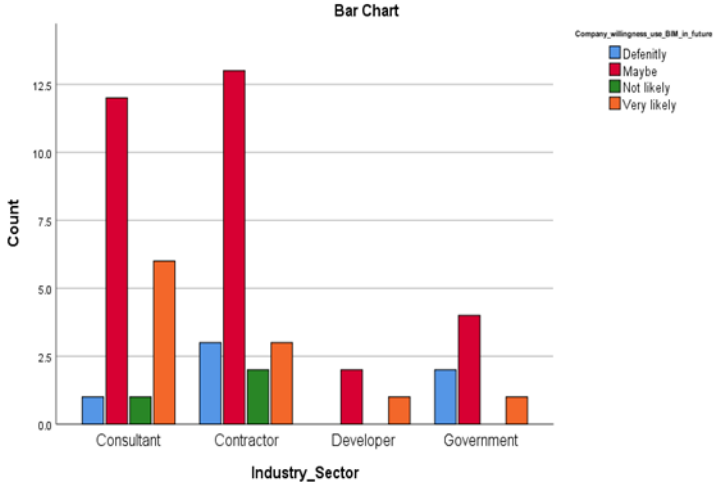

Figure 2. Correlation between industry sector personnel and willingness to use BIM in the future

Figure 2 show correlation between industry personnel willingness to use BIM in the future. The figure above indicates that most of the industry personnel is uncertain either to implement BIM or

not in the future. Among the consultants, it indicates that 60% is uncertain to implement BIM in the future and upcoming projects. However, it also shows that 30% is looking forward to implement BIM in the future. While for the contractors, the doubt of using BIM in the future is 61.9% which is considerably high as it can highly improve the after-project completion facility management.

Based on the literature review, among the contributing factors that that affects the willingness of industry personnel in involving themselves in BIM is cost factor. Setting up BIM consultant firm involves high initial cost in which will be spent on training and investment on software. Other than that, lack of knowledge and local expert in BIM to conduct training will involve high cost as trainers has to be obtain from overseas.

Analysis of How does BIM Potentially Improve Project Implementation

This questionnaire section specifies how BIM could potentially improve the construction industry project implementation. Both options, which is BIM enhances operation performance and encourages better collaboration, shared the same number of correspondents agreed to it, 50 out of 51 correspondents. The majority of the correspondents agreed that BIM enhances operation performance (refer Figure 3 for clarity). One of the functions available in BIM is computer-generated work scheduling. This optimises the project's time management, construction planning and material management as all of these aspects of the project are generated within BIM.

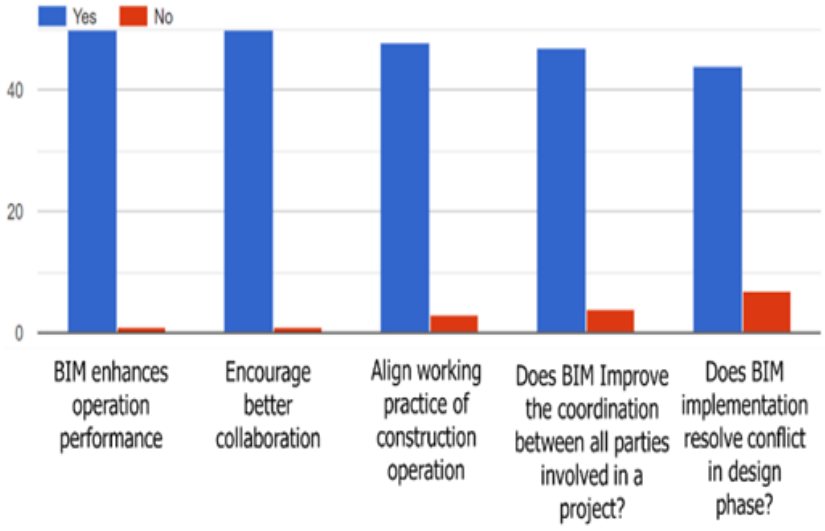

Figure 3. How BIM could potentially improve project implementation

This optimisation highlights the exclusive function available in BIM, which involves computerised analysis, including information in the modelling and management of all aspects of the project. One of the highlights of this questionnaire section is whether it improves coordination between all parties involved in a project. Of the total correspondents, 94.11% agreed to it. This is possible within BIM as BIM provide a niche of software that all parties involved in the project could access and share information, amend adjustment and develop the design simultaneously within the design team.

In conjunction with the above, 88.0% agreed that BIM implementation resolves conflict in the design phase. Among the features of BIM is the architecture design, civil and structure design and mechanical and electrical design are modelled in a single model, which reduces time in design crosschecking. Therefore, issues such as design discrepancy, design clash and structure inconsistency could be decreased within BIM.

Analysis of Which Aspect of Infrastructure Works Could Be Improved by Application of BIM

Figure 4 shows the components of civil and infrastructure works that could be improved by applying BIM. For the consultants, it indicates that there are looking to utilize the 3D modelling function of CIM. Most correspondents agreed that 3D modelling in CIM could improve the industry. Of all the contractors, 38.1% are looking to capitalize on the budget estimation aspect of CIM. While for the developers, 66.7% are looking to improve from the currently available system in modelling. Lastly, the government sectors are looking to capitalize on the modelling aspect of CIM, with 57.1% opting for it.

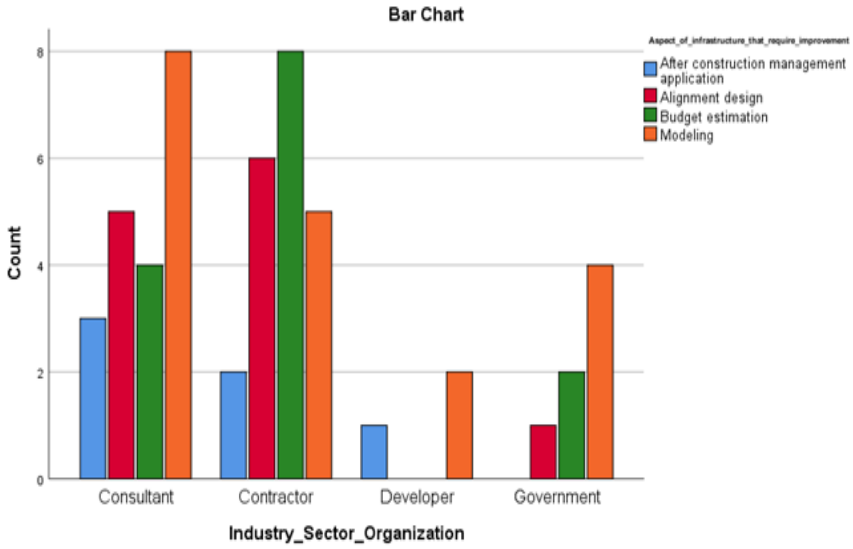

Figure 4. Correspondent Response to Which Aspects of Infrastructure Works Could Be Improved by Application of BIM

As the result shows, personnel from different sectors are looking to utilize various aspects of CIM, which could be operated in a niche of family software that could interact with one another. Through the CIM system, the system could include all components in a family of software in which adjustment of any aspect of the project will simultaneously update the other elements. Taking responsibility for updating building information model data and ensuring its accuracy entails a great deal of risk (Azhar, 2011). This update reduces the time consumed in an adjustment of other components hence reducing time for amendment, increasing the performance rate, and improving the time management in conducting the project.

Modelling Analysis

A 3D modelling has been designed to identify the interoperability of the currently available software in the market as shown in Figure 5. Parametric modelling is the essence of the full application of BIM in practice. It allows quick implementation of changes in 3D model when it is necessary during the interdisciplinary coordination process (Czmoch & Adam, 2014). The main objective of this modelling is to determine how CIM works in a family of software and to include information in the model. The software that has been used in this study is Google Earth Pro to obtain a topographic satellite survey, Global Mapper 20 to create a digital elevation model, Autodesk Civil 3D to build a bridge alignment and topographical plan, Bentley's LEAP Bridge Concrete CE V18 to design a bridge and Autodesk Revit 2019 to include information in the mode and create a 3D model of the project.

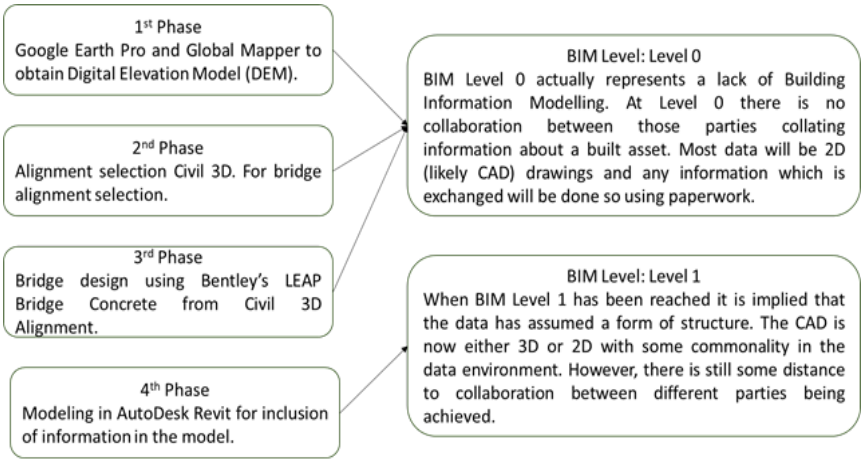

Figure 5. Modelling Workflow and Objective Findings from the Model

There are not many challenges for the first three-phase modelling process as it only includes topological mapping and alignment design. The challenges arise when the bridge model in LEAP Bridge Concrete produces drawings in a .dgn file which is not compatible with AutoCAD 2019 and Revit 2019. Since the software could not import the picture generated from the model into Revit 2019, I had to remodel the bridge in Revit. Other than that, information in the model could be included in the schedule function of Revit 2019. It enables the inclusion of information in the model which is not available in the current design system.

CONCLUSION

The data collection is divided into two parts: quantitative for the survey section and qualitative for the modelling section. For the quantitative result, an analysis was carried out using IBM SPSS Statistic 25, and a conclusion was drawn. The quantitative area of this study is used to satisfy objectives a and b. While the quantitative data, which is from the modelling in which the compatibility of different software is tested in creating a single model, is carried out to satisfy objective c. The survey also includes a qualitative section in which correspondents are asked about the possible strategy that could be applied to expand the outreach of BIM.

The responses from the correspondents on the barriers to BIM indicate that the significant issue that stalls the implementation of BIM is the lack of understanding, knowledge, and awareness of the benefit and advantages of utilizing BIM. Lack of local expertise issue also is brought forward by the correspondents as a significant constriction. The lack of local experts means that a high cost is required in hiring experts from abroad. Other than that, a high initial investment cost is required to start a firm competent and well versed in BIM. Training costs, investment in software and change in the existing working system caused the construction industry to lose interest in tiny firms. In addition, without client demand, it will be hard to implement BIM to the construction industry (Memon *et al.*, 2014).

Even though we are still in the infant stage of the application of BIM, some industry personnel are aware of the advantages of the application of BIM. One of the main features of modelling in BIM is incorporating different aspects of the project, which is designed by other design teams. The modelling is among the features that correspondents are looking to utilize for the consultants, with the majority of 40.0%. While for the contractors, 38.1% are looking forward to using the budget estimation of the project. Other than that, the developers, 66.7%, are looking to improve the

currently available system in modelling. Lastly, the government sectors are looking to capitalize on the modelling aspect of CIM, with 57.1% opting for it.

Lastly, for section c of the objective, a model is created to identify the applicability of BIM in infrastructure works and software interoperability. The infrastructure designed in this study is a bridge. The bridge was initially developed using Bentley's LEAP Bridge Concrete for structural analysis and remodelled in Autodesk 2019 to include information in the model. The problem in the modelling only occurs when the drawing design produced by Bentley's LEAP Bridge Concrete is not compatible with Autodesk. The different files show that we could not import the model design from Bentley's LEAP Bridge Concrete to Autodesk Revit 2019. This incompatibility means remodelling of the bridge in Revit 2019 is required.

REFERENCES

[1] Ali, M., Haron, T., & Marshall-Ponting, A. 2014. Exploring the Barriers and Driving Factors in Implementing Building Information Modelling (BIM) in the Malaysian Construction Industry: A Preliminary Study. *The Journal of the Institution of Engineers, Malaysia*, 75(1), 1–10.

[2] Sarman, A. M., Jaison, C., Mazlan, E. M. & Nazeri, N. N. 2021. Potential and Opportunities of Building Information Modeling (BIM) For Housing Maintenance. *IOP Conference Series: Materials Science and Engineering*, 1176(2021), 012041.

[3] Azhar, S. 2011. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges of the AEC Industry. *Leadership and Management in Engineering*, 11(3), 241–253.

[4] Czmoch, I. & Adam, P. Ċ. 2014. Traditional Design versus BIM Based Design. *Procedia Engineering*, 91, 210-215.

[5] Jabatan Ukur dan Pemetaan Malaysia. 2022. *Pelan Strategik 2016-2020* (https://www.jupem.gov.my/v1/wp-content/uploads/2016/12/Pelan-Strategik-2016-2020-JUPEM-1.pdf). Last accessed on 3 March 2022.

[6] Latiffi, A. A., Mohd, S., & Brahim, J. 2015. Application of Building Information Modeling (BIM) in the Malaysian Construction Industry : A Story of the First Government Project. *Applied Mechanics and Materials*. 773-774, 943–948.

[7] Memon, A. H., Rahman, I. A., Memon, I., & Azman, N. I. A. 2014. BIM in Malaysian construction industry: Status, advantages, barriers and strategies to enhance the implementation level. *Research of Journal of Applied Sciences, Engineering and Technology*, 8(5), 606–614. https://doi.org/10.19026/rjaset.8.1012

[8] Wikforss, O. & Lofgren, A. (2007). Rethinking communication in construction. *Journal of Information Technology in Construction*, 12, 337–345

[9] Zakaria, B., Ali, M., Haron, T., Ponting, M., Zakaria, B., Ali, M. Hamid, A. 2013. Exploring the adoption of Building Information Modelling (BIM) in the Malaysian construction industry : A qualitative approach . *International Journal of Research in Engineering and Technology*, 2(8), 384-395.