OPTIMISATION OF 4D (PROJECT TIMELINE) AND 5D (BUDGET ANALYSIS) IN BUILDING INFORMATION MODELLING (BIM) FOR HOUSE REFURBISHMENT AND RENOVATION

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FACULTY OF ENGINEERING
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ABSTRACT

The potential of 4D and 5D Building Information Modelling (BIM) have been proven to facilitate project timeline and budget analysis in construction industry, however the implementation of 4D and 5D BIM in house renovation and refurbishment is still underdeveloped especially in Malaysia. Therefore, this study was conducted purposedly to identify the advantages of 4D and 5D BIM, to analyse the level of awareness of 4D and 5D BIM implementation and to pave a proper strategy for house refurbishment and renovation using BIM in Malaysia. The method uses to achieve the objectives was questioners survey that was analyse using SPSS and modelling using Autodesk Revit for 3D model and Navisworks Manage for 4D and 5D BIM. The selected model is based on the two and a half storey terrace houses at Taman Bukit Sepangar Kota Kinabalu Sabah. This study manages to collect 45 responded from construction player. The results revealed that the significant advantages of 4D BIM are early simulation that will detect any clashes which usually lead to construction delay with mean rank of 4.36, 4D BIM could provide a clear walk through before the construction begin rated second with 4.22 mean rank and 4D BIM could serve as centralized data rated third with 4.20 mean rank. 5D BIM on the other hand will significantly contribute to faster and accurate quantity take off with scored of 4.40 mean rank, forecast early cost estimation and can improve collaboration between project stockholders on early stage of construction rated second and third with mean rank of 4.29 and 4.20 respectively. However, it is found that the level of BIM implementation in Malaysia currently is still low due to low BIM adoption and unreadiness of organization to adopt BIM. Thus, to carter this problem, it is suggested to set a standard of curriculum at higher institution to train and introduce what is BIM, provide subsidy for BIM software and provide training for construction players will significantly enhance BIM implementation.

ABSTRAK

PENGOPTIMUMAN 4D (GARIS MASA PROJEK) DAN 5D (ANALISIS BELANJAWAN) DALAM MEMBINA PEMODELAN MAKLUMAT (BIM) BAGI PEMBAIK PULIH DAN UBAHSUAI RUMAH

Potensi 4D dan 5D dalam Pemodelan Maklumat Bangunan (BIM) telah terbukti memudahkan garis masa projek dan analisis bajet dalam industri pembinaan, namun pelaksanaan 4D dan 5D BIM dalam pengubahsuaian dan pembaikpulihan rumah masih kurang dibangunkan terutamanya di Malaysia. Oleh itu, kajian ini dijalankan bertujuan untuk mengenal pasti kelebihan BIM 4D and 5D, menganalisis tahap kesedaran pelaksanaan BIM 4D dan 5D dan merintis strategi yang betul untuk baik pulih dan ubah suai rumah menggunakan BIM di Malaysia. Kaedah yang digunakan untuk mencapai objektif adalah tinjauan soal selidik yang dianalisis menggunakan SPSS dan pemodelan menggunakan Autodesk Revit untuk model 3D dan Navisworks Manage untuk BIM 4D dan 5D. Model yang dipilih adalah rumah teres dua setengah tingkat di Taman Bukit Sepangar Kota Kinabalu Sabah. Kajian ini berjaya mengumpul 45 maklum balas daripada pemain industri pembinaan. Hasil kajian menunjukkan bahawa kelebihan ketara 4D BIM adalah simulasi awal yang akan mengesan sebarang pertembungan dalam pembinaan yang biasanya membawa kepada kelewatan pembinaan dengan kedudukan min 4.36, BIM 4D boleh memberi gambaran yang jelas sebelum pembinaan bermula dengan kedudukan min kedua 4.22 dan BIM 4D boleh berfungsi sebagai data berpusat dengan kedudukan min ketiga 4.20. BIM 5D sebaliknya akan memberi sumbangan ketara dalam pengiraan kuantiti bahan yang lebih pantas dan tepat dengan skor 4.40 kedudukan min, meramalkan anggaran kos awal dan boleh meningkatkan kerjasama antara pemegang saham projek pada peringkat awal pembinaan yang diberi penarafan kedua dan ketiga dengan kedudukan min 4.29 dan 4.20 masing-masing. Walau bagaimanapun, didapati tahap pelaksanaan BIM di Malaysia pada masa ini masih rendah disebabkan penggunaan BIM yang rendah dan ketidaksediaan organisasi untuk menerima pakai BIM. Oleh itu, untuk menangani masalah ini, adalah dicadangkan untuk menetapkan standard kurikulum di institusi tinggi untuk melatih dan memperkenalkan apa itu BIM, menyediakan subsidi untuk perisian BIM dan menyediakan latihan kepada pemain pembinaan akan meningkatkan pelaksanaan BIM dengan ketara.

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AEC	Architecture, Engineering, and Construction
BIM	Building Information Modelling
BCA	Building and Construction Authority
CAD	Computer Aided Drawing
CIDB	Construction Industry Development Board
COBie	Construction Operations Building Information Exchange
CREAM	Malaysian Construction Research Institute
GSA	General Services Administration
HKIBIM	Hong Kong Institute of Building Information Modelling
HVAC	Heating, ventilation, and air conditioning
IFC	Industry Foundation Classes
JKR	Jabatan Kerja Raya
LOD	Level of Development
MEP	Mechanical, Electrical and Plumbing
MSC	The Multimedia Super Corridor
PWD	Public Works Department
SPSS	Statistical Package for Social Sciences
SME	Small Medium Enterprise

CHAPTER 1

INTRODUCTION

1.1 Background of study

New advancement has been recently adopted in the construction industry to facilitate the construction process efficiently. Traditionally, buildings and infrastructure were managed, designed, and built using 2D drawings and paper-based documentation (Georgiadou, 2019). The rapid growth and implementation of Building Information Modelling (BIM) have been referred to as a new paradigm Azhar, (2011) or most likely as the most promising evolution in the construction industry (C. M. Eastman et al., 2011). The architectural, engineering, and construction (AEC) field is widely seen as low productivity and efficiency as well as fragmented. However, the emergence of BIM tackles the need for a more articulate exchange of information among construction participants to address issues such as fragmented project delivery, excessive expenditure, compromised quality, and ineffective facility management of projects evident in the traditional method of procurement (Babatunde et al., 2020).

The potential applicability and benefits of BIM have been agreed upon by academicians and practitioners as it increases collaboration and maximizes productivity during the project life cycle. There are several interpretations of BIM by the previous researcher that illustrate the significance of BIM implementation. Ilhan & Yaman (2013) stated that in digital format, BIM is considered as a novel approach for managing building design and project data. It enables the sharing and interoperability of information across stakeholders. Alreshidi et al. (2017), on the other hand, stated that BIM enables collaboration between stakeholders at all phases of a building's lifecycle, allowing them to input, retrieve, update, or modify

information throughout the BIM process. Numerous studies have established the critical benefits of BIM implementation in increasing production and efficiency. BIM enables the integration of time and cost, enabling real-time updates and assessing the efficiency of tracking and monitoring processes throughout the project's phases (Jrade & Lessard, 2015; Scheer et al., 2014)

In building, renovation and refurbishment is the typical way of maintaining the excellent state of the facility to their users. According Farahani et al., (2019), building renovation purposedly controls deterioration and maintains building elements. For example, in the housing sector, maintaining their functionality is vital to serving their user from generation to generation. During the renovation and refurbishment of a building, the main concern is the complexity of concurrent use by users and workers and it is less likely to evacuate a building to carry out a single-phase renovation.

Additionally, there may be conflicts between the building workers and the occupants. To overcome these problems, renovations are frequently carried out in portions over various periods of time. As a result, the negative impact on tenants is minimized, and the remodelling work can proceed as planned (Damtew & Enday, 2019). On the other hand, during the renovation and refurbishment process, various decisions need to be taken. Considering the current condition of the building, multiple factors influence the type of renovation, such as the urgency with which the structure must be repaired, building age, and serviceability life of a building (Lee, 2012). Therefore, a proper strategy is crucial to assess a reasonable project timeline that directly affects the project cost. Visualization techniques such as 4D, project timeline, and 5D budget analysis BIM will facilitate the renovation process.

The implementation of 4D (project timeline) BIM is associated with the relationship between 3D modelling and scheduling information, while 5D (budget analysis) BIM is associated with project cost monitoring. The most common planer used in 4D BIM to recognize project schedules is CPM-based network and bar charts. Compared to the conventional method that uses a CPM network and 2D site layout, 4D BIM is proven to support site personnel efficiently to coordinate the space requirement of the equipment (Mahalingam et al., 2010). According to the study conducted by Russell et al. (2009), when it comes to enhancing traditional planning

via 4D modelling, visualization of construction processes received the highest score. To create 5D BIM, the existing model of 4D BIM was integrated, resulting in more sophisticated cost management services. Conventionally, the project cost, requirement, and material quantities were obtained by doing manual quantity take-off. This conventional method was prone to human error due to the interpretation of data manually while completing the task. However, the integration of 5D BIM enables the project team to provide more accurate cost and critical estimation information related to the model elements such as size, area, object family type, and productivity projection (Barnes & Davies, 2019). The BIM model incorporates digital data on 4D, and 5D BIM is expected to contribute to a holistic project life cycle.

Internationally, BIM deployment has reached a significant level in certain developed and developing countries. In countries such as Singapore, Sweden, Great Britain, and Finland, the government has reinforced BIM application towards public clients as part of project delivery (Lennartsson et al., 2018). In Malaysia's economy, the construction industry contributes approximately 3 to 5 percent of Gross Domestic Production (GDP) annually. The Malaysian Public Works Department (PWD) has adopted BIM and aims to use it on 10 percent of public projects under Rancangan Malaysia ke-11 (RMK11). Furthermore, at the beginning of 2018, BIM would be required for any public project with a budget of RM100 million or more. Unfortunately, based on the study conducted by Memon et al. (2014), while Malaysia BIM implementation meets the criteria during the design phases, it lags during the construction phase. BIM is used extensively throughout the design stage but not during construction. Thus, an extensive study regarding BIM implementation during construction stages focusing on the project timeline and budget analysis is needed as it is expected to benefit the project life cycle. The idea and concept of BIM 4D (project timeline) and 5D (budget analysis) in this study will be implemented in housing renovation and refurbishment. The study on BIM implementation for housing is still rarer, especially in Malaysia .Added to the fact by study conducted by Abanda et al. (2017) stated that the potential of BIM is more significant in industrialized house construction than in conventional construction methods. Additionally, research conducted in the United Kingdom indicates that industrialized house construction and BIM can increase productivity(Goulding et al., 2012).

1.2 Problem statement

The implementation of 4D (project timeline) and 5D (budget analysis) BIM in Malaysia is still far behind many countries, especially in Sabah. Despite the benefits that have been studied exhaustively and Sabah still needs more construction to develop, the application of BIM is still low. In fact, according to the results based on the study conducted by Memon et al. (2014b), the rate of BIM adoption in the construction sector was far behind, which needs attention and substantial efforts to achieve a profitable construction project. Therefore, the study to identify significant barriers are required

As Other country moves forwards toward BIM adoption in Architecture, Engineering and Construction (AEC) Industry, the construction industry in Malaysia rarely imposes BIM implementation in their project. Most of the construction players in Malaysia are still reluctant to change from conventional method to BIM. As shown in Figure 1.1 below, population growth in Malaysia is keep increasing. As this population increase the demand of producing house is also increase. Thus, an efficient construction method is crucial to facilitate in every construction phases.

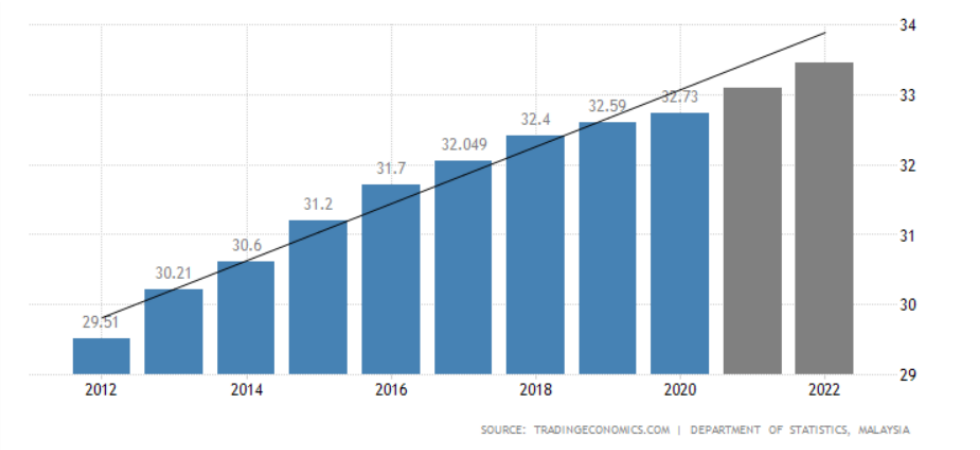

Figure 1. 1 : Malaysia population growth

Source : (Trading Economics, 2021)

The contributing factors that cause this scenario might be because they are still a limited number of studies investigate the benefits of BIM 4D/5D for housing refurbishment and renovation. In practice taking care of the full functionality is important to ensure the comfortability of occupancy. However, the process of renovation and refurbishment often face a lot of challenges since the construction was done in existing structure.

Furthermore, in Malaysia there is still a lack of skills, training, education, and investment for adopting BIM in housing development. The possible circumstances are higher educational institution are still lack in BIM exposure towards their student especially those that will work in construction industry.

1.3 Objectives

This study is purposedly conducted to study the implementation of 4D (project timeline) and 5D (budget analysis) to optimize housing renovation and refurbishment in the double storey and up to two-storey and half storey house. The objectives of this study are as follows:

a. To identify the advantages of 4D and 5D BIM for house refurbishment and renovation
b. To analyse the level of awareness of 4D and 5D BIM implementation for house refurbishment and renovation
c. To evaluate standard procedure and strategies for 4D and 5D BIM in Malaysia for house refurbishment and renovation

1.4 Scope of work

Building information modeling (BIM) is considered the new era of the Malaysian construction industry and is utilized infrequently. This new emerging technology will facilitate the construction with the digital representation of the building process (Baba, 2010). The application of BIM can be expanded into several dimensions, as claimed by Hassan & Yolles (2009). The usage of BIM is developed from 3D modeling to project timeline 4D, budget analysis 5D, and sustainable design, also known as green design 6D and facility management 7D. However, this study focuses on project 4D (project timeline) and 5D (budget analysis). Implementing these two dimensions of BIM mainly concentrates on the housing sector for renovation and refurbishment. The number of stories for the house is limited to two and two and a half storey houses, and the proposed location is a terrace house at Taman Bukit Sepangar Kota Kinabalu Sabah.

This research will be performed based on three methods. The first method is conducting a literature review regarding the benefits, challenges, and strategies of BIM implementation. As it is essential to specify specific boundaries in a literature review, journals were limited from 2000 to 2021. The medium used to access the journal was from the E-Resources by Universiti Malaysia database. The second method used is questionnaire distribution to collect the data from construction player regarding. The last method is simulation of 4D and 5D BIM for renovation and refurbishment based on the proposed area. The modelling tool that will be used is Autodesk Revit 2020 and Naviswork Manage 2020.

1.5 Significant of Study

This study is expected to significantly contribute towards increasing awareness and application of 4D (project timeline) and 5D (cost analysis) BIM in the construction

industry in Malaysia, especially in Sabah, by implementing 4D and 5D BIM in the housing sector. Among the significance of this study are:

1. Help the construction sector acknowledge the benefits of using BIM even though it requires a large amount of cost on the early implementation stage.
2. The implementation of BIM will enhance time and cost efficiency during construction.
3. There are some potentials that this study will assist the strategies of BIM implementation for housing renovation in future.

1.6 Project outline

In this study, the main highlight of BIM application is 4D, which is project timeline, and 5D, which is budget analysis. To successfully achieve the objectives of this study, this study was divided into three chapters: chapter 1 introduction, chapter 2 literature reviews, and chapter 3 methodology. For chapter 1, the introduction, what and why this study was conducted was explained, and a clear explanation about the purpose and significance of this study was briefly explained. Chapter 2, which is the literature review, contains the documentation of state of art with respect to the objectives of this study. The range of journal publications is set to be more prominent from 2000 to 2021 to obtain a clear development of BIM from all around the world and Malaysia. The medium chosen to collect this quantitative study is based on the provided E-Resources database by University Malaysia Sabah, such as ResearchGate, ScienceDirect, SpringerLink and Emerald Insight. Chapter 3, the methodology, explains how to conduct this study to achieve the objectives. The flow regarding conducting this study will be described further in this chapter. Chapter 4 is cantered by the data collected based on distributed questionnaires and modelling simulation. Chapter 5 is conclusion and recommendation based on the results and analysis in chapter 4.