ADOPTION OF BUILDING INFORMATION MODELLING (BIM) ON RAILWAY TRANSPORTATION PROJECT IN MALAYSIA

By

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A dissertation submitted to the Department of Surveying,
Faculty of Engineering and Science,
Universiti Tunku Abdul Rahman,
in partial fulfillment of the requirements for the degree of
Master of Project Management
April 2018

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DECLARATION

I hereby declare that this dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this dissertation entitled **"ADOPTION OF BUILDING INFORMATION MODELLING (BIM) ON RAILWAY TRANSPORTATION PROJECT IN MALAYSIA"** was prepared by **NG WEI YEAN** has met the required standard for submission in partial fulfilment of the requirements for the award of Master of Project Management at Universiti Tunku Abdul Rahman.

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Signature : ______________________________

Supervisor : ______________________________

Date : ______________________________

Specially dedicated to

my beloved family and colleagues

ABSTRACT

ADOPTION OF BUILDING INFORMATION MODELLING (BIM) ON RAILWAY TRANSPORTATION PROJECT IN MALAYSIA

Ng Wei Yean

This research is aimed to explore the implementation of Building Information Modelling (BIM) in construction industry, especially railway projects in Malaysia. One of the objectives of this research is to determine the level of adoption of BIM in Malaysian construction industry. Subsequently, this research is also to identify the benefits and barriers of using BIM on railway projects in Malaysia. A set of questionnaire was developed through literature review and revised with comments from practitioners was then distributed to approximately 120 respondents. However, 90 responses were successfully received. Out of these 90 respondents, 42 respondents are BIM users while 48 respondents are non-BIM users. From the results obtained, we can say that the level of BIM adoption in Malaysian construction industry was between Level 1 and Level 2. Further analysis and discussion on the BIM users were made to fulfil the objectives of this research. The results of analysis show that, the top three benefits that can be gained in implementing BIM are better visualization of a design, better understanding of concept and feasibility of a project and improve project quality. On the other hand, the top three barriers that they may face during the implementation of BIM are high initial cost of software, high cost of implementation process and challenges of collaboration with other disciplines. This research can provide extra knowledge of BIM implementation for the construction industry players. Besides, it is also can be a reference for academicians to conduct further study on similar research. In a nutshell, this research investigated the implementation of BIM on railway projects in Malaysian construction industry.

ACKNOWLEDGEMENTS

I would like to thank everyone who had contributed to the successful completion of this project. I would like to express my gratitude to my research supervisor, Mr. Lim Chai Chai for his invaluable advice, guidance and his enormous patience throughout the development of the research.

In addition, I would also like to express my gratitude to my loving parent and colleagues who had helped and given me encouragement during this study.

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysian construction industry plays an important role in contributing to the growth of Malaysia's economy. However, in the era of globalisation, the Malaysian construction industry needs to evolve. Nowadays, the Malaysian construction industry is facing huge challenges from the communities to increase their productivity, efficiency, quality and value. The Malaysian construction industry must upgrade and improve the current construction approach, whether in terms of practice, management or technology, in order to be globally competitive. This is because since the 1960's, construction industry has not transformed much in terms of technology or construction approach. It was still depending on traditional approaches and relies heavily on foreign labour. This caused many problems or issues in the Malaysian construction industry.

Besides that, since the construction process was complex and involved many parties, these also became reasons for the issues happened in the construction industry, such as cost overrun, delay of project delivery and the production of low quality products (CIDB, 2009 and Zaini, 2010).

Information exchanged among parties participated in a project mostly involves a lot of documents and drawings. This practice would create errors where the large quantity of documents and drawings are mostly in paper-based format which are not properly managed. Thus, miscommunication among themselves will be happened (Wikforss & Lofgren, 2007). Having wrong information in the construction process could create difficulties to the productivity of projects. This is because information can be considered as the most important construction “material” for a construction project. Therefore, there is the need for managing the information properly to ensure all parties in the construction projects receive the right information.

In order to improve and transform the current situation in the Malaysian construction industry, the implementation of Building Information Modelling (BIM) is one of the platforms to increase the productivity and minimise the errors that could be happened in a construction project (Kaner, et al., 2008 and Khanzode, et al., 2008).

Many construction key players in Malaysian construction industry would consider BIM as a new technology. This is because BIM was not widely used in current market. Usually, a two-dimensional (2D) design or drawing that has been approved for construction (i.e. Issue For Construction drawing) would be checked manually on site. This method was more time consuming, especially for complex designs or complex projects. By using this traditional method, manually checking for discrepancies in designs were involved and it was depends on the complexity of the designs or project.

On the other hand, BIM can be described as the process which involving to create and use three-dimensional (3D) parametric computer-aided-design (CAD) technologies for design. This can ease all the construction project team players to exchange design information in a digitalised model, i.e. BIM model (Eastman, et al., 2011 and Taylor & Bernstein, 2008). This model was convenient to use and can be passed easily not only among the consultants, but also other players involved in the construction projects. This leads to the coordination among the team members can be ensured (Kymmell, 2008).

1.2 Problem Statement

The adoption of BIM is getting more frequently used in construction industry. However, the implementation of BIM in Malaysia construction industry is still lagging behind compared to other countries. There are many researches studied on the adoption of BIM in buildings, such as existing building by Tristan, et al., (2017), medical research lab by Manning and Messner (2008) and sustainable building by Krygiel and Nies (2008). Besides, there is few research works studied on the adoption of BIM in infrastructure projects, such as bridge construction by Blaine, et al. (2015).

However, there is very few evidence to show the percentage of construction players implementing BIM in their construction projects, especially railway projects in Malaysia context.

Therefore, this research is to study the implementation of BIM on railway projects in Malaysia. Due to the researcher of this research involved in two railway projects in real working life as the progress of this research, namely the Klang Valley Mass Rapid Transit (KVMRT) Line 2 (SSP Line) Project and Gemas to Johor Bahru Electrified Double Track Project (GJBEDTP). Thus, these would be used to collect data from the practitioners or key players from these two projects to achieve the objectives of this research.

1.3 Research Aim

The aim of this research is to explore the implementation of BIM on construction projects, especially railway projects in Malaysia's construction industry.

1.4 Research Objectives

The objectives of this research are as follows:

a) To determine the level of adoption of BIM in Malaysian construction industry.
b) To identify the benefits of using BIM on railway projects in Malaysia.
c) To examine the barriers faced during the implementation of BIM on railway projects in Malaysia.

1.5 Research Scope

This research focused only on the construction industry of Malaysia. Besides that, respondents from various backgrounds in construction industry were invited to give their feedback in this research. However, the majority of the works was more focused on the two railway projects as stated above, namely Klang Valley Mass Rapid Transit (KVMRT) Line 2 (SSP Line) Project and Gemas to Johor Bahru Electrified Double Track Project (GJBEDTP) and majority of the feedbacks was also from the parties involved in that two projects.

1.6 Significance of Research

This research is to study the adoption of BIM in Malaysian construction industry. Therefore, the findings from this research can be served as an extra knowledge to the key players of Malaysian construction industry who willing to implement BIM in their organisations. In addition, this study discussed the benefits that can be gained and also issues that might need to overcome for a construction project if they planned to implement BIM.

Apart from that, this research can also be useful for academicians. As there is no prior research study on the implementation of BIM on railway projects in Malaysia. Thus, this research can serve as a support or reference to provide information for further researchers who are willing to study on similar case or research.

1.7 Layout of Research

This research consists of five chapters. The content of each chapter is as follows:

Chapter 1 – Introduction

Chapter 1 introduced the research background, problem statement, research aim, research objectives, research scope, significance of research and layout of research.

Chapter 2 – Literature Review

The previous research or studies from published papers, articles and journals will be discussed in this chapter. In addition, chapter 2 focused on the review of literature related to this research, such as BIM processes, adoption of BIM, BIM tools, benefits and barriers in implementation of BIM.

Chapter 3 – Research Methodology

This chapter described the research approach used to develop and achieve the objectives of this research. It described the research method, research instrument, survey sample, survey questionnaire and data collection.

Chapter 4 – Results and Discussions

This chapter analysed and discussed the data collected from the questionnaire survey by using appropriate techniques, such as Cronbach's Alpha test, Relative Importance Index (RII), and presented by using charts and tables.

Chapter 5 – Conclusions and Recommendations

This chapter summarised and concluded the research related to the research objectives. In addition, this chapter presented the limitation of the research and recommendations for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Construction Industry Transformation Programme (CITP) 2016 - 2020 was the Malaysia’s national agenda which aimed to transform the construction industry into a highly productive and environmentally sustainable together with globally competitive key players and driven by the Ministry of Works (CIDB, 2017). Under this programme, Construction Industry Development Board (CIDB) was responsible for leading, managing and assisting the implementation of CITP. Basically, there were four strategic thrusts which consisted of 21 initiatives in total to transform the construction industry in Malaysia as shown in the Table 2.1 below.

Table 2.1: Initiatives of Strategic Thrusts in CITP (CIDB, 2017)

Strategic Thrust	Initiatives
Quality, Safety and Professionalism	Q1: Increase emphasis on quality and implement quality assessments Q2: Improve workplace safety and workers' amenities Q3: Improve ease of doing business by addressing regulatory constraints Q4: Promote and raise awareness of CITP initiatives Q5: Enhance integrity and increase governance
Environmental Sustainability	E1: Drive innovation in sustainable construction E2: Drive compliance to environmental sustainability ratings and requirements E3: Focus on public projects to lead the charge on sustainable practices E4: Facilitate industry adoption of sustainable practices E5: Reduce irresponsible waste during construction
Productivity	P1: Continue investment in human capital development in construction P2: Enhance control and balance of workforce supply P3: Accelerate adoption of IBS, mechanization and modern practices P4: Roll out technology advantage across project life-cycle P5: Enhance availability of strategic information via National Construction Industry Information (NCIIC) P6: Advance SME/Bumiputera capacity and capacity building
Internationalisation	I1: Internationalise construction practices and standards I2: Strengthen access to financing for Malaysian champions going abroad I3: Support consortia formation and strengthen overseas market intelligence I4: Intensify contractor's capacity and capability building I5: Elevate the use of Malaysian construction resources in local and overseas projects

In the era of digitalisation, construction industry must carry out some changes to stay more competitive. In order to transform the construction industry, new technology and modern construction would be the key factor to bring in an improved performance in construction industry and thus, a better global competitiveness can be developed. In such case, information communications technology (ICT) can be utilised to transform the construction industry which was still preferring the traditional approach. There were many methods available in nowadays, one of the platform to transform the construction industry is by utilising Building Information Modelling (BIM).

In Malaysia, BIM was first introduced by the Director of Public Work Department (PWD) in 2007 (JKR, 2013). This is because the government aware of the BIM can bring to the reduction of construction cost and also the design related problems in planning phase of a construction project can be prevented (Latiffi, et al., 2013). Although the implementation of BIM could bring many advantages for a construction project, it is also being hindered by several factors (Kherun, et al., 2013).

On 27th August 2007, PWD committee was established by the government to ensure the level of interoperability and standardisation of work methods by using BIM can be developed for all the parties involved for a construction project (JKR, 2013).

In Malaysia, the first project that utilised BIM was the Multipurpose Hall of Universiti Tun Hussein Onn Malaysia (UTHM) in the Southern region of Malaysia (CREAM, 2012). According to Latiffi, et al. (2013), there are other projects which utilised BIM as well. For instances, the National Cancer Institute of Malaysia, Educity Sports Complex in Johor, Healthcare Center Type 5 in Pahang, Administration Complex of Suruhanjaya Rasuah Malaysia (SPRM) in Selangor and others.

“Property developers will be mandated to use BIM by 2020 for their construction works”, statement pressed by the chief executive officer of CIDB, Datuk Ahmad Asri Abdul Hamid in November 2016. In addition, “Beginning 2019, public projects worth RM100 million and above would be required to use the Building Information Modelling (BIM) system”, said by Works Minister Datuk Seri Fadillah Yusof in the Construction Information Modeling Center (myBIM) on 20 November 2017 (Nurafizah, 2017). These aligned with the aim of CITP which is to transform the Malaysian construction industry with the implementation of BIM by 2020 (CIDB, 2016).

2.2 Building Information Modelling (BIM)

There are many definitions of BIM by various researchers. BIM can be defined as the process of generating and managing building data throughout its life cycle (Enegbuma, et al., 2014). According to Latiffi, et al. (2013), the effectiveness of a construction project can be managed by using a set of digital tool such as the BIM. In addition, Sawhney (2014) defined that the BIM was not just a software tool or a simply technology, it was a modal that could combine technology with people and processes in the industry. BIM was a mixture of advanced processes and technology that can promote the collaboration among the parties involved in a construction project (Zahrizan, et al., 2014). BIM has many meanings and can be defined in different ways. Table 2.2 shows some of the meaning of BIM defined by different researchers in previous research.

Table 2.2: BIM Definitions by Researchers

No	Statement	Author
1	The process of generating and managing building data during the building's life cycle	Enegbuma et al. (2014)
2	BIM is not just a software tool or simply a technology that can be acquired and implemented.	Sawhney (2014)
3	BIM is one of the new emerging technologies to be deployed in design, construction and facility management, where a digital representation of the building is created to facilitate the exchange and interoperability of information in digital format	CREAM (2014)
4	Building Information Modelling (BIM) represents the formation of digital models for use during the planning, design, construction and operation stages of a facility's life	Thurairajah et al. (2013)
5	A set of digital tools that can manage the construction project's effectiveness	Latiffi et al. (2013)
6	BIM can be viewed as a combination of advanced process and technology that offers a platform for collaboration between different parties in the construction project by exploiting the uses of Information Technology (IT).	Zahrizan et al. (2014)
7	The utilisation of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders	Arayici et al. (2012)

However, BIM in the Malaysian context can be defined as "A modelling technology and associated set of processes to produce, communicate, analyse and use of digital information models throughout construction project life-cycle" (CIDB, 2016).

2.3 BIM Processes

BIM is a methodology which involves the following processes of different stage of a construction project (CIDB, 2016):

a) during the design stage, the digital model is created,

b) in construction stage, the model is develops progressively or always up-to-date, and

c) the model is used throughout the operation and maintenance stage.

In order to develop a digital model or BIM model, it was important to gather all the parties involved in a construction project in early stage to create a better collaboration. Definitely this would improve the productivity and efficiency of the project. BIM was needs to be involved in the early stage of a project, as early as the design stage. This is to ensure that the model was reliable and enriched with data will be used throughout the project life-cycle (CIDB, 2016).

According to CIDB (2016), the BIM processes evolved in few stages and it was depending on the level of information collaboration. The maturity of BIM process was determined by the process of collaborated information. Figure 2.1 shows the BIM maturity and implementation processes.

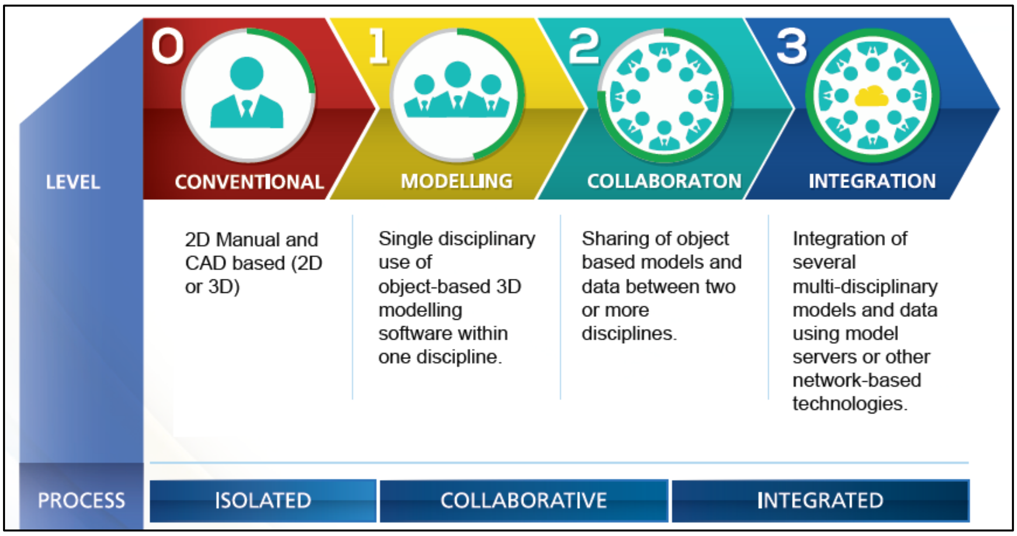

Figure 2.1: BIM Maturity and Implementation Process (CIDB, 2016)
(Source: https://www.mybimcentre.com.my/download/bim-guide-book-1/)

The further or detail explanation of the BIM maturity level is shown in Figure 2.2.

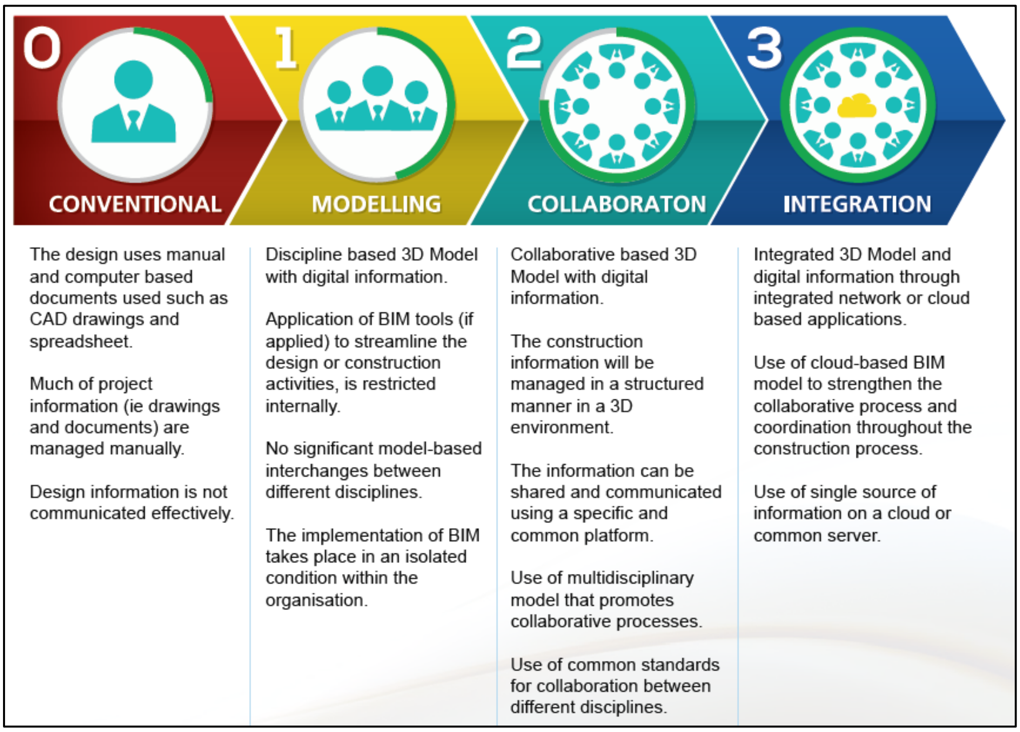

Figure 2.2: Detail Explanation of BIM Maturity Level (CIDB, 2016)
(Source: https://www.mybimcentre.com.my/download/bim-guide-book-1/)

The BIM model would be different as it evolved progressively throughout the project life-cycle. This can be categorised into six stages as follows:

Stage 1: Concept Stage (also known as the massing model)

This stage involved only the surface and shape of building.

Stage 2: Preliminary Stage

This stage involved space planning.

Stage 3: Detail Design Stage

This stage involved comprehensive design for tender purpose.

Stage 4: Construction Stage (also known as construction model)

This stage involved comprehensive design for construction.

Stage 5: Detail Information Stage

BIM model at this stage consists of comprehensive data and it is used to support the construction.

Stage 6: Facility management Stage (also known as operation and maintenance model)

BIM model at this stage consists of comprehensive data and it is used to support the asset and facility management.

By implementing BIM, the data of a construction project can be managed in a more systematic way. This is because the BIM model was a 3D model which enriched with building information as the design and construction of the project are the same as they are built. The model was always up-to-date or revised with any changes happened.

2.4 BIM Tools

Due to the complexity of gathering relevant information on a construction project with BIM, it was important that a BIM framework needs to be developed, so that all the parties involved can be worked closely with each other.

In order to support BIM process, BIM tools are necessary to be utilised. Due to the BIM process involves many procedures, such as creating, managing, analysing and using the model throughout the project lire-cycle, thus it is essential for the key players involved in a construction project to use BIM software to generate and exchange information, as well as to collaborate with each other.

According to CIDB (2016), the two main categories of BIM software to be used for the modelling process are the primary tools and supporting tools. Primary tools, in other words, design authoring software were the BIM authoring tools that provide a common platform for designers to create and manage the BIM model. It was usually depends on the nature of the designers, such as architect, structural, civil, electrical, mechanical and other disciplines involved in a project. On the other hand, supporting tools was additional tools that required based on the specific purpose and objective, such as analysis, estimation, visualisation, simulation and coordination. Table 2.3 and Table 2.4 show the example of primary tools and supporting tools available in market respectively.

Table 2.3: Example of Primary Tools

Product Name	Provider	BIM Uses	Category	Website Link
Allplan Architecture Allplan Engineering	Nemetschek	Universal BIM planning tool with extensive CAD functionality. Supports the entire planning process in engineering and design offices, as well as construction companies	Architecture	www.allplan.com www.nemetschek.com
ArchiCAD	Nemetschek Graphisoft	Focus on architecture, design, and creativity, combined with cutting-edge technology and innovation, allowing architects to design buildings.	Architecture	www.graphisoft.com www.nemetschek.com
AutoCAD AutoCAD Architecture AutoCAD Mechanical AutoCAD Electrical AutoCAD Civil 3D	Autodesk	2D and 3D computer-aided design and drafting software application used in architecture, construction, and manufacturing to assist in the preparation of blueprints and other engineering plans.	Architecture Structural MEP	www.autodesk.com
CypeCAD / CypeCAD LT Cype 3D	Cype	Analysis and design of reinforced concrete and steel structures	Structural	www.cype.com
CypeCAD MEP	Cype	Design of the envelope, distribution and services of the building	MEP	www.cype.com
Graitec Advance BIM Designers Advance CAD Advance Concrete Advance Steel	Graitec Group	Superior solution for the structural analysis and design of Reinforced Concrete, Steel and Timber structures.	Structural	www.graitec.com
Microstation	Bentley	Provides the power & versatility to precisely view, model, document, & visualize information-rich 2D & 3D designs of all types and scales for professionals in every discipline on infrastructure projects of every type.	Architecture	www.bentley.com
Revit Architecture Revit Structure Revit MEP	Autodesk	Supports BIM workflow from concept to construction. Use for modeling designs with precision, optimize performance, and collaborate more effectively. Also a 4D BIM capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later demolition.	Architecture Sructural MEP	www.autodesk.com
Renga Architecture	Ascon Group	Focused on making design comfortable, and on making all tools available in 3D.	Architecture	www.rengacad.com www.ascon.net
SketchUp Pro	Trimble	Mainly for concepting, visualization, communication, and planning. An intuitive way to design, document and communicate your ideas in 3D.	Architecture	www.trimble.com www.sketchup.com
Tekla Structures	Trimble	Models created in the software carry the accurate, reliable and detailed information needed for successful construction execution.	Structural	www.tekla.com www.trimble.com
TiffinBIM Architecture TiffinBIM Structure TiffinBIM MEP	Innovacia Sdn Bhd	A local product powered by European technology, used for the object-oriented creation of architectural plans and sections, interactive 3D previews and realistic visualisation.	Architecture Structural MEP	www.innovacia.com.my www.tiffinbim.com.my www.tm2u.com
Vectorworks Architect	Nemetschek	Offers a full range of design and documentation capabilities with a user-friendly interface	Architecture Engineering	www.vectorworks.net www.nemetschek.com

(*Source: https://www.mybimcentre.com.my/download/bim-guide-book-2/*)

Table 2.4: Example of Supporting Tools

Product Name	Provider	BIM Uses	Category	Website Link
3ds Max Maya	Autodesk	The 3D software for modelling, animation, & rendering that allows you to create massive worlds in games and stunning scenes for design visualization & presentation.	Architecture Design visualization	www.autodesk.com
Allplan Allfa	Nemetschek	A browser-based CAFM software	Facilities Management	www.allplan.com www.nemetschek.com
Accubid Enterprise	Trimble	Emulate and optimize the project lifecycle from bid to completion. Use bid data to quantify changes.	Quantity Surveyors MEP	www.trimble.com www.accubid.com
Allplan BCM	Nemetschek	Simple, straightforward software solution for your construction cost planning, tenders, allocation and accounting.		www.allplan.com www.nemetschek.com
ArchiBus	ArchiBus	Simplify work, without adding technical complexity, by automating the flow of information from property design & build phases - to full asset lifecycle management of the global portfolio.	Facility and Asset Management Sustainability	www.archibus.com
Arquimedes	Cype	Tool for Project Management: bills of quantities, project certifications and specifications.	Quantity Surveyors Contractors	www.cype.com
Cadastral Mapping Software	Bentley	Take control of your data capture, management, processing, provisioning, and analytical requirements.	Structural Existing Condition Modelling	www.bentley.com
CAFM	McLaren Software	A fully integrated FM Application Suite for Safe, Efficient and Compliant Facilities.	Facility and Asset Management Sustainability	www.cafmexplorer.com
Cost X	Exactal	Taking advantage of the all-electronic estimation platform and offers interactive projects to clients and co-workers complete with detailed cost breakdowns and building revisions with live links.	5D Modelling	www.exactal.com
CypeTherm Suite	Cype	Group of programs for thermal and energy analysis of buildings.	Structural Designers	www.cype.com
Ecotect Analysis (discontinued)	Autodesk	A comprehensive concept-to-detail sustainable building design tool. Ecotect Analysis offers a wide range of simulation and building energy analysis functionality that can improve performance of existing buildings and new building designs	Engineering (Energy) Analysis	www.autodesk.com
Cubicost TAS Cubicost TRB Cubicost TME Cubicost TBQ	Glodon	Cubicost provides construction industry a more efficient, precist and convenient exclusive BIM integrated solution. 3D models that contain massive engineering data can be created and high-tech cutting-edge technologies.	5D Modelling	www.glodon.com
Insight 360 Green Building Studio	Autodesk	Provides a sensitivity analysis and combined factors for high performance building design.	Sustainability Analysis	www.autodesk.com
Innovaya	Innovaya	Automate and streamline the entire process of design and project management.	Estimators Project Coordinator and Construction Managers Owners	www.innovaya.com
LumenRT	Bentley Aeon Software	Quickly create images, videos and real-time presentations of Architecture, Landscape, Urban and Infrastructure Designs.	Visualization Presentation	www.lumenrt.com

(*Source: https://www.mybimcentre.com.my/download/bim-guide-book-2/*)

Table 2.4: Example of Supporting Tools (cont')

Product name	Manufacturer	BIM Uses	Category	Website Link
Lumion	Act-3D BV	Real time animation authoring software to create a stunning walkthrough animation presentation.	Visualization Presentation	www.lumion3d.com
Navisworks	Autodesk	Enable architecture, engineering, and construction professionals to holistically review integrated models and data with stakeholders to gain better control over project outcomes.	3D Coordination 4D Modelling	www.autodesk.com
Solibri	Nemetschek	Offering 3D visualization and walk in functionality to reveal potential clashes, flaws and weaknesses. Allows you to quantify the amounts of building materials needed	Structural 3D Coordination	www.solibri.com www.nemetschek.com
StaadPro	Bentley	A 3D structural analysis and design software, with comprehensive and integrated finite element analysis and design offering, including a state-of-the-art user interface, visualization tools, and international design codes.	Structural	www.bentley.com
StruBIM Suite StruBIM Pro	Cype	Calculates structural elements: analysis, design, check and provide technical drawings for the structural project.	Structural	www.cype.com
Tekla BIMsight	Trimble	Enables the entire construction workflow to combine models, check for clashes, and share information, empowering project participants with the insight to solve issues in the design phase, before construction begins.	Structural	www.tekla.com www.trimble.com
Vico Office	Trimble	Delivers an integrated BIM workflow for construction projects. Extends the basic 3D model with constructability analysis and coordination, quantity takeoff, scheduling and production control, estimating, and layout.	4D & 5D Modelling	www.vicosoftware.com www.trimble.com

(Source: https://www.mybimcentre.com.my/download/bim-guide-book-2/)

There are various types of BIM software available in the market nowadays. It is important to choose the right tools for the project. There are several factors needed to be considered in selecting the BIM tools. These factors are included the following:

a) BIM Requirement

The users must determine the specific BIM requirements and outcomes they wish to achieve in implementing BIM, so that the right BIM tools can be employed.

b) Initial Cost of BIM Tools

The users must know clearly their financial capabilities before implementing BIM. This is because there is no guarantee on the return on investment (ROI) for BIM software. It involved also values that are uncountable, such as time that can be reduced and productivity and efficiency that can be increased.

c) Hardware Capability

Different software has different hardware requirements. Users must decide whether to maintain the existing software, upgrade or purchase new hardware to implement BIM.

d) Resources to use BIM Tools

Users must know clearly that the availability of resources, such as manpower, facility and others that can cope with the implementation of BIM. Users must also consider whether to train the existing staff to use BIM or recruit BIM modeller to support the BIM implementation.

2.5 Adoption of BIM in Malaysia

Most developed countries utilise BIM in their construction industry. Figure 2.3 shows the foremost countries in implementing BIM, which is the Australia, United States, Europe, Middle East and India (Sawhney, 2014).

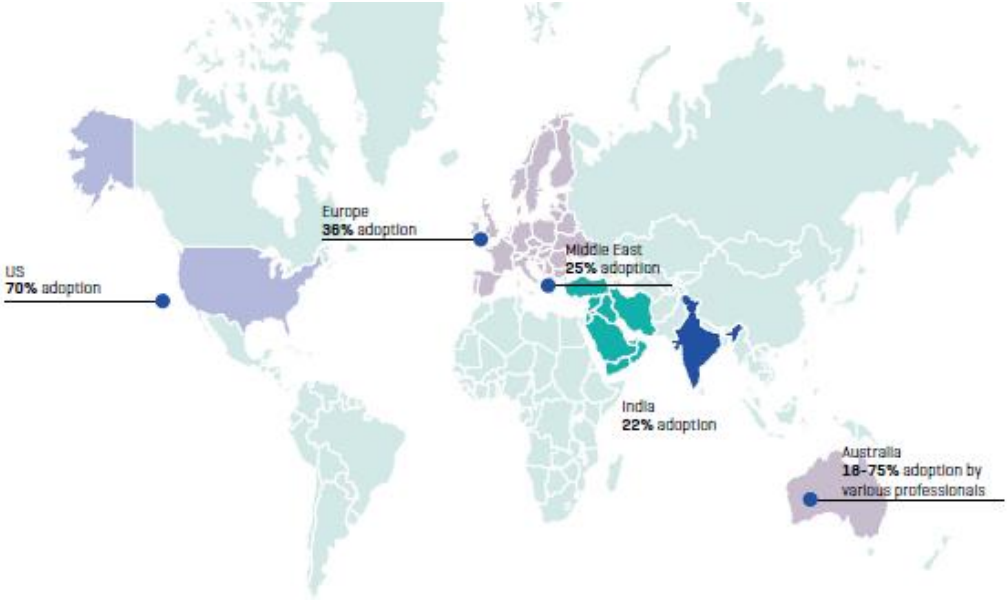

Figure 2.3: The Countries Most Implementing BIM (Sawhney, 2014)

They believed that by utilising BIM in the construction projects, they can gain benefits such as enhancing the communication process, construction process, sharing of latest information and easier for them to make decision (Alshawi, et al., 2003; Baldwin, et al., 1999; Froese, et al., 1997). Due to these advantages, the Malaysian construction industry has started to use BIM recently (Haron, et al., 2016). There are research studied on the BIM implementation in Malaysia context with different point of view, such as clients' perspectives (Husairi, et al., 2015), public sector (Aizul, et al., 2016), BIM perceptions (Enegbuma et al, 2015) and also research studied in general (Latiffi, et al., 2013 and Tahir, et al., 2017). However, in Malaysia, there is very few evidence to show the percentage of construction players implementing BIM in their construction projects, especially railway projects.

In order to improve the current situation of Malaysian construction industry, the players of the construction industry must change their current working system. This is because there are many changes need to be carried out for the implementation of BIM. These are included of the changing of the managerial function and hierarchy due to the roles and responsibilities of the individuals of an organisation will be changed as BIM is implemented.

According to CIDB (2016), there are five steps to implement BIM in an organisation or a project. Implementation of BIM is not only involved the changes on technology or process, it is also involved culture change which required tactical strategies to go step by step. Figure 2.4 shows the step to be taken for the implementation of BIM.

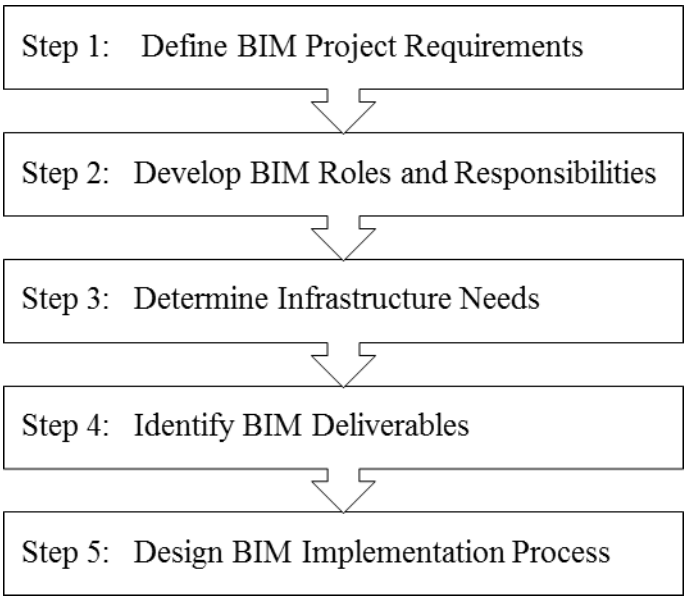

Figure 2.4: Steps for BIM Implementation (CIDB, 2016)

It is important to determine the project requirement in the very first step for the implementation of BIM. So that the use of BIM and level of detail required for the construction project can be established with the BIM goals and objectives. Secondly, the BIM staffs with their respective roles and responsibilities need to be developed to enhance the competencies of the disciplines in an organisation. The roles and responsibilities of BIM staffs, such as BIM Manager, BIM Coordinator and BIM Modeller are different and it was based on the organisation requirements or BIM requirement. Next, an organisation need to invest in BIM and this is depending on the organisation whether to upgrade the existing systems or buy in new systems for the implementation of BIM. This may affect the maturity and level of BIM that to be adopted. After these all process, the suitable BIM deliverables need to be identified based on the BIM project requirement as specified in the first step. These would be the outcomes of the BIM process of a project. Last but not least, BIM implementation process would then be designed to create BIM Execution Plan (BEP). This BEP can be considered as the guidance for all the project teams and it consists of the design standards, data references and important information of the project. After all these processes, definitely there will be significance outcomes for the implementation of BIM.

2.6 Benefits of BIM Adoption in Construction

By adopting BIM in construction projects, many benefits can be bring to the construction players such as communication between multiple construction players can be improved and faster design decision can be made (Cho, et al., 2011). In addition, the use of BIM can brought to the time spent in design reduced, as well as cost and duration of construction can also be reduced. This is because BIM enables detection of clash and analyse the clash during the design stage. Hence, the quality of the construction project can be ensured (Azhar, et al., 2012).

One of the BIM features is users can easily use the BIM tools throughout the project life-cycle, which consists of pre-construction phase, construction phase and post construction phase (Furneaux & Kivit, 2008). It can be said that by adopting BIM in construction industry, the construction project can be managed more efficiently. Table 2.5 shows the uses of BIM in different stages in a construction project.

Table 2.5: Uses of BIM in Different Phase of Construction Project (Furneaux & Kivit, 2008)

Phase	Stage	Uses of BIM
Pre-construction	Exisitng conditions modeling	-Enhances accuracy of existing conditions documentation.
	Planning	-Identifies schedule sequencing or phasing issues
	Design	-Facilitates better communication and faster design decision. -Perform clash detection and clash analysis. -Increases design effectiveness
	Scheduling	Enables project manager and contractor to see construction work sequence, equipment, materials and track progress against logistics and timelines established.
	Estimation	-Enables generation of takeoffs, counts and measurements directly from a 3-Dimensional (3D) project model
	Site analysis	-Decreases costs of utility demand and demolition.
Construction	Construction	-Enables demonstration of construction process, including access and exit roads, traffic flows, site materials and machineries. -Provides better tracking of cost control and cash flow. -Enables tracking of work in real time, faster flow of resources and better site management.
Post-construction	Operation and facilities management	-Keeps track of built asset. -Manages facilities proactively. -Enables scheduled maintenance and provides review of maintenance history.

Furthermore, according to CIDB (2016), the benefits of BIM adoption can be categorised into two groups, which are national level and organisational or project level.

In order to transform the Malaysian construction industry to a higher level in national level, productivity and efficiency of construction industry must be enhanced. Thus, the aspiration as stated in CITP 2016-2020 can be achieved. The benefits of BIM adoption in construction industry at national level are as followss (CIDB, 2016):

a) Transparency and accountability of the construction process can be promoted.
b) The traditional skill-driven construction industry can be transformed into knowledge driven.
c) The Malaysian construction industry can be in lined with the international standard.

Besides, for the organisational and project level, the collaboration of various design teams can be enhanced throughout the project life-cycle which included of planning and design stage, construction stage and facility management stage. Table 2.6 shows the benefits of BIM adoption at organisational and project level as identified by CIDB (2016).

Table 2.6: Benefits of BIM Adoption at Organisational and Project Level (CIDB, 2016)

Planning and Design Stage	Construction Stage	Facility Management (FM) Stage
-Improved ability for analysis and design audit. -Improved efficiency for design production. -Improved planning and design. -Better understanding of project at early stages. -Quicker client approvals via visualisation design intent. -More upfront involvement of key stakeholders who can provide earlier feedback. -Allows Client/Building Owner to evaluate the proposed design, and modification. -Intelligent transfer of information between key project stakeholders. -Greater certainty between design intent and the final construction and operation of the building. -Project stakeholder have more informed decisions at the beginning of the project.	-Better outcomes through collaboration. -Improved multi-party communication. -Reduces project risk. -Increased prefabrication. -Enhanced project performance. -Reduces waste. -Improved safety and quality. -Reduces unbudgeted construction changes. -Ensure project documentation is coordinated, timely and in an accessible form. -Improve coordination between client-consultant-contractor.	-To create and maintain facilities in more efficient, lower carbon emissions, more effective and safer places to live and work. -Provide a single source of accurate and up-to-date information for FM activities. -To systematically design maintenance strategy based on the information of design information, asset history lifecycle cost. -Better information for the whole life cycle of asset management. -Better lifecycle data for facility management. -Enhanced evaluation on maintenance approach based on cost. -Maintain up-to-date facility and equipment. -Allow for future updates of current asset information.

2.7 Barriers in Implementation of BIM

Apart from the benefits that determined previously, the implementation of BIM was hindered by some factors. Griffith, et al., (1999), O'Brien (2000) and Whyte, et al., (2002) believed that, the new information technology (IT) failed to implement in construction industry was because of technical issues instead of social issues such as lack of hardware and expertise supports. On the other hand, Ruikar, et al., (2005) and Rojas & Locsin (2007) believed that human issues also part of the barrier for the implementation of new IT in construction industry. According to Martinko, et al., (1996), people are satisfied with their current situation and not willing to learn new technology. So, human was also one of the factors that hindered the BIM implementation.

Apart from the factors of technology and human, the failure to implement new technology such as BIM was also due to the organisational issues (Stephenson & Blaza, 2001). This is because the organisation process might change if implement something new and they may not able to accept uncertainty, especially when it is involved cost. Besides, by implementing new technology, the organisation may restructure and the productivity of human will be affected due to the transition period from traditional method to a collaborative approach (Taylor & Levitt, 2007). In order to encourage the people change the current situation, the top management of an organisation plays a vital role. So that the awareness and strategies for BIM implementation can be carry out smoothly (Giligan & Kunz, 2007).

On the other hand, lack of knowledge and skill in using new technology will also hinder the implementation of new technology (Stewart & Mohamed, 2003). Hence, training must be provided by the organisation for the implementation of new technology.

Besides that, legal issues also part of the barriers in implementing BIM. This is because there will be conflicts happened for the model, such as the ownership of the design, the accuracy of the input or data of the model and so on. The most important issue is who will responsible if there are any inaccuracies or discrepancies in the model (Azhar, et al., 2008).

Last but not least, the high cost was needed for the implementation of BIM. This cost may include of hardware cost, software cost and overhead cost, such as training cost (Eastman, et al., 2011, Furneaux & Kivit, 2008 and Forbes & Ahmed., 2011). Cost may also affect the compatibility and complexity of the tools that will be used. This is because higher compatibility and more user-friendly tools will have a higher cost. This can easily make the people faster to familiarise and adapt the changes from traditional working method to the new technology for working purpose (Lederer et al, 2000).

In general, these all factors result in the low adoption rate of BIM in the Malaysian construction industry.

2.8 Summary

The background and introduction of BIM were described in this chapter. Besides that, the BIM related topic such as BIM processes and BIM tools also studied and included to further illustrate what is all about the BIM. The adoption of BIM in Malaysia also studied from previous research for the purpose of this research. Thus, the benefits and barriers in implementation of BIM can be further demonstrated.

The benefits as studied and presented in the sub-section 2.6, it can be further categories into three main groups, i.e. cost, time and quality. On the other hand, the barriers as presented in sub-section 2.7 can also be further categorised into three main groups, i.e. factors related to people or human, process and technology. In order to implement BIM in Malaysian construction industry and reach certain level as planned by the CIDB, it is urgent for not only key players of construction industry, but also the government or authority to take responsibilities to tackle these issues accordingly.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the research method, survey instrument, survey sampling technique, questionnaire survey, data collection, data analysis and also case study used for the research are presented and discussed.

3.2 Research Method

The purpose of research is to discover answers to questions on the application of scientific procedures. According to Kothari (2004), there are five types of research as followss:

a) Descriptive and analytical research

b) Applied and fundamental research

c) Quantitative and qualitative research

d) Conceptual and empirical research

e) Other types of research

In this research, quantitative and qualitative research approach was employed to achieve the objectives of this research. Quantitative research is applicable to the phenomena that can be expressed in terms of quantity or amount. In this research, quantitative data was collected from the questionnaire which consists of Likert scale questions. On the other hand, qualitative research is concerned with qualitative phenomenon which related to quality (Kothari, 2004). In this research, qualitative data was collected from the interviews with industry experts.

3.3 Survey Instrument

Generally, there are many methods to collect data that needed to achieve the research's objectives. The main instruments used for questionnaire in a mixed method research consist of closed-ended and open-ended questions (Reja, et al., 2003). The closed-ended questions will provide quantitative data and the qualitative data can be obtained through open-ended questions. In this research, a mixture of closed-ended and open-ended questions were adopted for the questionnaire.

In addition, there are two-choice questions and multiple choice questions in the questionnaire. The two-choice questions are the simplest question which involved only yes or no and the result can split the data into two different groups (Statistics Canada, 2010). For instance, in this research, the two-choice question was whether the respondents are exposed to or used BIM for their working. On the other hand, multiple choice questions had also been adopted in this research. However, some confusion might happen if respondents pick more than one choice in a question (Statistics Canada, 2010). Thus, in order to eliminate such confusion, respondents are only allowed to select the one most appropriate for the question in this research.

3.4 Survey Sampling Technique

A sample was a finite part of a statistical population whose properties are studied to gain information about the whole (Webster, 1985). When dealing with people, it can be defined as a set of respondents (people) selected from a larger population for the purpose of a study.

Basically, there are two categories of sampling method, which is probability sampling and non-probability sampling. The goal of the research will affect the choice of sampling method. In this research, non-probability sampling method was used. There are four types of sampling under non-probability sampling methods, which are convenience sampling, purposive sampling, snowball sampling and quota sampling (Henry, 1990).

In this research, purposive sampling method was used to achieve the objectives of this research. Purposive sampling is to select a sample "on the basis of your own knowledge of the population, its elements and the nature of your research aims" (Babbie, 1990). This method is useful in this research which wanted to study "a small subset of a larger population in which many members of the subset are easily identified but the enumeration of all is nearly impossible" (Babbie, 1990). Therefore, the participants involved in this research were those key players in construction industry exposed to or utilised BIM in their working life. It is important to note that purposive sampling is only selecting the specific respondents to answer the questionnaire and the outcomes are not representing the whole population.

In addition, according to Morse & Niehaus (2009), the sample size for the research especially research that is the combination of qualitative and quantitative need to be at least to be 30 and even larger. So that statistical analysis can be carry out.

3.5 Questionnaire Survey

In this research, questionnaire survey was used to collect the data needed to achieve the research objectives. The questionnaire was designed and developed based on the review of literature on adoption of BIM in Malaysian construction industry. The questionnaire consists of three main sections, which is the Section A: Backgrounds of Respondents, Section B: Benefits and

Barriers in implementing BIM for BIM-users and Section C was for non-BIM users. The questions in Section B were designed based on 5-point Likert scale, which is from 1 (strongly disagree) to 5 (strongly agree) according to the level of contribution (Jackson, 2012).

The result of the exploratory study shows that there are approximately 18 benefits and 17 barriers for implementing BIM. However, the questionnaire was then being pre-tested by several professionals in practice before officially distribute to respondents. This is called the Pilot test of the questionnaire.

3.5.1 Pilot Test

The purpose of pilot test is to ensure that the questions set in the questionnaire are clear and understandable by others. By conducting pilot test, mistakes of the questionnaire can be minimised.

In this research, the questionnaire was first tested by three industry professionals, which include of Engineering Directors, BIM Manager and Senior Engineer who related to the discipline of this research. Based on their advices and suggestions, the final questionnaire consists of 15 benefits and 15 barriers instead of 18 benefits and 17 barriers for implementing BIM. The changes of the number of items for benefit and barrier were due to some of the items can be merged and became one item. The benefits and barriers in implementing BIM are listed in Table 3.1 and Table 3.2 respectively.

Table 3.1: Benefits in Implementing BIM

Benefits	Code
Implementation of BIM will provide a better understanding of concept and feasibility of a project at an early stage.	BE1
Implementation of BIM will enable reductions in overall project costs.	BE2
Implementation of BIM will provide a more accurate cost estimation of a project.	BE3
Implementation of BIM will shorten the design planning and design period.	BE4
Implementation of BIM will shorten the project delivery time.	BE5
Implementation of BIM will provide better design optimization.	BE6
Implementation of BIM will improve project quality due to a more detailed building model achieved the demands or requirements of client.	BE7
Implementation of BIM will provide a better or more accurate visualization of a design.	BE8
Implementation of BIM will improve collaboration of multiple design disciplines, e.g. structure, foundation, drainage, mechanical, electrical, etc.	BE9
Implementation of BIM will provide a better procurement type due to a more accurate quantities for all material used in a project.	BE10
Implementation of BIM will enhance the planning and scheduling of material, manpower and equipment for a project.	BE11
Implementation of BIM will increase the efficiency and productivity of a project due to a better work schedule.	BE12
Implementation of BIM will enable to identify and analyze problems earlier in the project process.	BE13
Implementation of BIM will easier to make decision when there is a problem identified.	BE14
Implementation of BIM will improve commissioning and handover process of a project.	BE15

Table 3.2: Barriers in Implementing BIM

Benefits	Code
High initial cost of software.	BA1
High cost of implementation process, e.g. additional overhead cost.	BA2
Lack of professionals.	BA3
High cost of training and education	BA4
Time consuming to enroll staffs for BIM training.	BA5
Unwilling / not ready to change from current practice to BIM oriented method.	BA6
Challenges of collaboration / integration with other disciplines / stakeholders.	BA7
Lack of resources both software and hardware for implementation of BIM.	BA8
Lack of knowledge / information about BIM	BA9
Unclear BIM advantages and practices.	BA10
Incomplete national standards or guidelines for implementation of BIM.	BA11
Lack of top management or senior support / organization issue.	BA12
Lack of appropriate legal framework and tools for implementation of BIM.	BA13
Lack of resources both software and hardware for implementation of BIM.	BA14
Legal issue, i.e. certification or licensing problems.	BA15

3.6 Data Collection

In order to obtain adequate valid responses, the structured questionnaire was distributed to a total of 120 industry practitioners in construction industry. In order to get the responses in a limited time frame, the questionnaire was distributed and received through e-mail and social media, such as WhatsApp and Facebook Messenger.

3.7 Data Analysis

Data collected from the questionnaire will then be analysed. First of foremost, the data collected was analysed statistically by using Statistical Package for Social Science (SPSS) on its reliability to determine the Cronbach's Alpha (α) value.

Secondly, the data collected was also analysed by using descriptive method with the presentation of charts and tables. Last but not least, Relative Importance Index (RII) method was used to determine the relative importance of benefits and barriers identified by the respondents.

3.7.1 Cronbach's Alpha Test

Cronbach's Alpha (α) test is a commonly used to measure reliability, which is also a measurement of internal consistency. It is commonly used to determine the reliability of the multiple Likert scale questions in a questionnaire.

When the items measuring a single construct are highly correlated and also when the α-value is relatively high, it can be said that the items are reliable. According to Nunnally (1978), when the α-values are above 0.7, it is acceptable for social science research. In addition, if the Cronbach's Alpha value is in the range of 0.7 and closer to 1, it can be said that the data is reliable (Laerd Statistics, n.d.).

3.7.2 Relative Importance Index (RII)

The Relative Importance Index (RII) was employed to empirically ascertain the benefits and barriers in implementing BIM to give an understanding as to the extent to which each factor contributes the most, both by itself and in combination of the other factors. RII is a type of relative importance analyses and it can best fit the purpose of this research. According to Johnson and LeBreton (2004), RII was used to find the contribution of a particular variable makes to the prediction of a criterion variable both by itself and in combination with other predictor variables. According to Badu et al. (2013), the formula for calculating RII is as below:

$$\text{RII} = \frac{\Sigma W}{A \times N}$$

where W = weighting given to each statement by the respondents (ranges from 1 to 5)

A = Higher response integer (in this research, A = 5)

N = Total number of respondents

3.8 Case Study

Case study was also used to support and strengthen the findings from the responses obtained. Case study research method is an empirical inquiry that studies the current phenomenon within its real-life context. It is used when the boundaries between phenomenon and context are not clear and also when multiple sources of evidence are used (Yin, 1984). Case study research method can bring a better understanding of a complex issue or object. This is because this research method can have a detailed contextual analysis of a limited number of events or conditions and their relationships.

3.9 Structured Interview

Besides questionnaire, structured interviews with targeted respondents from the cases were also used to collect additional information. The outcomes of structured interview were analysed by using content analysis and used to strengthen the findings of the questionnaire.

In order to obtaine different types of “courses of typical interviews”, the respondents who are targeted for the interview session were asked the same questions in same order (Morse & Niehaus, 2009).

3.10 Summary

In this research, the questionnaire was prepared in Google form to ease the researcher to distribute for respondents by just sharing the form’s link and can also been notified once there is a response received. By doing this, the respondents can easily fill in the form and submit immediately at anytime and anywhere.

Besides that, data collection was done by retrieval of information from published or available sources through review of literature. In addition, this research was done by collecting data directly from the questionnaire and also from the interviews with targeted respondents. In overall, these are to ensure that the objectives of this research can be achieved.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter basically is to present the data collected through the valid responses of the questionnaire (refer Appendix A) and structured interviews with targeted respondents.

The data collected from the questionnaire (refer Appendix B) was analysed by using Statistical Package for Social Science (SPSS) to test the internal consistency, i.e. Cronbach's Alpha (α-value). Then, the Relative Importance Index (RII) of each factors and barriers was also determined by using Microsoft Excel. All these results were presented in appropriate format, such as tables and charts. Besides that, descriptive analysis was used to further discuss the findings.

Besides, case studies used in this research and content analysis (refer Appendix C) from the structured interviews was also presented and discussed in this chapter to strengthen the findings from the questionnaire.

4.2 Response Rate of Questionnaire

As mentioned in previous sub-section, the questionnaire was distributed to approximately 120 respondents. However, only 90 responses were successfully obtained due to the limited time period. Thus, a response rate of 75% was achieved to carry out the subsequent analysis. Table 4.1 shows the summary of data collected from questionnaire.

Table 4.1: Summary of Data Collected from Questionnaire

Number of Questionnaire Distributed	120
Number of Responses Collected	90
Response Rate	75%

Majority of the respondents came from the colleagues of the researcher and key players whom involved in the two railway projects, which is Klang Valley Mass Rapid Transit (KVMRT) Line 2 (SSP Line) and Gemas – Johor Bahru Electrified Double Track Project (GJBEDTP) and these will be further discussed in sub-section 4.7.

4.3 Background of Respondents

Frequency analysis method was used to analyse the 90 respondents involved in this research according to the six different types of background as followss:

a) Professions of respondents

b) Working experience of respondents

c) Projects' value range of respondents involved the most

d) Involvement in Railway Projects of Respondents

e) BIM practices of respondents

f) BIM tools used by the respondents

In addition, the respondents can be categorised into two groups, which are BIM users and non-BIM users. BIM users can be further divided into two groups, which are normal BIM users and BIM users involved in railway project. The responses from the BIM users involved in railway project will be further analysed and discussed on the benefits and barriers of implementation of BIM. However, 48 responses out of 90 were non-BIM users and this amount of responses will not be taken into consideration for the further analysis in order to achieve the objectives of this research. In other words, it is approximately 47% of the respondents are BIM users. Table 4.2 shows the results of valid responses from the questionnaire.

Table 4.2: Results of Valid Response

Category	**Number of Response**
BIM Users	
- Normal BIM Users	8
- BIM Users in Railway Project	34
Total	**42**

4.3.1 Professions of Respondents

From the responses, the number of respondents from different profession is shown in Table 4.3.

Table 4.3: Number of Respondents from Different Profession

Profession or Area of Specialisation	**Number of Respondent**
Client / Developer	3
Consultant / Architect	30
Contractor	7
Supplier / Vendor	0
Other	2
Total	**42**

As a result from the responses obtained, majority was come from consultant or architecture background which is approximately 71% in total. Besides, a total of 17% was come from contractor background. In addition, a total of 7% and 5% of the respondents were come from client or developer and other background respectively. However, in these responses, there is no respondent from supplier or vendor background. Figure 4.1 shows the profession or area specialisation of valid respondents for this study in percentage (%).

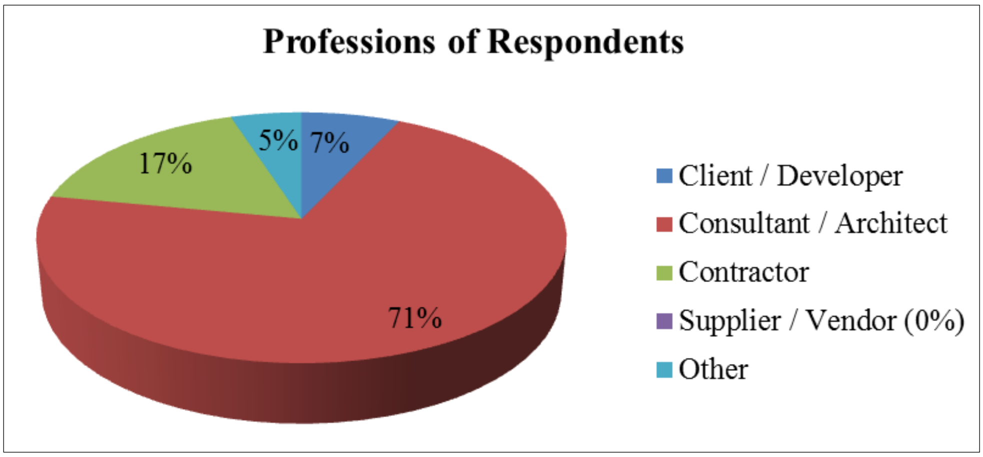

Figure 4.1: Profession of Respondents

4.3.2 Working Experiences of Respondents

There is various working experience of the respondents, which can be categorised into five ranges of years and this is shown in Figure 4.2.

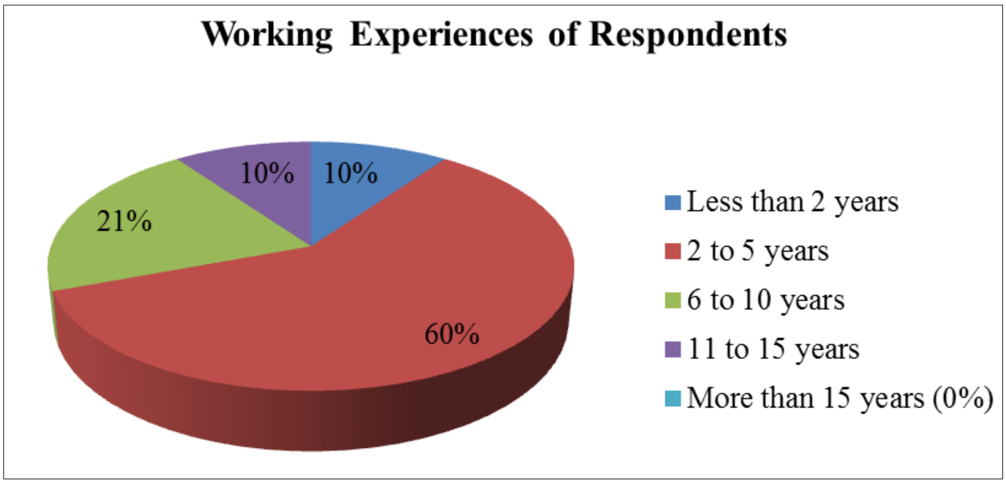

Figure 4.2: Working Experiences of Respondents

From the results of the responses, majority of the respondents (i.e. 60%) are having a working experience between 2 to 5 years, followed by working experience between 6 to 10 years which contributes 21% in total. Besides that, there was 10% of the respondents with experience of less than 2 years and 11 to 15 years each. However, there is no respondent having a working experience more than 15 years.

4.3.3 Projects' Value Range of Respondents Involved The Most

The five projects' value ranges from less than RM10 million to more than RM100 million which contributed by the valid respondents was shown in Figure 4.3.

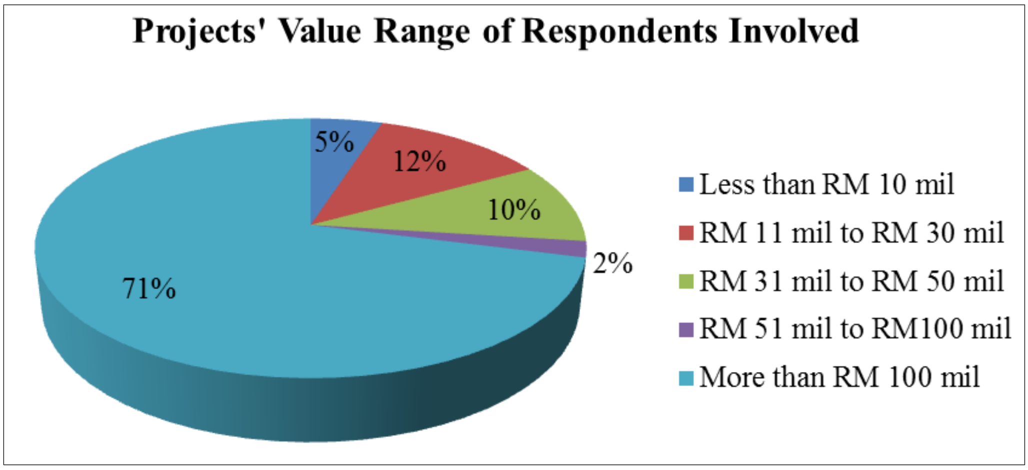

Figure 4.3: Projects' Value Range of respondents Involved The Most

From the figure we can conclude that, majority of the respondent which is 71% in total involved in the projects with project value of more than RM 100 million, followed by project value range from RM 11 million to RM 30 million and RM 31 million to RM 50 million with 12% and 10% respectively. Next, there are only 5% and 2% of the respondents involved in project with value of less than RM 10 million and range from RM 51 million to RM 100 million respectively.

4.3.4 Involvement in BIM of Respondents

In this research, the first objective is to determine the BIM adoption level in the construction industry. Thus, respondents are required to state that whether they are exposed to or involved in BIM for their working purpose.

Results show that, there are more than half of the respondents, i.e. 53% did not exposed to or utilised BIM, whereas only 47% of the respondents exposed too BIM and this figure will be further analyse in sub-section 4.3.5. Figure 4.4 shows the involvement in BIM of respondents.

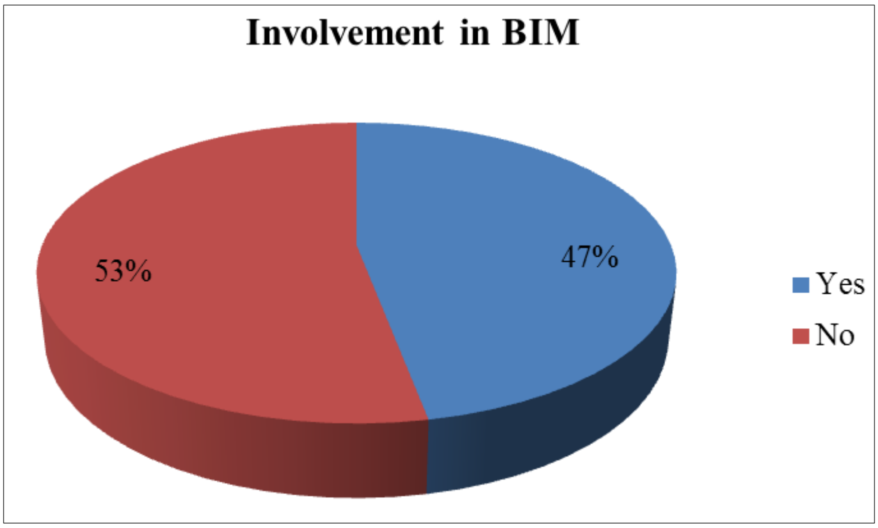

Figure 4.4: Involvement in BIM

4.3.5 Involvement in Railway Projects of Respondents

Among the BIM user as identified in sub-section 4.3.4, it is about 81% of them involved in railway project and only 19% is not involved in railway project as shown in Figure 4.5.

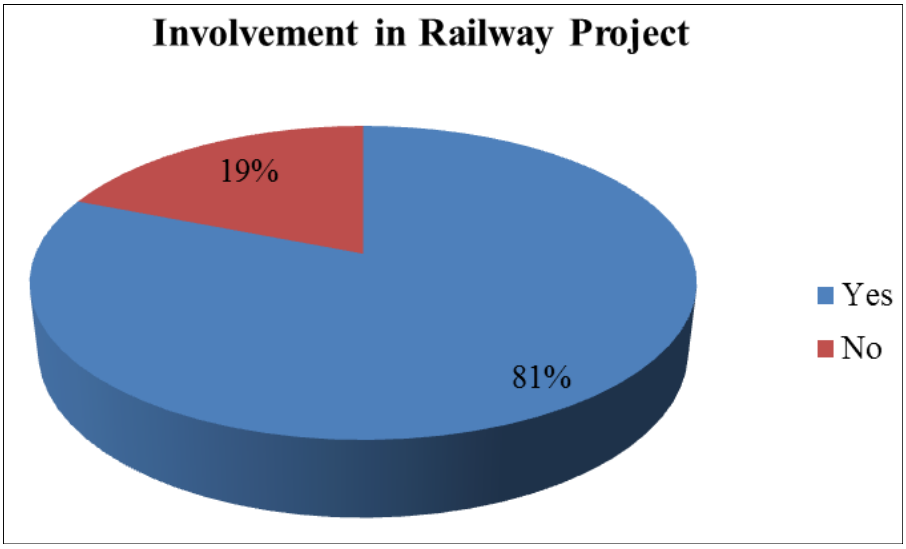

Figure 4.5: Involvement in Railway Project of BIM Users

4.3.6 BIM Tools Used by the Respondents

There are many tools can be utilised for the implementation of BIM as discussed in the literature review. However, there are few main tools that are available in market and practiced by the players in construction industry. Figure 4.6 shows the BIM tools that has been utilised by the BIM users.

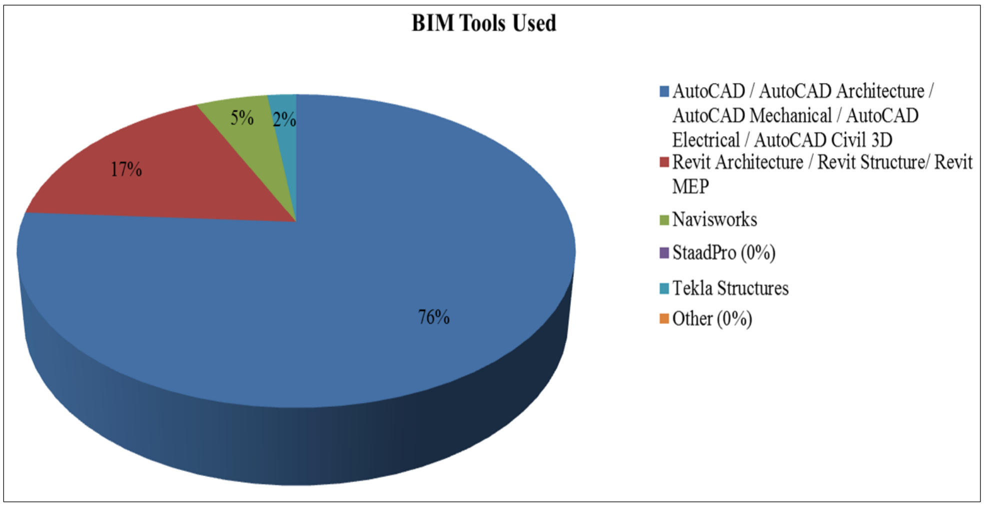

Figure 4.6: BIM Tools Used by the Respondents

From the results obtained, 76% of the BIM user utilised Autodesk product, such as AutoCAD, AutoCAD Architecture, AutoCAD Mechanical, AutoCAD Electrical and AutoCAD Civil 3D. This type of BIM tool is used for the 2D and 3D computer-aided design and drafting purpose. It is mainly used for the architecture and construction to assist the designers and engineers in the preparation of drawings and plans.

Besides that, 17% of the BIM user used Revit Architecture, Revit Structure and Revit MEP for their working. These tools are used to track and support the BIM workflow throughout the project life-cycle, which is from project design concept to construction. These can produce a model with full of data or information and the design can be optimised. It is also can ease the key players from different disciplines to collaborate with each other.

There are 5% of the BIM user utilised Navisworks software to review the integrated model that incorporated the disciplines from architecture, engineering and construction. In addition, only 2% of the BIM user utilised Tekla Structures tool to create the model which is accurate, reliable and consists of detailed information of a construction project. However, there is no results show that StaadPro has been utilised by BIM user.

4.4 Cronbach's Alpha Test

Cronbach's Alpha test needs to be conducted to determine the α-value before further analysis on the responses that obtained from the questionnaire. This is to ensure that the internal consistency of the questions that using the Likert scale format.

The respondents were divided into two main groups, which are the BIM user and BIM user in railway project. Both of these groups were asked to select the most appropriate of importance level on the benefits and barriers of BIM implementation. However, only the results from the BIM users in railway project will be further analysed and discussed. The results of the reliability test from the respondents, i.e. BIM users in railway project, are shown in Table 4.4.

Table 4.4: Result of Reliability Test

Part	**Cronbach's Alpha (α-value)**	**Number of questions, N**
BIM User in Railway Project		
- Benefits	0.894	15
- Barriers	0.873	15

From the results obtained from the respondents and analysis by using SPSS, we can conclude that the questions set in the questionnaire were reliable due to the Cronbach's Alpha (α-value) is above 0.7 in average.

In this research, the benefits and barriers in implementing BIM on railway project will be further analysed and discussed in the following sub-section to reach the objectives of this study.

4.5 Benefits in Implementing BIM

Table 4.5 shows the relative importance indices (RII) and the rank for the benefits of implementation BIM in construction industry which are based on the results obtained from the practitioners or respondents in railway projects.

Table 4.5: Rank for Benefits in Implementing BIM

Benefits in Implementing BIM	Code	RII	Overall Rank	Standard Deviation (SD)
Provide a better or more accurate visualization of a design.	BE8	0.853	1	0.70962
Provide a better understanding of concept and feasibility of a project at an early stage.	BE1	0.829	2	0.78363
Improve project quality due to a more detailed building model achieved the demands or requirements of client.	BE7	0.824	3	0.68599
Improve collaboration of multiple design disciplines, e.g. structure, foundation, drainage, mechanical, electrical, etc.	BE9	0.818	4	0.71213
Provide better design optimization.	BE6	0.812	5	0.69375
Provide a more accurate cost estimation of a project.	BE3	0.800	6	0.77850
Enable to identify and analyze problems earlier in the project process.	BE13	0.794	7	0.71712
Easier to make decision when there is a problem identified.	BE14	0.782	8	0.79268
Reductions in overall project costs.	BE2	0.771	9	0.85749
Enhance the planning and scheduling of material, manpower and equipment for a project.	BE11	0.765	10	0.62622
Provide a better procurement type due to a more accurate quantities for all material used in a project.	BE10	0.753	11	0.69887
Increase the efficiency and productivity of a project due to a better work schedule.	BE12	0.747	12	0.70962
Shorten the project delivery time.	BE5	0.724	13	0.81704
Improve commissioning and handover process of a project.	BE15	0.706	14	0.92884
Shorten the design planning and design period.	BE4	0.688	15	1.13328

From the results obtained from the questionnaire, the top five most important benefits that can gain from implementation of BIM in construction project are as follows and will be further discussed in the following sub-section.

a) Better visualization of a design

b) Better understanding of concept and feasibility of a project

c) Improve quality of project

d) Improve collaboration from multiple disciplines

e) Better design optimization

4.5.1 Better Visualization of a Design

By creating a BIM model, it can greatly enhance the understanding of the processes involved in a project through a better visualization of the construction process. The model created will be revised and always up-to-date with the current design information. Thus, the development of the model is undergoing a process of evolutionary design throughout the project life-cycle. Through this process, the issues or problems happened whether in design or construction stage can be identified and solved prior construction. Besides that, a quicker client approval via visualization design intent can be obtained by using BIM (CIDB, 2016).

4.5.2 Better Understanding of Concept and Feasibility of a Project

By using BIM, the proposal and concept of a project can be easily understood by key players. This is because the BIM model can demonstrate the processes involved in a project. For instance, traffic flows of the project will be affected by the proposed access and exit roads. Thus, by using BIM, more than one solution can be studied in order to design the most appropriate and suit to the project. Besides that, on site activities can also be demonstrated by using BIM, such as the methods for material storage, scheduling of machineries and working staffs and others. By doing this, the key players can understand better the concept and feasibility of a project. Similarly with the benefits as stated by CIDB (2016), a better understanding of project can be developed at the early stage of the construction project.

4.5.3 Improve Project Quality

Due to the implementation of BIM can improve the design and scheduling of a project as discussed in previous sub-sections, in other words, BIM can increase the quality of project. This is because, BIM provides a platform for designers and architects which is more effective way to improve the design of a project. Subsequently, the quality of a project can be improved due to the efficiency and effectiveness of the project. Besides that, as stated by Azhar, et al. (2012), the quality of the construction project can be ensured due to the BIM enables clash detection and analyse such clash during the design stage.

4.5.4 Improve Collaboration from Multiple Disciplines

The benefits of adopting BIM are the project coordination and communication with multiple disciplines, such as structure, geotechnical, mechanical, electrical, signalling and others can be improved. This enables the team members understand better on the information and design the project. By integrating all key systems into the BIM model, design conflicts or internal conflicts can be easily detected prior construction due to some components are linked to each other and can be updated accordingly. This was similar with the outcome of researcher Cho, et al. (2011), which stated that the communication among players can be improved.

4.5.5 Better Design Optimization

By using BIM, the designs for a project can be optimized. This is to search and study the optimal solutions with some predefined criteria or limitations. By applying an optimization model, a wider knowledge can be studied and thus the designs or outcomes can be improved. In other words, BIM tools can simulate the model with enriched of design data and thus, the optimal solutions can be easily obtained in a shorter time frame. Besides that, the ability for analysis and design can be improved by using BIM and thus, the design can be optimized CIDB, 2016).

4.6 Barriers of Implementing BIM

Table 4.6 shows the relative importance indices (RII) and the rank for the barriers of implementation BIM in construction industry which based on the results obtained from the practitioners or respondents in railway projects.

Table 4.6: Barriers in Implementing BIM

Barriers in Implementing BIM	Code	RII	Overall Rank	Standard Deviation (SD)
High initial cost of software.	BA1	0.824	1	0.87956
High cost of implementation process, e.g. additional overhead cost.	BA2	0.818	2	0.79268
Challenges of collaboration / integration with other disciplines / stakeholders.	BA7	0.782	3	0.90009
High cost of training and education.	BA4	0.776	4	0.91336
Lack of professionals.	BA3	0.771	5	1.07682
Lack of knowledge / information about BIM.	BA9	0.765	6	1.11384
Time consuming to enroll staffs for BIM training.	BA5	0.759	7	1.09488
Unwilling / not ready to change from current practice to BIM oriented method.	BA6	0.741	8	1.11544
Lack of appropriate legal framework and tools for implementation of BIM.	BA13	0.741	8	1.05971
Lack of top management or senior support / organization issue.	BA12	0.729	10	1.06976
Lack of resources both software and hardware for implementation of BIM.	BA8	0.724	11	0.95393
Lack of resources both software and hardware for implementation of BIM.	BA14	0.718	12	1.10420
Incomplete national standards or guidelines for implementation of BIM.	BA11	0.712	13	1.02073
Legal issue, i.e. certification or licensing problems.	BA15	0.647	14	1.10258
Unclear BIM advantages and practices.	BA10	0.629	15	1.15817

From the analysis, we can say that the top five most important factors or barriers that hinder the implementation of BIM in construction project are as follows and will be further discussed in the following sub-section.

a) High initial cost of software

b) High cost of implementation process

c) Challenges of collaboration with other disciplines

d) High cost of training and education

e) Lack of professionals

4.6.1 High Initial Cost of Software

The implementation of BIM required a high initial cost of investing in BIM technology. By implementing BIM, it requires specific software and data storage which may cost significantly to a company. The cost of purchasing new software is also depends on the existing IT facility that owned by the organisation. Besides, there is also lack of evidence show that there are financial benefits in implementing BIM. These issues of cost force the investors and potential BIM adopters (i.e. developers, architects, consultants, etc.) to consider whether to adopt BIM or not for the construction projects. As studied by various researchers, cost was the main issue for implementing BIM for a project in an organisation.

4.6.2 High Cost of Implementation Process

Apart from the initial cost of BIM technology, there are also indirect costs for the BIM implementation processes. The perceived costs of implementing BIM technology are included but not limited to administration costs, transition costs and behavioural costs. This is because the working staffs need to utilise BIM for their design purpose instead of using traditional methods. This transition process is an additional cost for the implementation of BIM. As mentioned in previous sub-section, cost was the main issue as studied by various researchers, no matter the cost for hardware cost, also the cost for the associated process for the implementation of BIM.

4.6.3 Challenges of Collaboration with Other Disciplines

One of the benefits in implementing BIM is can improve the collaboration from multiple disciplines. However, this is also one of the barriers to implementation of BIM. As various researcher studied previously, human issue was one of the barriers for the implementation of BIM. This is because a project with multi-disciplinary working on the same compatible BIM model. All the team members need to have the necessary technology and software which is capable and compatible for the BIM implementation. However, BIM is not effective if the players are working outside the model due to issues regarding of software and hardware. Thus, it is essential to overcome the integration of various participants of a construction project throughout the project life cycle.

4.6.4 High Cost of Training and Education

By implementing BIM, the organisation may have to train the existing staffs to use BIM for their working purpose. This may because the staffs were lack of knowledge and skill in using new technology as studied by Stewart and Mohamed (2003). Thus, the organisation might need to provide the related training courses for the staffs to enrol. However, the costs for such training are not cheap and if there are a lot of staffs that the organisation has to send for the training, it will be a large amount of cost. Time and human resources are the associated issues for the training process.

4.6.5 Lack of Professionals

Apart from training the existing staffs, an organisation can also hire new professionals in BIM field to establish and manage the BIM implementation. However, there is a lack of adequately trained BIM professionals even though the organisations are willing to hire BIM professionals.

4.7 Case Study

In this research, there are two cases were used to study. The two cases are Klang Valley Mass Rapid Transit (KVMRT) Line 2 (SSP Line) and Gemas – Johor Bahru Electrified Double Track Project (GJBEDTP) which are part of the current core infrastructure projects in Malaysia. These two cases were chosen is because the researcher of this research is involved in these two projects in real life. These projects will be further discussed in following sub-sections.

4.7.1 KVMRT Line 2 (SSP Line)

The SSP Line is the abbreviation of Sungai Buloh – Serdang – Putrajaya Line. The SSP Line is the second line of the KVMRT Project to be developed. According to MRT Corporation (MRTC, 2017), this alignment is having an approximately length of 52.2km (38.7km of elevated tracks and 13.5km of underground tunnels) and consists of 35 stations (24 elevated stations and 11 underground stations). Figure 4.7 shows the alignment map of the SSP Line.

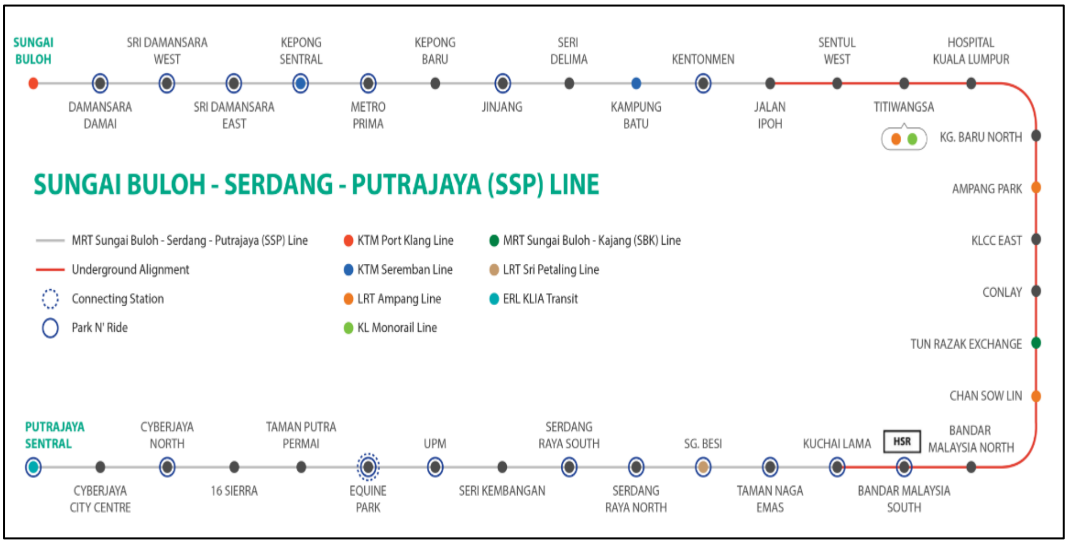

Figure 4.7: Alignment Map of SSP Line

According to MRTC (2017), the Malaysia government approved the implementation of SSP Line in 2014 and then public gave their feedback and objections if there is any in a fixed period of time frame. The SSP Line Railway Scheme was finally approved by the government in October 2015 and thus the land acquisition (LA) and procurement process can proceed. The commencement of construction works for the SSP Line was started on 15 September 2016. It is estimated to begin the operation of Phase One (Sungai Buloh station to Kampung Batu station) in July 2021 and the rest, i.e. Phase Two (Kampung Batu station to Putrajay Sentral station) in one year later of Phase One, which is July 2022.

“We have not finalised the actual cost for the SSP Line but for the construction alone, we have budgeted RM32 billion, with the project delivery partner and all, we expect the total cost to be between RM35 billion and RM40 billion”’ said by the MRTC chief executive officer Datuk Seri Shahril Mokhtar (Sharen, 2016).

4.7.2 Gemas to Johor Bahru Electrified Double Track Project (GJBEDTP)

GJBEDTP is the electrified railway project that connects to the southern part of Malaysia, which is from Gemas (in border of Negeri Sembilan and Johor) to Johor Bahru (in Johor state). This alignment is having an approximately length of 197km and consists of 11 stations and 3 future stations. Table 4.7 shows the list of stations for the GJBEDTP and Figure 4.8 shows the alignment map of GJBEDTP.

Table 4.7: Stations of the GJBEDTP

Stations	Segamat, Genuang, Labis, Bekok, Paloh, Kluang, Mengkibol, Reggam, Layang-Layang, Kulai and Kempas Baru
Future Stations	Tenang, Chamek and Senai

Figure 4.8: Alignment Map of GJBEDTP

Throughout the alignment, there are viaducts, river bridge, road over bridge (ROB), road under bridge (RUB), pedestrian bridges (PB), level crossings, electrification and signalling systems will also be the main elements of the project.

According to State Public Works, Rural and Development Committee chairman Hasni Mohammad, this rail project supposed to begin on 1st January 2017, but it was postponed due to some issues such as land survey, land acquisition, design constraints and to get feedback from community. He also said that “The new date announced by the transport ministry for the project to commence is Jan 1, 2018, with the construction work to take 48 months, and expected to be completed in the fourth quarter of 2021” (Bernama, 2018).

He also said that, this RM9.43 billion rail project will be handled by China contractors, which is China Railway Construction Corp (CRCC), China Railway Engineering Corp (CREC) and China Communication Construction Consortium Sdn Bhd (CCCC).

4.8 Structured Interviews

There are various methods can be used to conduct structured interviews. In this research, the interviews were conducted by face-to-face method due to the interviewees are working in the same company with the interviewer or the researcher. In this research, the targeted interviewees were come from the background of civil and structure (C&S) consultancy. The time and date were normally set after working hour (i.e. after 5.30pm) on weekdays which was to suit the convenience of the interviewees. The identity of the targeted interviewees will only be known to the researcher and will not be disclosed to others.

The experts who involved in BIM implementation of these two cases are invited to provide detail information related to this research subject matter. There are total of 12 experts and mainly the Engineering Directors, Project Managers, BIM Manager, BIM Modellers, P-Way Engineer, Senior Engineers and Lead Engineers of the two cases. The duration of interview was usually around 30 minutes. However, there is no time constraint for them to share more. The question for them to provide more detail information was "Please share your knowledge or opinions on benefits and barriers for the BIM implementation for the project". The details of the interview transcript can refer to Appendix C and further content analysis is shown in following sub-section.

4.8.1 Content Analysis

From the responses collected through interviews with targeted respondents, all of them agreed that the quality of the project can be improved by utilising BIM. Besides that, 4 out of 12 respondents said that a better understanding of concept or design can be established and this may due to the better visualisation of the design by using BIM. In addition, there are 3 out of 12 respondents said that their design can be optimised and also 2 out of 12 respondents said that collaboration with various disciplines can be improved by using BIM. There are also some other benefits that the respondents mentioned, such as the information of the model is accessible by various key players (i.e. client, contractor, etc.), better efficiency and productivity of a project.

On the other hand, majority of the respondents (i.e. 7 out of 12) said that the initial cost of software is quite high for implementing BIM in organisation. The second highest is followed by the high cost of implementation process and lack of professionals (i.e. 6 out of 12). Furthermore, there was also 5 out of 12 respondents said that there are challenges of collaboration with other disciplines and high training cost. There are also some other issues, such as the software licence issues, size of the model file and also lack of BIM information.

In short, the opinions of the targeted respondents from the two cases are similar with the outcomes from the questionnaire. Majority of their opinions are converging to the findings from the responses collected through the questionnaire. Hence, this structured interview can be used to strengthen the findings from the questionnaire,

4.9 Proposed Improvement for BIM Implementation

The most important factor to drive the implementation of BIM in Malaysian construction industry is through the support and enforcement by the government (Zahrizan, et al., 2014). Besides, CREAM (2014) stated the government and its agencies need to ensure that the BIM technology will be successfully implemented in Malaysian construction industry as well. Without the support from government to enforce the implementation of BIM, the construction industry in Malaysia will be still slow or stagnant. A structured BIM course for the construction key players should be provided to share the knowledge and application of BIM. In addition, a standard code of practices and guidelines of BIM should be generated in order to ease the construction key players to implement and manage BIM in their organisation.

Apart from government support, leadership of top management or senior management is also one of the methods to accelerate the BIM implementation in the Malaysian construction industry (Zahrizan, et al., 2014). By having a strong support from top management, the process of migration which is from traditional method to BIM technology can be carry out easily and smoothly. This is because the top management committed in adopting new technology and subsequently this can motivate their staffs to implement it and moving forward.

On the other hand, implementation of BIM can also be improved through education. For instance, a university can provide and offer course or curriculum related to BIM, so that students can have an idea about BIM in the early stage and thus they are ready to work with new technology in real working life. Zahrizan et al. (2014) stated that “As we know, BIM technology in Malaysia is really new, therefore there are many opportunities for university researchers to conduct research related to BIM and they could collaborate with the industry to identify the needs and the area for exploration”.

Besides that, there are also other proposed improvements can be carry out to increase the implementation of BIM in Malaysian construction industry. Table 4.8 shows the summary of proposed improvement in implementing BIM in construction industry.

Table 4.8: Summary of Proposed Improvement for BIM Implementation

Proposed Improvement	Source
- Offer motivation programmes such as seminars and workshops - Incorporate BIM courses in the syllabus of educational institutions - Offer properly structured BIM courses at the university level - Prepare a standard code of practices and guidelines for BIM	- CREAM (2014) - Smith, P. (2014) - Rogers et al. (2015)
- Support and enforce the implementation of BIM by the government - Seek initiative of senior management and related industry players	- Zahrizan et al. (2014) - Smith, P. (2014)

4.10 Summary

In this chapter, we have discussed what BIM is all about and the current situation of construction industry in Malaysia regarding the implementation of BIM.

From the responses obtained from the questionnaire, majority of the respondents were utilised 2D and 3D computer-aided design tools for their working. They are working in different disciplines with different BIM tools and this caused the BIM takes place in an isolated condition. This is Level 1 of BIM which is about the modelling produced by various disciplines. Besides that, they worked collaboratively with other disciplines or players of a project as well. The model from various disciplines will then be collaborated and the BIM model with information can only be produced. This is related to the Level 2 of BIM which sharing of models and data are involved in this level.

Secondly, the benefits and barriers in implementing BIM in Malaysian construction industry were studied and discussed in this chapter. With the responses obtained from the practitioners from the railway projects, the top five benefits that can gain are discussed in sub-section 4.5. Besides that, the barriers faced during the implementation of BIM on railway project were also discussed in sub-section 4.6.

From the structured interview with targeted respondents of the two cases, the responses as mentioned in sub-section 4.8.1 were similar with the findings from the questionnaire. This can be used to further support the outcomes of the analysis on the questionnaire.

Last but not least, some of the proposed or potential improvement that can be carry out to tackle the barriers faced during the implementation of BIM was also discussed in sub-section 4.9.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Generally, this chapter is summarising the findings and outcomes obtained for this research study through the literature review, responses collected from the questionnaires distributed and interviews with targeted practitioners. Conclusion will be made with those outcomes to achieve the objectives of this research. Last but not least, limitations of this research will be stated in this chapter, as well as the recommendations for further research.

5.2 Conclusions

In order to achieve the objectives of this research, review of literature was the very first thing to carry out to study the BIM related issues in worldwide and in Malaysia context. Next, questionnaire was developed and distributed based on the literature review to obtain relevant data and interviews with targeted respondents or practitioners who involved in railway projects were carry out to obtain advices and opinions on BIM related matters. The results or responses of the questionnaire received via e-mail and social media was then analysed and further discussed. These will then be supported with the opinions from practitioners in order to achieve the objectives of this research.

The first objective of this research is to determine the level of BIM adoption in Malaysian construction industry. As discussed and mentioned in sub-section 4.10, the level of adoption BIM in Malaysian construction industry can be said that is between Level 1 and Level 2.

The second objective of this research is to determine the benefits of implementation of BIM on railway project. From the analysis of the results obtained, the top five benefits that the respondents can gain from their project are as follows:

a) Better visualization of a design
b) Better understanding of concept and feasibility of a project
c) Improve quality of project
d) Improve collaboration from multiple disciplines
e) Better design optimization

Last but not least, the third objective of this research is to examine the barriers faced during the implementation of BIM on railway project. From the analysis of the data gathered, the top five barriers that the respondents faced throughout the implementation of BIM are as follows:

a) High initial cost of software

b) High cost of implementation process

c) Challenges of collaboration with other disciplines

d) High cost of training and education

e) Lack of professionals

These conclusions were further support and strengthen with the opinions obtained through interviews with targeted experts or practitioners from the two cases. From the responses obtained, all of them agreed that the quality of a project can be improved by utilising BIM. On the other hand, majority of them were said that the most important factor of barrier for BIM implementation was the high initial cost of BIM software. Apart from that, there are also some other benefits and barriers as mentioned by the experts which were similar with the top five benefits and barriers as determined from the questionnaire responses.

In order to improve the adoption level of BIM in Malaysia construction industry, the necessary solutions or improvement must be carry out to overcome the barriers faced by the construction players. So that the BIM can be widely used and construction players can gain benefits from the implementation of BIM on the projects.

5.3 Limitations of Research

There are some limitations in order to achieve the objectives of this research. First of all, time constraint was one of the limitations in this research. As this research has to be completed within a stipulated time period, the researcher was left a short period of time to carry out the study due the researcher has a professional occupation in place.

Due to the time constraint, the number of respondents involved in this research may not represent the entire population of the Malaysian construction industry. Initially, there are approximately 120 sets of questionnaire have been distributed through e-mail and social media. However, only 75% of the distributed questionnaire received. Majority of the respondents were come from the same background of the researcher, which is consultancy. Besides, the low response rate from other professions may be one of the reasons for the imbalance of data which will then affect the sample size of this research. As a result, the analysis and outcomes of this research may not sufficient to represent the perception of the entire population of the key players in Malaysian construction industry.

Besides that, the interviews conducted in this research were mainly from consultancy background or point of view. This was also one of the limitations for this research. Wider group of interviewee in different professions of construction industry should be considered in order to obtain more accurate and precise information or data.

5.4 Recommendations for Further Research

Research is about searching for knowledge. Even though this research is has been carry out, further study or research on this similar trend or issue can be investigate in future with some recommendations.

First is to obtain more valid responses to get a more accurate analysis and result. This mean that a wider range of responses obtained can lead to a more accurate analysis and thus the precise result can only be withdrawn. However, it is subjected to the availability of time period for the study.

Last but not least, an in depth study and more detail understanding on the BIM related matter in specific sector are needed for future research. So that it can be used to support or argue with the general understanding of BIM matter. Hence, the additional knowledge of BIM can be discovered and will be more relevant in specific field of construction industry rather than a generalised aspect.

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APPENDICES

Appendix A: Questionnaire

Building Information Modelling (BIM) in Malaysian Construction Industry Survey

Dear Valued Participant,

I greatly appreciate your valuable time and effort that you spent your 10 minutes to fill out this questionnaire.

I am Ng Wei Yean (student ID: 16UEM05832) and currently pursuing Master in Project Management at University Tunku Abdul Rahman (UTAR), Sungai Long campus. As part of my research study, I am conducting this survey to study the implementation of Building Information Modelling (BIM) in Malaysian construction industry, especially railway projects. As such, I am seeking the assistance of key players in construction industry, especially involved in railway projects, to participate in this research by completing the following questionnaire.

All your responses in this questionnaire will be kept as confidential and will only be used for educational research. Should you have any inquiries, please do not hesitate to contact me at 018-3114338 or wyng1106441@1utar.my

Last but not least, thank you very much and greatly appreciate of your kind assistance.

* Required

Section A: Background of Respondents

Please tick (√) the one most appropriate for the following questions.

1. **What is your profession or area of specialization in construction industry? ***

   Mark only one oval.

   ◯ Client / Developer
   ◯ Consultant / Architect
   ◯ Contractor
   ◯ Supplier / Vendor
   ◯ Other: ______________________

2. **How long is your working experience in construction industry? ***

   Mark only one oval.

   ◯ Less than 2 years
   ◯ 2 to 5 years
   ◯ 6 to 10 years
   ◯ 11 to 15 years
   ◯ More than 15 years

3. **What is the construction projects' value range that the most you involved in? ***
Mark only one oval.

- ◯ Less than RM 10 mil
- ◯ RM 11 mil to RM 30 mil
- ◯ RM 31 mil to RM 50 mil
- ◯ RM 51 mil to RM100 mil
- ◯ More than RM 100 mil

4. **Do you involved in any railway projects? ***
Mark only one oval.

- ◯ Yes
- ◯ No

5. **Do you expose to or involve in using of BIM for the projects that the most you involved in? ***
Mark only one oval.

- ◯ Yes *Skip to question 6.*
- ◯ No *Skip to question 39.*

6. **What tool of BIM that the most you have been used? ***
Mark only one oval.

- ◯ AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D *Skip to question 7.*
- ◯ Revit Architecture / Revit Structure/ Revit MEP *Skip to question 7.*
- ◯ Navisworks *Skip to question 7.*
- ◯ StaadPro *Skip to question 7.*
- ◯ Tekla Structures *Skip to question 7.*
- ◯ Other: ____________________ *Skip to question 7.*

Section B (BIM Users)

Part 1: Benefits of Implementing BIM

Please select the one most appropriate for the following questions.

7. **1. Implementation of BIM will provide a better understanding of concept and feasibility of a project at an early stage.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. **2. Implementation of BIM will enable reductions in overall project costs.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. **3. Implementation of BIM will provide a more accurate cost estimation of a project.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. **4. Implementation of BIM will shorten the design planning and design period.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

11. **5. Implementation of BIM will shorten the project delivery time.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

12.
6. Implementation of BIM will provide better design optimization. *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

13.
7. Implementation of BIM will improve project quality due to a more detailed building model achieved the demands or requirements of client. *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

14.
8. Implementation of BIM will provide a better or more accurate visualization of a design. *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

15. **9. Implementation of BIM will improve collaboration of multiple design disciplines, e.g. structure, foundation, drainage, mechanical, electrical, etc.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

16.
10. Implementation of BIM will provide a better procurement type due to a more accurate quantities for all material used in a project. *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

17.
11. Implementation of BIM will enhance the planning and scheduling of material, manpower and equipment for a project. *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

18.
12. Implementation of BIM will increase the efficiency and productivity of a project due to a better work schedule. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

19.
13. Implementation of BIM will enable to identify and analyze problems earlier in the project process. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

20.
14. Implementation of BIM will easier to make decision when there is a problem identified. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

21. **15. Implementation of BIM will improve commissioning and handover process of a project.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

22.
Any other comment(s)?

Skip to question 23.

Section B (BIM Users)

Part 2: Barriers of Implementing BIM

Please select the one most appropriate for the following questions.

23. **1. High initial cost of software.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

24. **2. High cost of implementation process, e.g. additional overhead cost.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

25. **3. Lack of professionals.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

26. **4. High cost of training and education.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

27. **5. Time consuming to enroll staffs for BIM training.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

28. **6. Unwilling / not ready to change from current practice to BIM oriented method.** *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

29. **7. Challenges of collaboration / integration with other disciplines / stakeholders.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

30. **8. Lack of resources both software and hardware for implementation of BIM.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

31. **9. Lack of knowledge / information about BIM.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

32. **10. Unclear BIM advantages and practices.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

33. **11. Incomplete national standards or guidelines for implementation of BIM.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

34. **12. Lack of top management or senior support / organization issue.** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

35.
13. Lack of appropriate legal framework and tools for implementation of BIM. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

36.
14. Lack of resources both software and hardware for implementation of BIM. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

37.
15. Legal issue, i.e. certification or licensing problems. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

38.
Any other comment(s)?

Stop filling out this form.

Section C (Non-BIM Users)

Please tick (√) the one most appropriate for the following questions.

39. What is/are your reason(s) for not implementing BIM? *

Mark only one oval.

- ◯ Cost of implementing BIM is high.
- ◯ Time consuming to train the staffs to use BIM in projects.
- ◯ Not necessary or no contract agreement to adopt BIM for projects.
- ◯ Other: ____________________

40. Will you think that your organization will be left behind or struggle to survive if do not implement BIM in projects? *

Mark only one oval.

- ◯ Yes
- ◯ No

41. Will you considering the implementation of BIM within your organization /projects? *

Mark only one oval.

- ◯ Yes
- ◯ No

42. What stage of a project you plan on utilizing BIM? *

Mark only one oval.

- ◯ Planning and design stage
- ◯ Detailed design stage
- ◯ Construction stage
- ◯ Facility management or operation stage
- ◯ Other: ____________________

43. Have you had any external requests for implementing BIM in a project? *

Mark only one oval.

- ◯ Yes
- ◯ No

44. From whom that the external requests for implementing BIM in a project? *

Mark only one oval.

- ◯ Client / Developer *Stop filling out this form.*
- ◯ Consultant / Architect *Stop filling out this form.*
- ◯ Contractor *Stop filling out this form.*
- ◯ Other: ____________________ *Stop filling out this form.*

Appendix B: Raw Data of Questionnaire

Background of Respondents						
Respondent	Profession or area of specialization	Working experience	Construction projects' value range	Involvement in railway project (Yes/No)	Exposure to BIM (Yes/No)	BIM tool
R1	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R2	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R3	Consultant / Architect	2 to 5 years	More than RM 100 mil	No	No	
R4	Consultant / Architect	11 to 15 years	More than RM 100 mil	Yes	Yes	Revit Architecture / Revit Structure/ Revit MEP
R5	Consultant / Architect	2 to 5 years	Less than RM 10 mil	Yes	Yes	Revit Architecture / Revit Structure/ Revit MEP
R6	Consultant / Architect	Less than 2 years	RM 51 mil to RM100 mil	No	No	
R7	Consultant / Architect	6 to 10 years	RM 11 mil to RM 30 mil	Yes	Yes	Navisworks
R8	Consultant / Architect	2 to 5 years	RM 11 mil to RM 30 mil	Yes	No	
R9	Consultant / Architect	2 to 5 years	RM 11 mil to RM 30 mil	No	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R10	Consultant / Architect	Less than 2 years	Less than RM 10 mil	No	No	
R11	Consultant / Architect	Less than 2 years	Less than RM 10 mil	No	No	
R12	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R13	Client / Developer	6 to 10 years	Less than RM 10 mil	No	No	
R14	Contractor	Less than 2 years	RM 51 mil to RM100 mil	No	No	
R15	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R16	BIM Modeler	2 to 5 years	RM 11 mil to RM 30 mil	No	Yes	Tekla Structures
R17	Consultant / Architect	11 to 15 years	Less than RM 10 mil	No	No	
R18	Lecturer	Less than 2 years	Less than RM 10 mil	No	No	
R19	Consultant / Architect	2 to 5 years	More than RM 100 mil	No	No	
R20	Consultant / Architect	2 to 5 years	RM 31 mil to RM 50 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R21	Contractor	2 to 5 years	RM 31 mil to RM 50 mil	No	Yes	Navisworks
R22	Consultant / Architect	Less than 2 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R23	Consultant / Architect	6 to 10 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R24	Consultant / Architect	2 to 5 years	RM 11 mil to RM 30 mil	No	No	
R25	Client / Developer	Less than 2 years	Less than RM 10 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R26	Consultant / Architect	More than 15 years	More than RM 100 mil	Yes	No	
R27	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R28	Consultant / Architect	6 to 10 years	More than RM 100 mil	Yes	Yes	Revit Architecture / Revit Structure/ Revit MEP
R29	Client / Developer	2 to 5 years	More than RM 100 mil	No	No	
R30	Consultant / Architect	2 to 5 years	RM 31 mil to RM 50 mil	No	No	
R31	Contractor	2 to 5 years	Less than RM 10 mil	Yes	No	
R32	Consultant / Architect	6 to 10 years	More than RM 100 mil	Yes	Yes	Revit Architecture / Revit Structure/ Revit MEP

Background of Respondents						
Respondent	Profession or area of specialization	Working experience	Construction projects' value range	Involvement in railway project (Yes/No)	Exposure to BIM (Yes/No)	BIM tool
R33	Consultant / Architect	2 to 5 years	Less than RM 10 mil	No	No	
R34	Client / Developer	2 to 5 years	Less than RM 10 mil	No	No	
R35	Client / Developer	11 to 15 years	More than RM 100 mil	No	No	
R36	Contractor	6 to 10 years	More than RM 100 mil	No	No	
R37	Client / Developer	More than 15 years	More than RM 100 mil	No	No	
R38	Project Delivery Partner (PDP)	11 to 15 years	More than RM 100 mil	Yes	No	
R39	Consultant / Architect	11 to 15 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R40	Project Delivery Management	6 to 10 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R41	Supplier / Vendor	Less than 2 years	Less than RM 10 mil	No	No	
R42	Consultant / Architect	2 to 5 years	RM 11 mil to RM 30 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R43	Contractor	More than 15 years	More than RM 100 mil	No	No	
R44	Client / Developer	Less than 2 years	RM 51 mil to RM100 mil	Yes	No	
R45	Client / Developer	Less than 2 years	More than RM 100 mil	Yes	No	
R46	Contractor	2 to 5 years	RM 11 mil to RM 30 mil	No	No	
R47	Client / Developer	Less than 2 years	RM 51 mil to RM100 mil	Yes	No	
R48	Consultant / Architect	2 to 5 years	RM 11 mil to RM 30 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R49	Consultant / Architect	Less than 2 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R50	Client / Developer	2 to 5 years	RM 51 mil to RM100 mil	Yes	No	
R51	Contractor	2 to 5 years	RM 31 mil to RM 50 mil	No	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R52	Consultant / Architect	2 to 5 years	More than RM 100 mil	No	Yes	Revit Architecture / Revit Structure/ Revit MEP
R53	Client / Developer	6 to 10 years	RM 31 mil to RM 50 mil	No	No	
R54	Client / Developer	6 to 10 years	More than RM 100 mil	Yes	No	
R55	Consultant / Architect	More than 15 years	RM 31 mil to RM 50 mil	No	No	
R56	Contractor	Less than 2 years	RM 11 mil to RM 30 mil	No	No	
R57	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R58	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R59	Consultant / Architect	6 to 10 years	More than RM 100 mil	Yes	Yes	Revit Architecture / Revit Structure/ Revit MEP
R60	Contractor	6 to 10 years	RM 51 mil to RM100 mil	No	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D

Background of Respondents						
Respondent	Profession or area of specialization	Working experience	Construction projects' value range	Involvement in railway project (Yes/No)	Exposure to BIM (Yes/No)	BIM tool
R61	Contractor	6 to 10 years	RM 51 mil to RM100 mil	No	No	
R62	Contractor	11 to 15 years	RM 31 mil to RM 50 mil	No	No	
R63	Consultant / Architect	6 to 10 years	RM 51 mil to RM100 mil	No	No	
R64	Contractor	11 to 15 years	More than RM 100 mil	No	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R65	Contractor	11 to 15 years	More than RM 100 mil	No	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R66	Contractor	2 to 5 years	RM 51 mil to RM100 mil	No	No	
R67	Contractor	2 to 5 years	RM 51 mil to RM100 mil	No	No	
R68	Safety and Health Officer	More than 15 years	More than RM 100 mil	No	No	
R69	Contractor, Supplier / Vendor	More than 15 years	Less than RM 10 mil	No	No	
R70	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R71	Contractor	Less than 2 years	More than RM 100 mil	Yes	Yes	Revit Architecture / Revit Structure/ Revit MEP
R72	Contractor	2 to 5 years	RM 51 mil to RM100 mil	Yes	No	
R73	Consultant / Architect	6 to 10 years	RM 31 mil to RM 50 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R74	Consultant / Architect	More than 15 years	More than RM 100 mil	Yes	No	
R75	Contractor	2 to 5 years	RM 11 mil to RM 30 mil	Yes	No	
R76	Clerk of work	More than 15 years	More than RM 100 mil	No	No	
R77	Client / Developer	More than 15 years	More than RM 100 mil	No	No	
R78	Contractor	11 to 15 years	Less than RM 10 mil	No	No	
R79	Contractor	Less than 2 years	Less than RM 10 mil	No	No	
R80	Supplier / Vendor	2 to 5 years	Less than RM 10 mil	Yes	No	
R81	Client / Developer	Less than 2 years	Less than RM 10 mil	No	No	
R82	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R83	Consultant / Architect	6 to 10 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R84	Client / Developer	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R85	Client / Developer	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R86	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R87	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R88	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R89	Consultant / Architect	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D
R90	Contractor	2 to 5 years	More than RM 100 mil	Yes	Yes	AutoCAD / AutoCAD Architecture / AutoCAD Mechanical /AutoCAD Electrical / AutoCAD Civil 3D

Respondent	Benefits of BIM Implementation															Barriers of BIM Implementation														
	BE1	BE2	BE3	BE4	BE5	BE6	BE7	BE8	BE9	BE10	BE11	BE12	BE13	BE14	BE15	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8	BA9	BA10	BA11	BA12	BA13	BA14	BA15
R1	4	3	4	4	3	4	4	4	4	3	4	4	4	4	2	4	4	3	3	3	2	3	3	3	3	4	4	3	4	3
R2	4	5	5	2	3	4	4	5	4	4	4	3	3	3	3	4	3	1	3	2	4	4	3	3	2	2	2	3	3	3
R3																														
R4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	5	5	5	3	5	1	1
R5	5	3	3	3	3	4	5	5	5	4	4	2	3	4	4	1	4	3	3	3	5	5	3	5	3	5	5	5	3	5
R6																														
R7	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	1	1	1	1	2	3	1	1	1	3	1	1	2
R8																														
R9	4	3	4	4	4	4	4	4	4	4	4	3	3	3	3	2	4	4	4	2	2	2	3	2	2	4	5	3	3	3
R10																														
R11																														
R12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
R13																														
R14																														
R15	4	3	4	4	4	4	4	5	4	3	4	3	4	4	4	4	3	4	4	4	3	3	3	4	3	4	5	5	5	5
R16	3	3	3	2	4	3	2	4	2	5	4	3	4	3	5	5	3	4	3	3	5	5	3	3	3	2	3	2	3	4
R17																														
R18																														
R19																														
R20	3	4	4	4	4	3	5	5	3	3	3	3	4	3	3	5	5	4	4	5	3	3	3	3	2	3	4	3	3	3
R21	5	5	3	3	3	5	5	5	5	5	4	5	5	5	5	2	2	5	5	5	3	4	2	3	2	4	5	4	1	1
R22	5	4	5	4	3	5	4	4	4	4	4	5	4	5	4	4	3	5	4	4	5	4	4	5	4	3	5	4	4	3
R23	4	4	4	1	4	4	4	5	5	2	4	4	5	5	1	5	5	4	4	5	2	5	2	1	1	4	1	1	1	1
R24																														
R25	4	5	5	5	4	3	5	4	4	3	3	4	5	3	3	4	5	5	5	5	5	3	4	5	1	2	5	3	5	1
R26																														
R27	4	2	4	3	4	5	4	4	4	4	4	4	4	3	3	5	4	4	3	3	4	4	4	4	3	5	4	5	4	3
R28	5	3	4	1	4	4	5	5	5	4	3	4	5	5	2	4	4	4	2	4	2	5	4	2	2	2	2	4	4	2
R29																														
R30																														
R31																														
R32	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	3	3	4	3	1	5	3	5	5	3	5	5	5	5	4

Respondent	Benefits of BIM Implementation															Barriers of BIM Implementation														
	BE1	BE2	BE3	BE4	BE5	BE6	BE7	BE8	BE9	BE10	BE11	BE12	BE13	BE14	BE15	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8	BA9	BA10	BA11	BA12	BA13	BA14	BA15
R33																														
R34																														
R35																														
R36																														
R37																														
R38																														
R39	4	4	3	2	4	4	4	4	4	4	4	4	4	4	4	3	4	5	4	4	3	4	3	5	4	4	3	3	4	3
R40	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
R41																														
R42	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	4	4	5	4	3	3	3	3	3	3
R43																														
R44																														
R45																														
R46																														
R47																														
R48	3	4	4	3	3	4	5	4	5	3	3	3	3	3	3	4	3	4	4	5	4	3	3	5	4	3	5	3	3	4
R49	5	5	4	4	4	4	4	4	5	4	4	4	4	5	4	3	4	5	4	3	5	2	3	4	2	3	2	4	4	4
R50																														
R51	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	3	4	3	3	3	3	3	3	3	2
R52	5	2	4	5	5	5	4	5	5	5	3	3	3	3	4	5	4	3	5	5	3	3	3	1	5	2	5	3	3	3
R53																														
R54																														
R55																														
R56																														
R57	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
R58	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
R59	5	5	5	1	1	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	3	4	4	5	3
R60	4	4	3	5	4	3	4	4	4	4	4	4	4	4	4	4	4	3	3	4	4	3	3	3	2	3	2	2	3	3

Respondent	Benefits of BIM Implementation															Barriers of BIM Implementation														
	BE1	BE2	BE3	BE4	BE5	BE6	BE7	BE8	BE9	BE10	BE11	BE12	BE13	BE14	BE15	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8	BA9	BA10	BA11	BA12	BA13	BA14	BA15
R61																														
R62																														
R63																														
R64	4	3	3	4	3	4	3	4	4	3	4	4	4	3	3	5	5	4	5	4	3	4	3	3	3	3	3	3	3	3
R65	5	3	4	4	3	4	4	4	5	4	3	3	4	4	4	4	3	2	3	3	3	3	3	3	3	3	4	4	3	3
R66																														
R67																														
R68																														
R69																														
R70	5	5	5	2	2	4	4	5	4	4	5	4	5	4	4	5	5	5	5	4	2	4	5	4	2	3	3	3	4	3
R71	5	4	5	5	4	5	5	5	5	4	4	4	5	5	5	3	5	5	4	5	5	5	5	4	5	5	5	5	4	5
R72																														
R73	4	3	4	4	4	5	4	5	4	4	4	4	4	4	3	4	4	4	4	4	4	5	4	4	2	4	4	4	4	4
R74																														
R75																														
R76																														
R77																														
R78																														
R79																														
R80																														
R81																														
R82	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	4	4	3	4	4	3	4	4	3	4	4	3	4	4	3
R83	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4
R84	3	3	3	3	3	4	4	4	4	4	3	3	3	3	3	5	4	3	4	5	4	3	4	5	4	3	4	5	4	3
R85	4	4	3	4	4	3	4	4	3	4	4	3	4	4	3	4	4	3	4	3	4	4	3	4	3	4	4	3	4	3
R86	3	3	3	3	3	4	4	4	4	4	3	3	3	3	3	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3
R87	4	4	4	4	4	3	3	3	3	3	4	4	4	4	4	5	5	4	4	3	3	4	4	3	3	3	3	4	4	3
R88	5	3	3	3	3	5	3	5	4	3	3	3	4	3	3	5	5	3	5	3	3	5	3	3	3	3	3	3	3	3
R89	3	3	3	4	4	4	3	3	3	4	4	4	3	3	3	5	5	2	5	3	3	4	3	3	3	3	3	3	2	2
R90	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3

Respondent	Non-BIM Users					
	Reason for not implementing BIM	Will your organization will be left behind if do not implement BIM?	Will consider BIM?	Stage of a project plan on utilizing BIM?	Any external requests for implementing BIM?	From whom that the external requests for implementing BIM in a project?
R1						
R2						
R3	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	No	
R4						
R5						
R6	Company is implementing, its in a transition condition	Yes	Yes	Planning and design stage	No	
R7						
R8	Time consuming to train the staffs to use BIM in projects.	No	Yes	Planning and design stage	Yes	Client / Developer
R9						
R10	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	No	
R11	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Planning and design stage	Yes	Client / Developer
R12						
R13	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	Yes	Contractor
R14	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Detailed design stage	No	
R15						
R16						
R17	Cost of implementing BIM is high.	Yes	Yes	Planning and design stage	No	
R18	Not necessary or no contract agreement to adopt BIM for projects.	No	No	No	No	
R19	Time consuming to train the staffs to use BIM in projects.	Yes	Yes	Detailed design stage	No	
R20						
R21						
R22						
R23						
R24	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Detailed design stage	No	
R25						
R26	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Detailed design stage	Yes	Client / Developer
R27						
R28						
R29	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Detailed design stage	No	
R30	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	Yes	Client / Developer
R31	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Construction stage	Yes	Consultant / Architect
R32						

Respondent	Non-BIM Users					
	Reason for not implementing BIM	Will your organization will be left behind if do not implement BIM?	Will consider BIM?	Stage of a project plan on utilizing BIM?	Any external requests for implementing BIM?	From whom that the external requests for implementing BIM in a project?
R33	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	No	
R34	Time consuming to train the staffs to use BIM in projects.	Yes	Yes	Detailed design stage	No	
R35	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Planning and design stage	No	
R36	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Detailed design stage	No	
R37	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Planning and design stage	No	
R38	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Detailed design stage	No	
R39						
R40						
R41	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Planning and design stage	No	
R42						
R43	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Facility management or operation stage	No	
R44	Cost of implementing BIM is high.	Yes	No	Planning and design stage	No	
R45	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Planning and design stage	No	
R46	Cost of implementing BIM is high.	No	Yes	Planning and design stage	No	
R47	Time consuming to train the staffs to use BIM in projects.	Yes	Yes	Planning and design stage	No	
R48						
R49						
R50	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Planning and design stage	No	
R51						
R52						
R53	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Planning and design stage	No	
R54	My working area doesnt need BIM	No	Yes	Detailed design stage	No	
R55	Cost of implementing BIM is high.	No	Yes	Detailed design stage	No	
R56	New to BIM for my personal	No	Yes	Construction stage	No	
R57						
R58						
R59						
R60						

Respondent	Non-BIM Users					
	Reason for not implementing BIM	Will your organization will be left behind if do not implement BIM?	Will consider BIM?	Stage of a project plan on utilizing BIM?	Any external requests for implementing BIM?	From whom that the external requests for implementing BIM in a project?
R61	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Planning and design stage	No	
R62	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	No	
R63	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Planning and design stage	No	
R64						
R65						
R66	Time consuming to train the staffs to use BIM in projects.	Yes	Yes	Construction stage	No	
R67	Cost of implementing BIM is high.	Yes	No	Planning and design stage	No	
R68	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Facility management or operation stage	No	
R69	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Construction stage	No	
R70						
R71						
R72	Not necessary or no contract agreement to adopt BIM for projects.	No	Yes	Planning and design stage	Yes	Client / Developer
R73						
R74	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Construction stage	No	
R75	Time consuming to train the staffs to use BIM in projects.	No	No	Construction stage	Yes	Client / Developer
R76	Not necessary or no contract agreement to adopt BIM for projects.	Yes	Yes	Planning and design stage	No	
R77	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Planning and design stage	No	
R78	Cost of implementing BIM is high.	No	Yes	Construction stage	No	
R79	Cost of implementing BIM is high.	No	Yes	Construction stage	No	
R80	Not necessary or no contract agreement to adopt BIM for projects.	No	No	Facility management or operation stage	No	
R81	Cost of implementing BIM is high.	Yes	No	Construction stage	Yes	Client / Developer
R82						
R83						
R84						
R85						
R86						
R87						
R88						
R89						
R90						

Appendix C: Interview Transcript

Interviewee	Please share your knowledge or opinions of benefits and barriers for the BIM implementation in the project.
P1	It took quite a big amount of money and time consuming to implement BIM in our company, because the computers need to be upgraded and installed with new software. However, company only allocated certain amount of money on this and staffs have to use the limited amount of computer with software licence according to how urgent of their work. The quality of the work is better because if there is any clashes happen, we can directly foresee what and how can be adjusted through the model. It is quite convenient for making decision. In the very beginning, it is more barriers than benefits for BIM implementation. This is because we have to invest more on this since our company did not have any BIM professional. But now our company got own BIM team to carry out the works. This brings more benefits for us, especially in design stage. These benefits include better understanding on design due to a better visualisation of the model, better decision making and most important is that collaboration with other disciplines can be improved in order to create the BIM model.
P2	There are many cost issue regarding BIM implementation. One of the issues is licence of the software. This is because there is a quota or limit of licence to be used in company. Each team has limited number of licence to assess the software with specific computer. Extra money need to be invested if more software licence is needed and it takes some time to process and install as well. The quality of work is depends on how detail the model it is but normally, the quality is better than traditional method. Basically the model can make client easier to understand the concept of design due to a better visualisation of the project. Unlike traditional method which has to explain with 2D drawings. If client wants to change the design, we can easily imagine with the BIM model produced. The main benefit of using BIM is that the model created is full of data or information. We can obtain what information we want for our design from the model directly. We can even know the details of one component of the building, such as door frame. The brand, size, colour, appearance, material and other information of one component can easily get from the model. The main barrier of using BIM is the complexity of the model due to various disciplines involved in the project. Due to the model is full of information, it is also a barrier which the computers need to be compatible and support such heavy file or model. In short, extra money needs to invest on the new software and carry out the BIM implementation. This is not a small amount eventually.
P3	As I know, company did invest certain huge amount in invest BIM. This is because the BIM team is hired from overseas, not local. So it is quite expensive to employ a BIM team for the project. It is also takes some times to implement BIM. This is because staffs need to work with BIM team so that a right

	model can be produced. The quality of design is quite good compare to traditional method. This is because drawing can be shown easily in 3D view now. So, if there is any discrepancy, we can easily capture and revise the design prior construction. For me, I think that the most important benefit is the client can easily understand our design by just showing them the 3D BIM model which is having a better visualisation of the project. The barrier that I faced most of the time is the collaboration of different disciplines. This involved many staffs and designs from various disciplines have to input into the model. Thus, the model is quite complicated and heavy file which may lag to open. In order to tackle this issue, the company has to invest the existing software which is quite a big amount since there are many computers used by the staffs.
P4	Although our company has a BIM team, but we also had to send our staffs for BIM training in order to work with them. Thus, this training cost quite a lot since the training fee that offers in market is not cheap. Besides, it is also takes time for staffs to familiarise with the new BIM software. The quality of the design can be improved due to the mistakes or errors can be minimised. This is because with 3D model, it is easier to notify where there is a problem. While traditional method we have to imagine ourselves with 2D drawings. Thus, BIM model provide a better visualisation of the design. For the barrier, I think the most hinder the design by using BIM are the cost and time consuming to train the staffs, including the engineers involved, because there are quite many engineers involved in a project and they need to know how to utilise the BIM software for design purpose.
P5	A company need to invest a lot of money and time in order to implement BIM for projects. The costs may include of software and hardware costs, training costs and other associated costs. However, it is worth to produce a better quality of design. This is because the model created is full of latest data and design information. It can be easily updated whenever there is a clash happened. For me, the benefit is that I can easily update the model with the latest, revised and approved design and information provided by various team members. So that the latest model can be shared among the team members of the project. However, this is also one of the barriers. Due to there are various disciplines involved in a project, hence it is confusing sometimes for me to update the model. Because there are too many version of a single design. Thus, a BIM model is complicated and complex.
P6	I think it is cost quite a lot to implement BIM in this organisation. This is because all the BIM team members are hired from foreign country. Besides, it is requires some times and cost to train the existing staffs to familiarise the BIM software, because there is no shortcut to use BIM software, must learn from step by step, in order to produce a high quality

	of design. By using BIM, the quality of the design can be assured. This is because the design standards or code of standard can be set as a guideline in the software for design and checking purposes. I think the most benefit of BIM is the information or data of the model can be easily obtained by team members and even key players such as client and contractor. They can just obtain whatever data they want to know by just clicking on the model and this can save a lot of time for them to contact, to ask and to refer certain personnel to get what they want. On the other hand, I think the most important barrier of BIM is the complexity of the model. The model file is too heavy and I always have to wait about 2 to 3 minutes to open the file. This is quite annoying. So, company must invest in BIM software in order to work efficient and this cost may be a huge amount of money.
P7	The cost of implementing BIM is quite high, no matter hire BIM professionals or train existing staffs. This requires certain time period to implement BIM successfully. However, I believed that the quality of the design or product by using BIM is better compared to traditional method. As I know, people used ruler and pen to draw 2D drawings in previous time. But nowadays, high technologies are available and ease people to produce a better quality and reliable designs and works. The most important benefit can get from BIM is various disciplines can work together with the same model and subsequently, thus will improve the quality of the model. However, it is also a barrier for me. This is because there are various disciplines I have to collaborate with, so that the model is always enriched with the latest design and information.
P8	I think the most important issue for BIM implementation is money related issues, such as software and hardware, and competent personnel. This is because BIM team need make use of different software to create the BIM model and BIM professional is needed to carry out these works. As I know, the BIM team in our company is hired from foreign country and this may cost a certain big amount. Thus, this is the most important barrier in BIM implementation. On the other hand, the benefits that I can get from my working are included of the design and concept of the project can be easily understood by client and authority. Besides, a better quality of design can also be produced due to the mistakes are minimised.
P9	As I start working, I was trained to use BIM software such as Autodesk Civil 3D for my design working purpose. As I know, the BIM software can produce a reliable and better quality of design which can countercheck what we have input into the design with the guidelines that have been set in the software. By using BIM software, we can optimise our design as well. In other words, we will not overdesign which will produce an extra cost for a project. Thus, better design optimisation is the most important benefit for a project. However, the most important

	barrier is the lack of senior or professional guidance on the use of BIM software. This is because I learned the software through the training provided by outside software company as instructed by company and this have to bond myself to the company for two years of employment.
P10	I think that BIM implementation requires a lot of money to invest. This is because the BIM related software is quite expensive. Besides, it takes time to train the new staffs to use BIM software, unless company provide training as offered in the market, but this is not encourage since there is staff who can train them in working space. Besides money issues, the other barrier is licencing issues of the software. This is because the BIM software is not installed in every engineer's computer. There is a limit or quota of licence available for each team. Despite of these barriers, BIM implementation brings also benefits for the project. I think that the most important benefit is the quality of the design can be improved. This is because the design can be optimise which also fulfilled the standards.
P11	For me I think that the most important benefit of BIM is a better quality of design can be produced. This can be seen through many aspects. For example, by using BIM tools, we can carry out clash analysis. If there is any clash happened in the model, we can easily identify and overcome such issue subsequently. This can lead to a better efficiency and productivity of a project, since the mistakes or errors can be tackled before construction. On the other hand, there are also some barriers during BIM implementation. For example, the newbies are lack of information about BIM. Normally, the new staffs (fresh graduate) are not clear what BIM is about. Besides, in order to create a BIM model, it is challenges of collaboration with other disciplines. This is because a BIM model is full of various disciplines data and information, such as architectural, C&S, MEP and others.
P12	In my opinion, the working process is depending on the company working standard. One of the barriers of BIM is that most of the working sequence is up to the real site condition which is cannot be detected by the software itself. Thus, site observation is required in advance. However, we can minimise the mistakes or errors by using software. Besides, we can also optimise our design and thus, quality of design can be improved.