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IMPROVING COST AND TIME CONTROL IN MALAYSIAN CONSTRUCTION INDUSTRY USING BUILDING INFORMATION MODELLING

MUHAMMAD, MUHAMMAD TAHIR

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By

MUHAMMAD, MUHAMMAD TAHIR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the degree of Master of Science

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Abstract of thesis presented to the senate of University Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

IMPROVING COST AND TIME CONTROL IN MALAYSIAN CONSTRUCTION INDUSTRY USING BUILDING INFORMATION MODELLING (BIM)

By

MUHAMMAD, MUHAMMAD TAHIR

SEPTEMBER, 2017

Chairman: **Nuzul Azam Haron, PhD**
Faculty: **Engineering**

Cost and time control in construction projects has been one of the most important issues in construction. A successful project should meet not only the quality output standards but also time and budget objectives. The management of cost and control of time are fundamental in every project. An effective cost and time management and control technique for construction projects is important in managing risk of cost overrun and delay in completion of projects. Construction projects are becoming more complex as they involve many stakeholders from different disciplines.

The emergence of Building Information Model (BIM) which is an alternative technology for management of construction projects is anticipated to be able to solve issues relating to project cost and time control. The aim of this research is to develop a framework strategy that can be used to control cost and time-related issues in the construction industry using BIM to reduce the frequency of occurrence of delays and cost overrun in Malaysia which are the main causes of disputes and abandonment of projects in the industry.

A mixed method of research design (qualitative and quantitative) was used in the data collection phase of the study to make enquires and to validate findings from the literature. The data obtained were analysed using content analysis, Cronbach's alpha test, descriptive statistics, Pearson's product moment correlation analysis, Pareto analysis, and Principal component analysis. The result from the Pareto analysis showed that "poor schedule and time control", "changes in scope of work", "poor budget and cost control", and "inaccurate estimates" are the most important factors that cause delays and cost overrun.

Similarly, the result from the principal component analysis showed that quantity take-off and estimation, clash detection and coordination, integration and collaboration of stakeholders, design and visualisation are the main application areas of BIM in Malaysian construction industry. The results of the study also showed that there is a negative relationship between the applications of BIM and the causes of delay and cost overrun, which means that an increase in BIM applications leads to a decrease in the occurrence of these causes of delay and cost overrun. The relationship was used as means for the development of the model which serves as a guide to contractors for improving control of cost and time in their various projects. The contribution of this research to the field of project management and Malaysian construction industry is that it identified the two most recent causes of delay and cost overrun each experienced by contractors in the construction industry. The study also provides a guide in the form of an improvement model for contractors and all key stakeholders in the industry on how to control cost and time in construction in order to mitigate the causes of delay and cost overrun in their various projects.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

MENINGKATKAN KOS DAN KAWALAN MASA DALAM INDUSTRI PEMBINAAN MALAYSIA MENGGUNAKAN MAKLUMAT BANGUNAN MODEL

Oleh

MUHAMMAD, MUHAMMAD TAHIR

SEPTEMBER, 2017

Pengerusi: **Nuzul Azam Haron, PhD**
Fakulti: **Kejuruteraan**

Kawalan kos dan masa dalam projek binaan telah menjadi salah satu isu yang paling penting dalam industri pembinaan. Projek yang berjaya bukan sahaja harus memenuhi hasil piawaian yang berkualiti tetapi juga memenuhi objektif masa dan bajet . Pengurusan dan kawalan kos serta masa dalam pembinaan adalah merupakan aspek asas dalam setiap projek. Kos yang efektif dan pengurusan masa serta kawalan teknik yang berkesan adalah penting dalam menguruskan risiko lebihan kos dan kelewatan menyiapkan sesuatu projek. Projek-projek pembinaan akan menjadi lebih kompleks disebabkan oleh penglibatan banyak pihak berkepentingan dari bidang yang berbeza. Kemunculan model maklumat bangunan (BIM) yang merupakan teknologi alternatif bagi pengurusan projek binaan dipercayai mampu untuk menyelesaikan isu-isu yang berkaitan dengan projek kawalan kos dan masa. Tujuan kajian ini adalah untuk membangunkan satu rangka kerja strategi yang akan digunakan untuk mengawal kos dan isu-isu yang berkaitan dengan masa dalam industri pembinaan dengan menggunakan BIM untuk menghapuskan atau mengurangkan kekerapan berlakunya kelewatan dan lebihan kos yang merupakan punca utama pertikaian dan pengabaian projek dalam sesebuah industri.

Satu kaedah campuran bagi rekabantuk penyelidikan (kualitatif dan kuantitatif) telah digunakan dalam fasa pengumpulan data kajian untuk membuat pertanyaan dan untuk mengesahkan penemuan daripada kesusasteraan. Data yang diperolehi dianalisis dengan menggunakan analisis kandungan, ujian alpha Cronbach, statistik deskriptif, analisis korelasi masa produk Pearson, analisis Pareto, dan analisis Komponen utama. Hasil daripada analisis Pareto menunjukkan bahawa "kelemahan penjadualan dan kawalan masa", "perubahan dalam skop kerja", "kelemalan kawalan bajet dan kos", dan "anggaran yang tidak tepat" adalah faktor yang paling penting yang menyebabkan kelewatan dan lebihan kos.

Keputusan yang sama diperolehi daripada analisis komponen utama menunjukan pengukuran kuantiti dan anggaran, mengenal pasti pertembungan dan koordinasi, integrasi dan kerjasama antara pihak berkepentingan, rekabentuk dan visualisasi adalah aplikasi utama kegunaan BIM di dalam industri binaan di Malaysia. Hasil kajian ini juga menunjukkan bahawa terdapat hubungan yang negatif di antara aplikasi BIM dan sebab-sebab kelewatan dan lebihan kos, yang bermaksud bahawa peningkatan dalam aplikasi BIM membawa kepada penurunan kepada punca kelewatan dan lebihan kos. Hubungan ini telah digunakan untuk pembangunan model yang berfungsi sebagai panduan kepada kontraktor untuk meningkatkan kawalan kos dan masa dalam pelbagai projek mereka. Sumbangan penyelidikan ini terhadap bidang pengurusan projek dan industri pembinaan Malaysia adalah dengan mengenal pasti dua punca terkini masalah dan lebihan kos pada setiap projek yang dialami oleh kontraktor dalam industri pembinaan. Kajian penyelidikan ini juga menyediakan panduan dalam bentuk penambahbaikan model untuk kontraktor dan semua pihak berkepentingan dalam industri mengenai bagaimana cara untuk mengawal kos dan masa dalam pembinaan untuk mengurangkan punca-punca kelewatan dan lebihan kos dalam pelbagai projek mereka.

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APPROVAL

I certify that a Thesis Examination Committee has met on (date of viva voce) to conduct the final examination of Muhammad, Muhammad Tahir on his thesis entitled "Strategies to Improve Cost and Time Control in Malaysian Construction Industry Using Building Information Modelling" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Helmi Zulhaidi bin Mohd Shafri, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Salihudin bin Hj Hassim
Associate Professor, Ir
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Kherun Nita Ali, PhD
Associate Professor
Department of Quantity Surveying
Faculty of Built Environment
Universiti Teknologi Malaysia
Johor, Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Nuzul Azam Haron, **PhD**
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Aidi Hizami Ales @ Alias, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
University Putra Malaysia

Date:

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I hereby confirm that:

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This is to confirm that:

- The research conducted and the writing of this thesis was under our supervision;
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Signature: _____
Name of Chairman
of Supervisory
Committee: Nuzul Azam Haron

Signature: _____
Name of Member
of Supervisory
Committee: Aidi Hizami Ales @ Alias

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CHAPTER 1

INTRODUCTION

This research starts with an introductory chapter. This chapter will introduce the background of this study, shed light on the relevance of the research problem, and to explain the relevance of this research. This chapter will also outline the research problem, research objectives, research questions, scope of the study, limitation of the study, and an insight into the research methodology. This chapter also outlines the thesis as a whole.

1.1 Background of the Study

Cost and time control in construction project has been one of the most important issues in construction since the emergence of the construction industry (Minchin Jr, Li, Issa, & Vargas, 2013). A successful project should meet not only quality output standards but also time and budget objectives. Time and cost performance are fundamental criteria's for the success of any project. However, it is very common in the construction industry that projects are rarely completed on time which is as a result of issues originating from ineffective cost and time controls (Forbes & Ahmed, 2010).

There are many definitions of project cost management and project time management in literature. According to Alzahrani and Emsley (2013), project cost management "is the process of planning and controlling the budget of a project, it is a form of management accounting that allows a project to predict impending expenditures to help reduce the chance of going over budget". Similarly, Westland (2006) defined project time management as the process of recording and controlling time spent by staff on the project.

More also, Kerzner (2013) referred to project cost and time control as an act of ensuring that projects are finished on time by constantly measuring progress, evaluation of plans, and taking appropriate actions on the project within the specified budget. Similarly, the project management body of knowledge (PMBOK) (2013) defined project cost and time as the process of monitoring the projects status to update project progress and manage changes to the cost and schedule baseline in other to achieve targeted objective.

Cost and time are two major concerns in managing construction projects (Rasdorf & Abudayyeh, 1991). Construction projects are becoming more complex as they involve many stakeholders from different disciplines. Most features of projects that give rise to delay and cost overruns do vary alongside with the project type, location, sizes, and scopes. Similarly, construction projects that are large in nature and scope are most times characterised by their complexity and capital demands.

The construction industry has many branches as it layers, and as such it contains so many information about a construction project. The information is very important to a project and can be the basic foundation for decision-making, procurement, collaboration, etc. Cost management starts at the initial stage with quantification, which takes a lot of time and is tedious in nature. Traditionally, the process is manually completed most times with high likelihood of human errors, the likelihood of error becomes more when preparing estimates for complex and large projects.

The management and control of cost and time in construction is fundamental to most projects. A study that was conducted on cost overrun by Chartered Institute of Building (CIOB) in 2008 reported that 90% of public works projects have issues associated with cost overruns (Flyvbjerg, Holm, & Buhl, 2012). Similarly, construction industries are flooded with high profiled projects globally that are faced with significant delays and cost overrun (P. Smith, 2014). This shows that delay and cost overrun are global issues. In Saudi Arabia, it was found out that only 30% of construction projects were completed within the scheduled completion dates and that the average time overrun was between 10% and 30% (Assaf & Al-Hejji, 2006). However, Malaysia a fast developing country in South-East Asia is not an exception from this global phenomenon. In 2005, about 17.3% government contract projects in Malaysia were considered sick for over 3 months of delayed work and abandoned (Shehu, Endut, & Akintoye, 2014).

The construction industry in Malaysia plays a vital role in its economic growth. It contributes 3-5% of the country's Gross Domestic Product (GDP) annually (CIDB, 2009). It offers job opportunities and increment to the people's quality of life by providing essential socio-economic infrastructures, such as offices, roads, houses, and schools. Malaysia is progressively marching towards industrialization and the construction industry role is been enhanced at the same time with the aim of bringing to reality the needs and aspiration of its population (Alaghbari, Razali, Salim, & Ernawati, 2007).

However, construction project delays and cost overruns are routine in Malaysian construction industry, leading to additional project costs and other negative effects (Enshassi, Al-Najjar, & Kumaraswamy, 2009). The industry, when compared to other industries in the country, has suffered approximately 20-25% decline in it productivity in the last few years (JBIM, 2007). More also, Malaysian construction industry is regarded as the industry facing poor performance leading to failure in achieving effective and efficient cost and time management (Ismail, Abdul Rahman, Memon, Karim, & Tarmizi, 2013; Rahman, Memon, Nagapan, Latif, & Azis, 2012).

The Chartered Institute of Building (CIOB) in 2008 has indicated that the quality of time-management on construction projects is generally poor (Purnus & Bodea, 2013). Therefore, an effective cost and time management and control technique for the construction project is important in managing risk of cost overrun and delayed completion of projects.

Presently, a number of tools that can be used for cost and time control have been developed (Mohd-Nor & Grant, 2014), some of which differ for their functions, and some are mostly designed for particular type of projects (Yamin & Harmelink, 2001). Tools such as Earned Value Management (EVM), Gantt Bar Chart, Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) were used for control of cost and time (John, 2003; Lester, 2003). More also, different software have been developed to assist in the use of these project control tools such as Microsoft Project, Primavera, Asta Power Project etc. Regardless of these tools and software packages, construction projects still suffer delays and cost overruns.

However for project cost and time control, the industry have put up lots of effort techniques considering only quantitative factors, but ignoring the qualitative factors (Zhang & Gao, 2013). A research conducted by CIOB in 2008 indicated that the growth in training, education and skill levels within the construction industry in the use of time management techniques has not kept pace with the technology available. The emergence of alternative technology is believed to solve or minimize the issues relating project cost and time control. Furthermore, it is also believed that the emergence of Building Information Model (BIM) can lead to greater efficiency by means of increasing collaboration (Zhang & Gao, 2013).

Aranda-Mena, Crawford, Chevez, and Froese (2009) stated that, "For some, BIM is a software application, for others it is a process for designing and documenting building information, for others it is a whole new approach to practice and advancing the profession which requires the implementation of new policies, contracts and relationships amongst project stakeholders."
A widely cited definition of BIM is provided by the US National Institute of Building Sciences (2007) which defined it as "a digital representation of physical and functional characteristics of a facility, and 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".

Similarly, the McGraw-Hill (2009) "The Business Value of BIM" Report (2009), a commonly referenced document by contractors, defines BIM as, "the process of creating and using digital models for design, construction and operations of projects." This report mainly defines the contractors' perspective in defining BIM. A clear definition of the term Building Information Model (BIM) must be established prior to discussions on it further.

For the purpose of this research, the definition credited to the National BIM Standard (NBIMS) Project Committee of the Building SMART alliance (2010) will be adopted, which defines it as, "a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward. The BIM is a shared digital representation founded on open standards for interoperability" (Succar, 2009).

Building Information Model (BIM) is an alternative approach to construction design, it does not only make easier the digital representation for designs but it also comes up with all the necessary information for any project before it is constructed. Not only is BIM an innovative design tool, it may basically alter the way a construction project is procured, constructed, managed and maintained (Xiao & Noble, 2014). The information in BIM models is very useful and can be analysed to optimize the design, planning and construction processes (Azhar, 2011). BIM is a technologically enhanced approach that enhances digital representation, storage, management, and sharing of building information in a way that allows access to the projects database throughout its lifecycle (Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013).

According to Bryde, Broquetas, and Volm (2013), BIM is an appropriate tool for project managers and should be considered by the project management profession as a way to help manage construction projects. BIM has been so far proved to be a beneficial technique in the construction industry, which has allowed it users in reducing uncertainties and achieving successful completion of a project (Enegbuma, Ologbo, Aliagha, & Ali, 2014).

BIM can be applied on all the stages of construction processes starting from planning to operation and maintenance. Major advantages of BIM are improved scheduling, improved drawing coordinated, controlling time and cost and single detailed model (Memon, Rahman, Memon, & Azman, 2014).

1.2 Problem Statement

The Malaysian construction industry contributed 10 to 12 percent to the national gross domestic product (GDP) in the fourth quarter of 2015 in Malaysia (D.O.S, 2016). Increasing construction sector productivity also means employing modern construction technologies, such as improved and increased mechanisation in technologies such as Building Information Model and Industrialised Building Systems. Similarly, the labour productivity of the construction sector is expected to rise to RM61,939 per worker by 2020 from RM39,116 in 2015. It therefore becomes very necessary that skills are improved and intensify to raise productivity that can handle more sophisticated building methods (CIDB, 2016).

The construction industry drives the economic growth and development in Malaysia, but unfortunately, its projects often suffer from delays and cost overruns. The construction industry in Malaysia faces lots of issues from cost and time overruns that transform what should have been successful projects, into those projects incurring additional costs, disagreements, litigation and in some cases abandonment (Kaming, Olomolaiye, Holt, & Harris, 1997; Ofori, 1991, 1993; Ramanathan, Potty, & Idrus, 2012; Shehu, Endut, & Akintoye, 2014; Ting, Khoo, & Wong, 2009). A study on 359 projects estimated to cost billions of Ringgit was conducted in Malaysia in 2009, it found out that only 42 percent out of the total projects were completed on time and within budget (Endut, Akintoye, & Kelly, 2009). This shows a deficit of 58 percent been delayed and incurring more cost.

According to studies conducted on delays and cost overrun in Malaysian construction industry projects, time and cost performance is an important issue that need to be addressed in the construction industry (Alaghbari et al., 2007; Bazjanac, 2006; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Shehu et al., 2014; Ting et al., 2009).

As a result of this, there is a demand for the use of a more advanced technology to manage projects information all through its life cycle. Presently, it is anticipated that the emergence of Building Information Model (BIM) can lead to greater efficiency by means of increased collaboration in the industry (Zhang & Gao, 2013).

According to the chief executive officer of CIDB, Datuk Ahmad Asri Abdul Hamid, "property developers will be mandated to use BIM by 2020 for their construction works" (Růžku, 2016). However, BIM as an alternative technology in Malaysia needs to be studied to provide proof that is can satisfy the industry's need to improve on cost and time control. The BIM maturity level appreciation in Malaysia with regard to increasing demand for efficiency and competitive advantages is been hindered by several factors (binti Ali & Boon, 2013) which includes low research on applications of BIM in management of construction projects. It is also important to further find out how cost and time control can be improved using BIM technology.

1.3 Research Questions

The research questions for this study which were identified from the statement of problems and background of the study are three (3). These questions are directed to address the issues with regards to improving cost and time control using BIM technology in the management of construction projects. This research seeks to answer the following questions:

i. What are the main causes of delay and cost overrun in Malaysian construction industry?
ii. What are the application areas of BIM in management of construction delays and cost overrun?
iii. What type of framework can be used, using BIM technology to improve cost and time control in construction projects?

1.4 Research Objectives

The aim of this research is to study how cost and time control can be improved in construction industry upon the use of BIM technology. To achieve the aim of this study, the following specific objectives have been defined:

1. To determine and rank the different causes of delay and cost overrun in Malaysian construction industry.
2. To identify the main application areas of BIM in the management of construction delays and cost overrun.

3. To develop a framework that can be used to improve cost and time control using BIM in Malaysia.

1.5 Significance of the Study

Building information model is changing the construction industry to a high productivity and high technology driven industry (Succar, 2009). Similarly, BIM has a great potential to be used by all the major stakeholders involved in a construction project. BIM technology can be used by the client to know the needs of the project, the design team make use of it to design, analyse and develop the project, and the contractor makes use of it to manage the construction phase of the project and finally by the facility manager for operation and maintenance of the project.

This research is significant as it is just in time in Malaysia and only few researches have been done to know the applications of BIM in the management of construction projects in Malaysia. This research is intended to investigate how BIM can be used to improve project cost and time control through a mixed method of enquiry. Another significance of this study is that at the end of the research, a new strategy will be developed to help improve on cost and time control in construction using BIM technology. This will serve as a guide for the construction industry stakeholders for the adoption of the technology to control cost and time related issues. At the end of the research, the result is expected to benefit all the stakeholders in the construction industry especially the contractors and project management practitioners through the provision of an insight on the barriers to cost and time control and how to solve the issues using BIM technology in Malaysia.

1.6 Scope of the Study

This research is primarily concerned with an investigation into the causes of delay and cost overrun in construction and the applications of building information model (BIM) in the management of construction projects. The causes of delay and cost overrun were investigated, analysed and ranked to know those that occur more often in the construction industry. Data for this study were obtained using questionnaire from construction company contractors with G7 rating who are members of CIDB in Selangor and Wilayah Persekutuan (Klang Valley).

The study also investigates the applications of BIM in construction industries in managing projects. Data for this investigation were obtained from architects, engineers, BIM coordinators, and project managers who are experts and have knowledge of BIM. The result from both of the investigation was used in drawing conclusion on recommending the strategies that will be used to improve the control cost and time in construction industries using BIM technology.

1.7 Content of the Thesis

The current research study is organized into five chapters as shown in the table below:

Table 1.1: Content of the thesis

Chapter	Content
Chapter one	An introductory chapter which introduces and outlines the background and approach to the research questions and the overall objectives of the thesis.
Chapter two	The relevant literature review is performed in this chapter which presents the theoretical framework of this research. In this chapter, the researcher discussed the information known prior to research and narrows it down to pinpoint the main focus areas of this study.
Chapter three	Methodological framework, identifies the most appropriate research methodology, detailing its design and strategy for data collection and method of data analysis. The researcher will make use of it answer the research questions.
Chapter four	The discussion, illustration of data collected, analysis and findings, themes that emerged from each of the interview and also the illustration of how the findings are relevant to answer the research questions.
Chapter five	The conclusion from the finding of the research study and recommendations for further research.

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