OPTIMIZING THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING BIM 4D(SCHEDULING) AND 5D (COST) IN HIGHWAY AND BRIDGE CONSTRUCTION

JIMMYSON ANAK MANGGI

FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH

2022

OPTIMIZING THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING BIM 4D(SCHEDULING) AND 5D (COST) IN HIGHWAY AND BRIDGE CONSTRUCTION

JIMMYSON ANAK MANGGI

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR OF CIVIL ENGINEERING

FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH
2022

UMS
UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS THESIS

PUMS 99:1

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN TESIS

JUDUL : OPTIMIZING THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING BIM 4D(TIME) AND 5D (COST) IN HIGHWAY AND BRIDGE CONSTRUCTION

IJAZAH : SARJANA MUDA KEJURUTERAAN DENGAN KEPUJIAN (KEJURUTERAAN AWAM)

SAYA : JIMMYSON ANAK MANGGI **SESI PENGAJIAN** : SEMESTER 2 2021/2022
(HURUF BESAR)

Mengaku membenarkan tesis *(LPSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
✓	TIDAK TERHAD	

Disahkan oleh:

JIMMYSON MANGGI (BK18160280)

(TANDATANGAN PUSTAKAWAN)

Alamat Tetap: NO. 35, BLOCK 10, TAMAN IXORA INDAH, JALAN SELIRIK, 96800 KAPIT, SARAWAK

Sr. Ts. Dr ASMAWAN MOHD SARMAN

TARIKH: 28 JUNE 2022

TARIKH: ____________

Catatan:
*Potong yang tidak berkenaan.
*Jika tesis ini SULIT dan TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.
*Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana Secara Penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM).

DECLARATION

I hereby declare that this thesis, submitted to University Malaysia Sabah as partial fulfilment of the requirements for the degree of Bachelor of Civil Engineering. This thesis has not been submitted to any other university for any degree. I also certify that the work described herein is entirely my own, except for quotations and summaries sources of which have been duly acknowledged.

This thesis may be made available within university library and may be photocopied or loaned to other libraries for the purposes of consultation.

19 July 2022

JIMMYSON ANAK MANGGI

BK18160280

VERIFICATION

NAME	:	**JIMMYSON ANAK MANGGI**
MATRIC. NO	:	**BK18160280**
TITLE	:	**OPTIMIZING THE IMPLEMENTATION OF BUILDINGINFORMATION MODELLING BIM 4D(TIME) AND 5D (COST) IN HIGHWAY AND BRIDGE CONSTRUCTION**
DEGREE	:	**BACHELOR'S DEGREE**
FIELD OF STUDY	:	**CIVIL ENGINEERING**
DATE OF VIVA	:	**19 JULY 2022**

APPROVED BY;

Signature

SUPERVISOR

Sr Ts. Dr. Asmawan Mohd Sarman ______________________

UNIVERSITI MALAYSIA SABAH

ACKNOWLEDGEMENT

First, I would like to express my gratitude to everyone who assisted me in completing my thesis since they are a part of my most outstanding achievement. I would not have been able to finish my thesis without the encouragement and support of everyone, including my loving parents, my most helpful supervisor, instructors, and beautiful friends. I want to thank the following individuals who have served as crucial advisers and supporters.

I'd want to begin by thanking God for blessing me with excellent health and joyful life, without which I could not have completed my dissertation. God has provided me with the fortitude to complete my thesis despite the Covid-19 epidemic. Next to Him are my parents and siblings, who have always supported me through good and terrible times, and who have consistently pushed me to reach this position.

I want to express my most profound appreciation to my supervisor, Sr. Ts. Dr. Asmawan Mohd. Sarman, for his unwavering support and counsel during my Final Year Project. I am grateful to him for his assistance through trying times, mainly because my thesis has been finished for him.

Finally, I would like to show my appreciation to my closest pals, whom you all know. When I need assistance, I always turn to them, and they always raise me with their love and support. Without your help and support, I would not complete my thesis. I am ecstatic to have you as a buddy.

Thank you.

Jimmyson Anak Manggi
19 July 2022

ABSTRACT

Building Information Modelling (BIM) is a shared knowledge repository for information about a facility that serves as a trustworthy foundation for decision-making throughout the facility's life cycle, which is described as "existing from inception to demise." BIM is still lacking in usage and awareness of BIM benefits in implementation in the road and bridges construction industry. Therefore, the objective of this study is to identify the current level of awareness of Building Information Modelling implementation in the highway and bridge construction industry, to produce a BIM 4D (Scheduling) and 5D (Cost Estimating) model based on the highway and bridge construction project and to recognize the benefits and challenges of implementing Building Information Modelling approaches in the highway and bridge construction industry. This research conducted an industrial survey, literature review, and 4D/5D BIM modelling focussing on the Malaysian highway and bridge construction industry. The results suggest that the industry had a moderate understanding of 4D/5D BIM but had superior scheduling and cost estimating skills. The three highest listed benefits are improved on-site cooperation, model-based cost estimation, and project visualization in preconstruction with 3.633, 3.767 and 3.900 mean rank respectively. The three highest-ranked challenges are technical problems, legal challenges, and reluctance to change with 3.500, 3.467 and 3.400 mean rank respectively. In order to replicate the 4D/5D model, modelling is constructed using Infraworks, MS Project, and Navisworks.

Keywords: BIM, 4D and 5D, Highway and Bridges construction.

ABSTRAK

MENGOPTIMALKAN PELAKSANAAN PEMODELAN MAKLUMAT BANGUNAN BIM 4D(MASA) DAN 5D (KOS), FAEDAH DAN CABARAN PELAKSANAAN BIM DI PEMBINAAN LEBUHRAYA DAN JAMBATAN

Pemodelan Maklumat Bangunan (BIM) ialah repositori pengetahuan dikongsi untuk maklumat tentang kemudahan yang berfungsi sebagai asas yang boleh dipercayai untuk membuat keputusan sepanjang kitaran hayat kemudahan itu, yang digambarkan sebagai "wujud dari permulaan hingga kematian." BIM masih kurang dalam penggunaan dan kesedaran tentang faedah BIM dalam pelaksanaan dalam industri pembinaan jalan dan jambatan. Oleh itu, objektif kajian ini adalah untuk mengenal pasti tahap kesedaran semasa pelaksanaan Permodelan Maklumat Bangunan dalam industri pembinaan lebuh raya dan jambatan, untuk menghasilkan model BIM 4D (Penjadualan) dan 5D (Anggaran Kos) berdasarkan pembinaan lebuh raya dan jambatan. projek dan untuk mengiktiraf faedah dan cabaran melaksanakan pendekatan Pemodelan Maklumat Bangunan dalam industri pembinaan lebuh raya dan jambatan. Penyelidikan ini menjalankan tinjauan industri, tinjauan literatur, dan pemodelan BIM 4D/5D yang memfokuskan kepada industri pembinaan lebuh raya dan jambatan Malaysia. Keputusan menunjukkan bahawa industri mempunyai pemahaman sederhana tentang BIM 4D/5D tetapi mempunyai kemahiran penjadualan dan anggaran kos yang unggul. Tiga faedah tersenarai tertinggi ialah kerjasama di tapak yang dipertingkatkan, anggaran kos berasaskan model dan visualisasi projek dalam prapembinaan dengan kedudukan min masing-masing 3.633, 3.767 dan 3.900. Tiga cabaran peringkat tertinggi ialah masalah teknikal, cabaran undang-undang, dan keengganan untuk berubah dengan kedudukan min 3.500, 3.467 dan 3.400 masing-masing. Untuk meniru model 4D/5D, pemodelan dibina menggunakan Infraworks, MS Project dan Navisworks.

Kata Kunci: BIM, 4D dan 5D, pembinaan Lebuhraya dan Jambatan.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BIM	Building Information Modelling
PWD	Public Work Department
JKR	*Jabatan Kerja Raya*
LoD	Level of Details
PtD	Prevention through Design
NIC	Newly Industrialised Country
GDP	Gross Domestic Output
AECO	Architectural, Engineering, Construction and Operation
O&M	Operation and Maintenance
NIBS	National Building System
AEC	Architectural, Engineering and Construction
BDS	Building Description System
GLIDE	Graphical Language for Interactive Design
BPM	Building Product Model
GBM	Generic Building Model

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia obtained independence from British domination in 1963, resulting in the formation of the Federation of Malaysia. The first members were Malaya, Sarawak, Sabah, and Singapore. Singapore seceded from the federation and became an independent state in 1965 as a result of internal political strife. Peninsular Malaysia has been separated into east and west portions. It is often referred to be one of the richest non-western nations. By the late twentieth century, it had made an extraordinarily seamless and steady transition to current economic prosperity. Malaysia was classified as a Newly Industrialized Country (NIC) in 1990. At current currency rates, it is the world's 37th largest economy in terms of gross domestic output (GDP). Former Prime Minister Tun Dr. Mahathir Mohammad forecasted a strong industrialised economy and a modernised Malaysia in February 1990 (Khan, 2014). He laid the groundwork for Malaysia's economic and social progress, political stability, government system, standard of living, social and spiritual values, national pride, and confidence to flourish. Malaysia 2020 is the initiative's official name. By 2020, this vision's principal objective is to transform Malaysia into an affluent, competitive, dynamic, strong, and resilient nation. The construction industry, with its dynamic nature and backward and forward connections to other sectors of the economy, has the potential to play a significant and intriguing role in this regard. This sector provides the socioeconomic infrastructure required for industrial growth and production, as well as essential amenities such as residential and commercial space, parks, playgrounds, and stadiums, health care facilities, roads, highways, railways, ports, airports, dams, and power generation and distribution stations.

Today, a country's transportation infrastructure may be thought of as its backbone, since the reliable, safe, and efficient movement of goods and people is important for economic and social growth. With population expansion growing and transportation infrastructure deteriorating, there is an enormous need for more efficient and cost-effective technologies and techniques for constructing, maintaining, monitoring, and repairing. There has been a significant push for the development and deployment of innovative transportation technologies, as well as the implementation of various existing building technologies and practises. In the building industry, Building Information Modelling is a very effective tool (BIM). BIM is "a digital representation of a facility's physical and functional attributes," as defined by the United States' National Building Information Model Standard Project Committee. A BIM is a shared knowledge repository for information about a facility that serves as a trustworthy foundation for decision-making throughout the facility's life cycle, which is described as "existing from inception to demise." (Moynihan & Harsh, 2015). Confusion and misunderstanding occur when BIM is seen just as a three-dimensional model of a facility enhanced with features and functions; however, BIM is about information, and the three-dimensional model is merely one technique of expressing the information. As a result of the emergence of centralised information generation, sharing, and management, a significant paradigm shift occurred in the Architecture, Engineering, Construction, and Operations (AECO) industry, with a shift away from traditional design methods toward more collaborative information-centric design. BIM is defined and interpreted variously based on the context, which may include a product, a collaborative process, or a need for facility lifecycle management (NIBS, 2015). BIM's objective was to collect all data and information associated with the design and construction of a facility in order to be utilised for operations and maintenance (O&M).

For decades, BIM has been widely accepted in the construction industry, but its acceptance and implementation in transportation infrastructure has been gradual (Kim, Kim, Ok, & Yang, 2015). While business and academia are making progress toward BIM adoption for non-building civil infrastructure, transportation-related activities have yet to be thoroughly examined. By combining BIM with existing infrastructure management technologies, it is possible to achieve more reliable, sustainable, and safe network performance while minimising maintenance costs and risks and generating revenue for all stakeholders. A thorough understanding of this technology, its applications, benefits and drawbacks, advancements and limitations, can assist owners, designers, and other transportation authorities in making more informed decisions and selecting the most appropriate set of automated and strategic plans for enhanced infrastructure network management over its life.

1.2 Problem Statement

Building Information Modelling (BIM) is still lacking in usage and awareness of BIM benefits in implementation in the road and bridges construction industry. BIM implementation in private and public construction sectors is still shallow. Most of the surveyed organizations are not using BIM, and the team is not practicing its concept. This results in a delay in the diffusion of BIM implementation (Ahmad-Latiffi & S. Mohd, 2013). As a result, future engineers must use BIM and devise implementation techniques to benefit society. The lack of awareness of BIM approaches benefits in highway and bridges construction industry.

In addition, majority of highway and bridge construction project lack a connection between the project scheduling, cost estimation to the generated BIM model that has been generated. This is due to the complicated and dynamic process of road and bridges construction process.

Lastly, most of the practitioners in the construction industry are lacking in interest to implement the 3D/4D/5D BIM in highway and bridges construction industry. Lack of true understanding of what BIM is (Alhumayn, E, & Ndekugri, 2017).

1.3 Objective

The purpose of this study is to provide perspectives on the optimization and application of Building Information Modelling 4D (Scheduling) and 5D (Cost Estimation) in the road and bridge building sector. The following are the study's objectives:

1. To identify the current level of awareness of Building Information Modelling implementation in the highway and bridge construction industry.

2. To produce a BIM 4D (Scheduling) and 5D (Cost Estimating) model based on the highway and bridge construction project.
3. To recognize the benefits and challenges of implementing Building Information Modelling approaches in the highway and bridge construction industry.

1.4 Scope of Work

Highway and bridge building is a demanding and dynamic process, and as the project's size and complexity increase, so do the construction management challenges. BIM allows for the visualisation of the whole building process (Shien, 2020). However, a few metrics have been restricted to research to accomplish the paper's aims. This article will focus only on the road and bridge building business. Road and bridge development is a critical component of every country's socioeconomic prosperity. Nonetheless, the business has several challenges because of its complexity, including low productivity, substandard quality, rising prices, construction waste, delays, and a lack of information sharing among project stakeholders. This paper is divided into three sections. The first section will be included inside the questionnaire. The questionnaire will be issued only to practitioners in Malaysia's road and bridge building industries. This technique will address the present phases of BIM implementation in the road and bridge building sector. The next section will discuss the literature review. The article published between 2015 and 2021 will be used as a source for this paper's references. Additionally, the articles were accessed through the University Malaysia Sabah's online platform. This section will discuss the advantages of utilising Building Information Modeling to estimate the timeframe and cost of road and bridge building projects. The last section of this paper's area of study is Scheduling and Timeline Management in 4D and Cost Estimation in 5D Building Information Modelling (BIM). This last section will discuss the difficulties associated with using Building Information Modelling techniques in the road and bridge building business.

1.5 Significant of Study

Time and expense overruns are linked with the conventional construction management method. BIM visualizes the whole construction process of a project in 4D and 5D. The project management team can see the phases of the construction process and quickly discover conflicts or issues with the construction organization plan. Consequently, examining the optimization potential of 4D and 5D BIM in construction may throw insight into how BIM addresses and resolves time and cost overruns in highway and bridge projects. It will assist readers in appreciating the advantages of BIM use in construction scheduling and estimation. As a result, the Malaysian construction sector will be compelled to integrate BIM 4D and 5D into highway and bridges construction projects, resulting in more reliable scheduling and cost estimation projects.

1.6 Summary

Building Information Modelling (BIM) is still lacking in usage and implementation strategy in the road and bridges construction industry. BIM implementation in private and public construction sectors is still shallow. The construction of highways and bridges is a complicated and dynamic process, and as the project grows in size and complexity, so make the difficulties of construction management. This paper will only cover the area of optimization and implementation of the road and bridge construction industry. This paper's objective is to identify the current implementation stages of Building Information Modelling in the road and bridges construction industry. Identify the benefits and challenges of using BIMs to improve project timelines and cost estimation for road and bridge construction projects

1.7 Report (Summary of all Chapter)

This study will focus on adopting and applying BIM 4D and 5D in the road and bridge building industry. The pattern of this study has been discussed in the first chapter, Introduction. This chapter has the following elements: background of the study, problem statement, aim of the investigation, scope of work, importance of the study, and summary. This factor all affected the direction of the research and the breadth of the inquiry.

Chapter 2 will be on Preliminary research. The first step in starting a research project is a literature review. This stage is accomplished by studying previous journals and publications related to this dissertation. Documented studies are essential for gathering relevant information and reducing the investigation area related to the objectives. Past research from the year 2015 to the year 2021 was evaluated using various sources to acquire relevant information on the optimization and implementation of BIM 4D and 5D on the road and bridges construction industry, particularly in Malaysia. SpringerLink, ScienceDirect, ResearchGate, Cabi, Taylor & Francis, and Gale were chosen as data collection mediums for the quantitative investigation. This website is fully accessible via the media supplied by the University. These websites are accessible via the UMS Library's Offline login.

Chapter 3 is the methodology, the foundation of the whole research framework. This study aims to provide insights into how to maximize the potential of BIM 4D and 5D for use in the road and bridge building industries. This chapter will go through the flow planning of the approach used in this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Building Information Modelling (BIM)

Building information modelling (BIM) has entered the mainstream, offering a new collaborative approach and a new style of working that is redefining established AECOO industry structures and practises to increase efficiency and achieve environmental goals (Alex, Haijiang, & Simon, 2016). The issue of BIM has become a focal area for AECOO industry improvement, to the point that the idea is being stretched into sectors for which it was not initially intended. Transforming BIM for infrastructure projects presented obstacles and highlighted the function Object() { [native code] } viewpoint of BIM. Numerous countries worldwide, including Norway, Singapore, Canada, the United States of America, and the United Kingdom, have adopted BIM; and surveys conducted by McGraw-Hill Construction revealed that western Europe lagged North America, which adopted BIM at a rate of 49%, compared to just over a third (36%) in western Europe. 47% of these users were architects, 38% were engineers, and 24% were contractors (McGraw-Hill, 2010). This demonstrates a lack of acceptance in the contracting industry, maybe owing to a lack of awareness of the contractor's role in BIM.

The National Building Specification in the United Kingdom has performed yearly BIM studies and surveys. The newest NBS BIM report (2015) illustrates a growing outlook, demonstrating that BIM adoption has gained momentum in the UK, going from 13% in 2010 to 40% in 2012 and continuing to 50% in 2014, a significant growth in a short time (NIBS, 2015). In comparison, comparable surveys performed by McGraw Hill Construction in the United States indicate that BIM adoption for infrastructure is around three years behind that for buildings, having reached 50% adoption in 2013 (McGraw-Hill, 2010). These levels will continue to expand as more academic research is performed and the UK industry reaches BIM level 2 and continues to level 3 (Nor et al., 2019) (Nor, Sarman, Che-Ani, Latiff, & W.Wahi., 2019).

The construction industry is crucial to the UK meeting the criteria set forth in the Climate Change Act 2008, which sets an 80 percent CO_2 reduction target for 2050 (Kassem, 2013). Consequently, the UK government issued a directive requiring the use of fully collaborative BIM at maturity level 2 by 2016 (Kassem, 2013). The mandate stipulates that BIM must be utilised on all public works projects, including those in the infrastructure sector such as rail, road, utilities, and energy that have a longitudinal rather than vertical shape. Infrastructure contractors and engineers have been driven to accelerate the adoption of BIM in the form of design and field (site) BIM in a sector infamous for its strong reliance on 2D design and enormous static documentation. Adapting the BIM concept to the unique needs of infrastructure projects is critical for efficient BIM deployment and compliance by UK contractors with the 2016 mandate.

BIM is a process that comprises the creation and administration of digital representations of a place's physical and functional characteristics (Du & Hindawi, 2021), which is aided by a variety of tools, technologies, and contracts. BIMs are digital models of constructed assets that can be viewed, replicated, and networked in order to assist decision-making about the asset (often but not always in proprietary formats and including proprietary data). Individuals, corporations, and government bodies use BIM software to plan, design, build, manage, and maintain buildings and a range of physical infrastructures, such as water, waste, electricity, gas, communication utilities, highways, trains, bridges, ports, and tunnels. The National Building Information Model Standard Project Committee defines building information modelling as follows:

“Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition (Moynihan & Harsh, 2015).”

2.2 BIM Development

The term "BIM" refers to the process of creating and managing digital information on a created asset, such as a building, bridge, highway, or tunnel. While it is believed that Building Information Modelling (BIM) would change the Architecture, Engineering, and Construction (AEC) industry, new study shows that adoption will come more slowly than optimistic predictions.

2.2.1 History of Building Information Modelling (BIM)

Professor Charles Eastman pioneered the BIM concept in late 1970 at Georgia Tech's School of Architecture. It has grown in a variety of ways since its start (Reddy, 2012). Design, estimation, construction process, building life cycle, performance, and technology are all considered. The objective of BIM implementation in construction projects varies according to project stage, which includes pre-construction, construction, and post-construction (Ahmad-Latiffi & S. Mohd, 2013).

As seen in Figure 2.1, the BIM idea has advanced. In 1975, Professor Charles Eastman founded Building Description Systems (BDS) to streamline the design development process (Eastman & A, 1995). BDS is defined as a database that allows for the definition of structures in order to ease their design and construction (Eastman & Lividini, 1975). Through element specification, BDS has been used to develop models of complex physical systems. Among BDS's capabilities include the ability to create, modify, and arrange a large number of components, as well as the detection of design incompatibilities (Eastman & Henrion, 1977). Due to technology constraints in the late 1970s, BDS was limited to certain libraries and design alternatives pertaining to architectural, structural, or energy-related elements.

Thus, in 1977, the Graphical Language for Interactive Design (GLIDE) was established, including several components of BDS (Eastman & Henrion, 1977). GLIDE provides a picture, a form, and a spiral staircase model. GLIDE has been developed to include specific building components and is now used to verify the correctness of data used in cost estimation and structural design review. As a result of GLIDE's enhancements, the 2D drawings created are more consistent and accurate. However, BDS and GLIDE are confined to including construction stakeholders only during the