THE BENEFIT OF BUILDING INFORMATION MODELLING TECHNOLOGY APPLIED IN PUBLIC TRANSPORTATION CONSTRUCTION

NURUL AAIN ISHAK

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Construction Management)

School of Civil Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

JANUARY 2020

DEDICATION

This thesis is dedicated to my family, who taught me to keep striving and improving in education and career.

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor Dr. Ain Naadia Bt Mazlan for the continuous support of my master degree study and research, for her patience, motivation and immense knowledge. Her guidance helped me in all the time of research and writing of the project report.

My sincere thanks also go to my family, for supporting me spiritually throughout my study. Last but not least, I would like to thank my company top management and colleagues for giving me support and understanding me during my journey to finish my master degree.

ABSTRACT

Malaysia has progressively becoming a developed country and the demand for construction projects came from government and private construction sectors to fulfil the economic needs of infrastructures and commercial building. Traditional methods of construction using 2D drawing during the planning phase cannot promise that the construction project will be completed within contractual time, budgeted cost and a good construction quality. Malaysia has started to implement BIM technology as it is one of the promising developments in the architecture, engineering, and construction fields (AEC) industry. The purpose of this study is to assess the benefits of BIM technology as an enabler in the construction industry in term of time, cost and quality. The research methodology was divided into two stages. In stage 1, existing data and suitable parameters were identified. For stage 2, elements of architecture, structure and MEP were coordinated and demonstrated in a 3D model using Autodesk Revit and clash detection of these elements were detected by Autodesk Navisworks Manage. The results of clash detection had resolved 2D drawing issues. The research of benefit usage of BIM technology was collected and summarized into likert scale questionnaire. The questionnaire was distributed to 20 respondents who were involved in BIM technology works. The result shows that the benefits of BIM were agreed and supported by all respondents. Thus, it is recommended to use BIM in construction and contractors are encourage to implement BIM in a future project and to meet demand of construction industry in Malaysia.

ABSTRAK

Malaysia semakin berkembang menjadi negara maju dan permintaan datang dari sektor kerajaan dan sektor pembinaan swasta untuk memenuhi keperluan ekonomi dalam infrastruktur dan bangunan komersial. Kaedah tradisional pembinaan menggunakan lukisan 2D tidak dapat menjanjikan projek pembinaan akan selesai dalam masa yang ditetapkan, mengikut kos yang dianggarkan dan tidak menjamin kualiti pembinaan yang baik. Malaysia telah mula melaksanakan teknologi BIM kerana ia merupakan salah satu perkembangan dalam industri seni bina, kejuruteraan, dan pembinaan. Tujuan kajian ini adalah untuk menilai faedah teknologi BIM dalam industri pembinaan dari segi masa, kos dan kualiti. Metodologi penyelidikan terbahagi kepada dua peringkat. Pada peringkat 1, data sedia ada dan parameter yang sesuai dikenalpasti. Untuk peringkat 2, unsur-unsur seni bina, struktur dan MEP diselaraskan dan ditunjukkan dalam model 3D menggunakan Autodesk Revit dan pengesanan percanggahan antara semua unsur dikesan menggunakan Autodesk Navisworks Manage. Hasil pengesanan telah menyelesaikan masalah lukisan 2D. Kajian penggunaan manfaat teknologi BIM dikumpulkan dan diringkaskan dalam soal selidik jenis skala likert. Soal selidik diedarkan kepada 20 kakitangan yang terlibat dalam teknologi BIM. Hasilnya menunjukkan manfaat BIM telah dipersetujui dan disokong oleh semua responden. Oleh itu, disyorkan penggunaan BIM dalam pembinaan dan kontraktor digalakkan untuk melaksanakan BIM dalam projek masa depan dan untuk memenuhi permintaan industri pembinaan di Malaysia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEC	Architecture, engineering & construction
AFC	Automatic Fare Collection
BIM	Building Information Modelling
CDE	Common Data Environment
CMMS	Computerised Maintenance Management System
COMMS	Telecommunication Systems
CSD	Combined Services Drawing
C&S	Civil & Structural
FCU	Fan coil unit
ICSS	Integrated Control & Supervisory System
KVMRT	Klang Valley Mass Rapid Transit
MRT	Mass Rapid Transit
MRTC	MRT Corporation
M&E	Mechanical & Electrical
PS&D	Power Supply & Distribution
SBK	Sungai Buloh-Kajang
SSP	Sungai Buloh-Serdang-Putrajaya
S&TC	Signaling & Train Control System
VDR	Visual Design Review

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Over the past decades, Malaysia has progressively becoming a developed country and the demand for construction projects came from government and private construction sectors to fulfil the economic needs of infrastructures and commercial building (Aryani et.al, 2013). This sector puts pressure to contractors to handle more projects to meet demand and complete them within shorter timeframes. In order to meet increasingly demanding needs, traditional methods of construction have to be replaced with new and more efficient methods (USG Boral, 2019). Traditional methods of construction using 2D drawing during the planning phase cannot promise that the construction project will be completed within contractual time, budgeted cost and a good construction quality. Building Information Modelling (BIM) is a new technology that has been introduced with the concept of 3D modelling to replace the traditional method of 2D drawing. There is a commendation that BIM technology contribute positively in a complicated project as it can correct errors during design stage and can help to produce schedule for construction from start to finish. (Kubba, 2012).

Malaysia has started to implement BIM technology in construction industry. In the architecture, engineering and construction fields (AEC), BIM technology is a new technology that can provide development as well as manage construction project throughout the entire construction phase. (Azhar, 2011). Construction of infrastructure from design stage until construction stage was transformed to be better as BIM deprive embellish all stages of construction. In 2007, BIM has started to be implemented and the idea was come from Director of Public Works Department (PWD). This shows that Malaysian government has realised that BIM technology provide benefit in the construction industry such as construction cost can be reduced,

minimise the error during design phase and BIM can provide a better coordination between all parties such as engineers, architectures, management team and client (Aryani et.al, 2013).

Since Malaysia has progressively develop a numerous of complex project as well as high-risk projects, it is encouraged BIM technology to be implemented by all parties in construction. (JKR, 2011). As a result of BIM offer a countless of benefit, construction companies will simultaneously get opportunities to explore more in the construction industry and apply BIM in a future project (Aryani et.al, 2013). With BIM applications, construction company can improve quality of project, able to provide a better planning stage to manage time and cost of construction. Hence, this paper discusses on how BIM can help construction company to provide a better design stage in 3D model drawing compared to traditional methods of 2D drawing in terms of time, cost and quality of construction.

1.2 Background of the Study

A traditional method in construction industry which using intense labour is currently changing to use information technology especially in the developing countries. The issues of wastage, errors and rework can be reduced when BIM technology can resolve the problem (T. Nath et.al, 2015). Though BIM has existed in the last 20 years ago, people only aware the usefulness of BIM that can make industry be more efficient and streamlined (Takim et.al, 2013). In Malaysia, it is proven when in 2016, MRT Corp has received mandates BIM Level 2 implementation for MRT Construction Line 2 Sungai Buloh – Serdang – Putrajaya (SSP) Line (MRT Corp, 2018).

BIM technology offering numerous benefit and opportunities. This has resulted for the Malaysian government to introduce BIM technology in the AEC industries (Aryani et.al, 2013). BIM technology can play as a coordination platform between all parties and this can benefit the construction players as well as provide a faster design decision. There are several tools in the BIM technology which can ease

the activity in the design stage. As a result, the time use during design stage can be shorten as well as decreasing the cost of construction (Aryani et.al, 2013).

BIM technology is made up of several tools that using three dimension and all elements of architecture, structure and MEP are coordinated together in a same 3D model. This model will be analyzed, detect clashes between all the elements, prepare a construction's schedule as well as can select a type of product which later benefit whole project conceptualization (Weygant, 2011). Starting form conceiving until operation of the building, BIM has started to play as an emerging technology in many countries (Wong et.al. 2009). The tools of BIM provide a user opportunity to create visual simulation as well as create a prototype of building prior to construction start (Takim et.al, 2013).

In view of the BIM evolution, MRT Corp has started to implement BIM in their MRT construction SSP line. A total of 66 packages with several Work Package Contractors involved (MRT Corp, 2018) made design stage and construction stage are difficult to handle if traditional methods of 2D drawing is still being used. Each contractor has their own design requirement and their individual design requirement must be combined with other contractors' requirement in a single drawing. Table 1.1 shows list of work package contractors who are involved in the MRT construction.

Table 1.1 Work Package Contractors involved in the construction of MRT line 2 (MRT Corp, 2018).

Contractors	Station Elevated Packages (S201-S210): Description of Works
Civil WPC	Construction of C&S works, architectural works, and MEP works.
System WPC (SY201)	Signalling & Train Control System (S&TC)
System WPC (SY202)	Integrated Control & Supervisory and Computerised Maintenance Management System (ICSS & CMMS)
System WPC (SY204)	Trackwork

System WPC (SY205)	Power Supply & Distribution (PS&D)
System WPC (SY206)	Telecommunication Systems (COMMS)
System WPC (SY207)	Automatic Fare Collection (AFC)

Based on Table 1.1, Civil Work Package Contractor (CWPC) is the responsible contractor to construct C&S works, architectural works, and mechanical, electrical and plumbing (MEP) works. Meanwhile, there are another contractor called System WPC (SWPC) which is divided into six system contractors with their own specialist works. Each contractor needs to coordinate their requirement of equipment location, routing of conduit, trunking, piping, cable containment and to check whether there is MEP clashes between the services itself or clashes between the MEP services with structure elements and architectural elements inside BIM model. All of this coordination works is resolved by using BIM technology as a platform centre of coordination.

From the results of coordination between elements involved in BIM model, the routing of each element and its location will be discussed among all contractors involved. Once the coordination results are agreed among all contractors, the drawing called Combined Services Drawing (CSD) will be proceed to the approval stage. This coordination is done during the design construction phase. From this approved drawing, it has resulted a lot of benefit in terms of cost, time and quality especially during construction phase until testing and commissioning.

1.3 Problem Statement

In construction industry, 2D drawing will be issued out to contractors for their reference during construction stage. This 2D drawings are separated into each specific discipline such as architectural discipline, structural discipline and mechanical, electrical and plumbing (MEP) disciplines. The individual 2D drawings

will be used by the designer during design stage and will be used by the contractors during construction phase. However, this traditional 2D drawing methods will not combine all disciplines in a single drawing which make contractors difficult in planning their task when they need to coordinate their works with other parties involved in a project.

Since years ago, countless problem had occurred in the construction industry globally. Time of construction has delayed due to failure of design stage and it impacts the construction cost to become higher. Poor work planning causes site construction to become dirty and it also led to a poor quality of construction. Besides, site condition is dangerous when contractor is lack of work coordination and information. It is proven when there is exist of failed construction project which is the collapsed of Jaya Supermarket located at Petaling Jaya, Selangor. These problems had caused negative impact to the industry. The event of collapsed of this building shows that construction industry in Malaysia is weak in design stage (Aryani et.al, 2013).

Construction planning must be effective starting from pre-construction phase until post-construction phase. In order to prepare an effective planning, BIM technology starting to become an innovative way which all contractors can start to implement. Even though BIM provide a countless of benefits in the construction industry, the application of BIM is still under infancy. Hence, the awareness of BIM must be spread to construction players in order for them to improve their works. Since Malaysia just started to implement BIM in AEC industry, it is noted that this technology is still new to the construction industries. The price to purchase or rental BIM technology is expensive. However, BIM is encouraged to be implemented by all construction players as BIM can provide solution to overcome numerous problems throughout construction stage. (Aryani et.al, 2013).

1.4 Aims of the Study

The aim of the study is to assess the benefits of BIM technology as an enabler in the construction industry in term of time, cost and quality.

1.5 Objectives of the Study

(a) To demonstrate the application of BIM technology in MRT design phase.

(b) To determine the benefit of BIM according to BIM technology in MRT design phase.

(c) To categorise the benefit according to time, cost and quality of the usage of BIM in MRT construction.

1.6 Scope of the Study

There are several types of software in BIM that can be used for coordination works but mainly this study focused on two pieces of software which are Autodesk Navisworks Manage and Autodesk Revit. Autodesk Navisworks Manage allows users to open and combine 3D models, navigate around them in real-time and review the model using a set of tools including comments, redlining, viewpoint, and measurements while Autodesk Revit is building information modelling software for architects, landscape architects, structural engineers, M&E engineers, designers and contractors which the software allows users to design a building and structure and its components in 3D, annotate the model with 2D drafting elements and access building information from the building model's database (Autodesk, 2019). As per mentioned earlier, BIM technology is used as a coordination platform centre to coordinate each drawing shared by contractors involved and superimpose work is done to identify the clashes captured in the drawing.

1.7 Limitations of the Study

In this study, there are two types of software in BIM that will be used which are Autodesk Revit and Autodesk Navisworks Manage. Each software has its own functionality and the usage of these two pieces of software are to focus on their benefit in construction. There are three groups of elements that need to be look at in order to meet overall objectives of this study which are civil and structural (C&S) works, architectural works, and mechanical, electrical and plumbing (MEP) works. These three groups of elements are coordinated in the BIM model in order to check their routing and location as well as to check if any clashing happen between the elements combined.

In order to analyse the benefit usage of BIM technology, a questionnaire was distributed to construction workers that involve with BIM technology. Through the results of survey conducted, the benefit usage of BIM technology can be analysed in terms of cost, time and quality. However, the cost only analysed generally as it is confidential details by construction industries involved.

REFERENCES

Achilleas Kostoulas (2013). On Likert scales, ordinal data and mean values. Retrieved from Achielleas Kostoulas website: https://achilleaskostoulas.com/2013/02/13/on-likert-scales-ordinal-data-and-mean-values/

Ahmad. (2018). MRT Corp is first in Asia to achieve BIM Level 2 accreditation. (2018, December 21). New Straits Times, p. 1.

Ahmad Ajwad Azman. (2018, December 21). MRT Corp is first in Asia to achieve BIM Level 2 accreditation. New Straits Times, p. 1.

Aryani Ahmad Latiffi, Suzila Mohd, Narimah Kasim, Mohamad Syazli Fathi. Building Information Modeling (BIM) Application in Malaysian Construction Industry. International Journal of Construction Engineering and Management. 2013. 2(4A): 1-6.

Autodesk (2019). What is Navisworks? Retrieved from Autodesk website: https://knowledge.autodesk.com/support/navisworks-products/troubleshooting/caas/sfdcarticles/sfdcarticles/What-is-Navisworks.html

Bethany (2017). Top 10 Benefits of Building Information Modeling (BIM). Retrieved from Scan2CAD website: https://www.scan2cad.com/cad/benefits-of-bim/

Constructiontuts (2019). 12 Advantages of BIM in Construction – Building Information Modeling Benefits. Retrieved from Construction Tuts website: https://www.constructiontuts.com/advantages-of-bim-in-construction/

Hariz Mansor (2018). MRTC BIM Industrial Collaboration Programme (ICP). Malaysia: MRT Corp.

USG Boral (2019). As Malaysia's construction industry continues to grow, innovation will be imperative. Retrieved from The Edge Markets website: https://www.theedgemarkets.com/content/advertise/as-malaysia-construction-industry-continues-to-grow-innovation-will-be-imperative

Sam Kubba (2012). Handbook of Green Building Design and Construction [online]. Available at: https://www-sciencedirect-

com.ezproxy.utm.my/science/article/pii/B9780123851284000056 (Accessed: 20 Dec 2019).

Salman Azhar. Building Information Modelling (BIM): Trends, Benefits, Risks and Challenges for the AEC Industry. 2011. 11(3):241-252.

Jabaran Kerja Raya (JKR) (2011). Laporan Tahunan JKR 2011. Pp 28-29. Retrieved March 12, 2013, from website: http://www.jkr.gov.my/var/files/File/dokumen/laporan_tahunan_jkr_2011.pdf

T. Nath et al. Productivity improvement of precast shop drawings generation through BIM-based process re-engineering. Automation in Construction. 2015. 54-68.

MRTCorp (2018). BIRAC BIM IN RAIL ACADEMY BY MRT CORP. Malaysia: MRT Corp.

Roshana Takim et al. Building Information Modeling (BIM): A new paradigm for quality of life within Architectural, Engineering and Construction (AEC) industry. Procedia - Social and Behavioral Sciences 101. (2013) 23 – 32.

MRTCorp (2017). SUNGAI BULOH-KAJANG (SBK LINE). Retrieved from MRT Corp website: https://www.mymrt.com.my/public/sg-buloh-kajang-sbk-line/

MRTCorp (2017). SUNGAI BULOH-SERDANG-PUTRAJAYA (SSP LINE). Retrieved from MRT Corp website: https://www.mymrt.com.my/public/sg-buloh-serdang-putrajaya- ssp-line/

MRTCorp (2018, July). Mass Rapid Transit Corporation Sdn Bhd – NGIS. Retrieved from MRT Corp website: https://ngis.mygeoportal.gov.my/sites/default/files/ngis8/NGIS_Conf_GIS_Tony_July20 18_V4.pdf

MRTCorp (2017). MRT CORP FIRST IN ASIA TO ACHIEVE BIM LEVEL 2 ACCREDITATION. Retrieved from MRT Corp website: https://www.mymrt.com.my/events/mrt-corp-first-in-asia-to-achieve-bim-level-2- accreditation/

RICS (2018, June 2018). A game-changing expansion for Malaysia. Retrieved from RICS website: https://www.rics.org/asean/news-insight/latest-news/news-opinion/a-game- changing-expansion-for-malaysia/

Maxson Chew (2018). MRTC REVIT STRUCTURE ESSENTIAL. Malaysia: MRT Corp. SAME (2019). BIM – UNDERSTANDING THE PROCESS. Retrieved from SAME website: http://www.samedcpost.org/docs/presentation_bim_031611.pdf

Tony Joseph MRT Corp (2018, July). Mass Rapid Transit Corporation Sdn Bhd. Retrieved from NGIS website: https://ngis.mygeoportal.gov.my/sites/default/files/ngis8/NGIS_Conf_GIS_Tony_July2018_V4. pdf

Juan Rodriguez (2018, August 25). Building Information Modeling (BIM) Benefits Per Profession. Retrieved from The Balance Small Business website: https://www.thebalancesmb.com/building-information-modeling-bim-benefits-845045

Niraj Thurairajah and Dan Goucher. Advantages and Challenges of Using BIM: a Cost Consultant's Perspective. PhD Thesis. Birmingham City University; 2013.

Thomas Goubau (2016, December 1). What is BIM? What are its Benefits to the Construction Industry? Retrieved from APROPLAN website: https://www.aproplan.com/blog/quality-management-plan-construction/what-is-bim-what-are- its-benefits-to-the-construction-industry

M.A. Nunez (2014). 15 advantages of using BIM. Retrieved from VisualARQ website: https://www.visualarq.com/2014/03/12/15-advantages-of-using-bim/