A MODEL OF AN EFFECTIVE MATERIALS MANAGEMENT FOR BETTER PROJECT PERFORMANCE IN CONSTRUCTION INDUSTRY

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DEDICATION

With the grace of the Almighty ALLAH SWT,

I dedicate this thesis to

My beloved father (Mat Jusoh Bin Ibrahim), my mother (Kamariah Binti Salleh) and siblings,

For your love, prayer, care and encouragement.

My supervisor,

For your help, encouragement and guidance to ensure the success of this thesis.

All friends,

For your help and encouragement.

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ABSTRACT

Materials management plays a significant role in the success of every construction project. However, as a result of ineffective materials management, construction projects have been plagued by poor performances namely time overrun, cost overrun, compromised quality, low productivity and wastage. Thus, to mitigate these issues and concurrently enhance project performance, an effective materials management appears to be a viable solution. Nonetheless, literature review have further highlighted various issues and challenges with materials management implementation in terms of the limited exploration of the factors associated with effectiveness, lack of recognition on its relationship with project performance, and therefore, depicting the need for a new model that incorporates all aspect of materials management. Hence, this study aimed at exploring the factors associated with effective materials management and developing a model as a mechanism to improve this management effectiveness. The quantitative method adopted for data collection involved a survey of 202 practitioners using structured questionnaires. The results of the univariate analysis via SPSS ranked the influential and effect factors. Meanwhile, multivariate analysis using Partial Least Square Structural Equation Modelling (PLS-SEM) technique via SmartPLS 3 tested the relationship between the exogenous construct (influential factors of effective materials management) and endogenous construct (effect factors of project performance). Findings revealed that effective materials management (i.e. transportation, management, purchasing, expediting, site storage and condition, contractual, governmental interference and suppliers) has a significant effect on project performance (i.e. waste, cost, time, productivity and quality). The findings from both analyses were used to develop an effective materials management model for better performance in construction projects. The developed model was evaluated by 28 practitioners to provide feedback on the model's usability and usefulness. This research model reflects the associated factors in a holistic view as well as integrated

all the processes in materials management supply chain that would contribute in enhancing materials management effectiveness. This model also has the capability of assisting in the decision-making process by facilitating an understanding of the influential and effect factors of effective materials management. In conclusion, effective materials management should be implemented in order to enhance better project performance.

ABSTRAK

Pengurusan bahan binaan memainkan peranan penting dalam kejayaan setiap projek pembinaan. Walau bagaimanapun, akibat daripada pengurusan bahan binaan yang tidak efektif, maka berlaku kelemahan prestasi projek pembinaan dari segi lebihan masa dan kos, kualiti yang terjejas, produktiviti yang lemah, dan pembaziran. Oleh itu, bagi menangani isu tersebut dan seterusnya meningkatkan prestasi projek, pengurusan bahan binaan yang efektif dilihat berkemampuan sebagai satu kaedah penyelesaian. Namun begitu, sorotan literatur mendapati pelbagai isu dan cabaran berhubung pelaksanaan pengurusan bahan binaan yang efektif seperti; penerokaan faktor penyumbang kepada tahap efektif yang terhad, perkaitan di antara pengurusan bahan binaan yang efektif terhadap prestasi projek juga kurang diperakui, dan keperluan terhadap model baru yang menggabungkan semua aspek di dalam pengurusan bahan binaan. Oleh demikian, kajian ini bertujuan meneroka pelbagai faktor berkaitan dengan pengurusan bahan binaan yang efektif dan membangunkan model faktor sebagai satu mekanisma untuk meningkatkan pengurusan bahan binaan. Kaedah kuantitatif melalui pengedaran soal selidik berstruktur kepada 202 pengiat industri pembinaan telah digunakan bagi pengumpulan data. Analisis *univariate* dilakukan melalui SPSS bagi memperolehi kedudukan faktor-faktor yang mempengaruhi dan memberi kesan terhadap pengurusan bahan binaan yang efektif. Manakala, analisis *multivariate* menggunakan teknik *Partial Least Square-Structural Modelling* (PLS-SEM) melalui SmartPLS 3 telah dilakukan untuk menguji hubungan antara konstruk *exogenous* (faktor-faktor pengumbang kepada pengurusan bahan binaan yang efektif) dan konstruk *endogenous* (faktor-faktor yang memberi kesan terhadap prestasi projek). Hasil dapatan daripada analisis ini menunjukkan pengurusan bahan binaan yang efektif (iaitu pengangkutan, pengurusan, pembelian, pengagihan, tapak penyimpanan dan keadaan tapak, kontraktual, penglibatan kerajaan, dan pembekal) mempunyai kesan penting terhadap prestasi projek (iaitu pembaziran, kos, masa,

produktiviti dan kualiti). Melalui kedua-dua analisis *univariate* dan *multivariate*, hasil dapatan yang diperolehi digunapakai bagi membentuk sebuah model pengurusan bahan binaan yang efektif untuk mencapai prestasi projek pembinaan yang lebih baik. Model yang dibentuk ini telah dinilai oleh 28 pengiat industri pembinaan bagi mendapatkan maklumbalas berkenaan kebolehgunaan dan kegunaan model yang dibangunkan. Model yang dibangunkan menunjukkan faktor-faktor yang berkaitan secara holistik serta bersepadu dengan merangkumi segala aspek dalam pengurusan bahan binaan, sekaligus ia bakal menyumbang dalam meningkatkan pengurusan bahan binaan yang efektif. Ianya juga berkemampuan dalam membantu pengiat industri untuk membuat keputusan dengan memahami faktor-faktor yang mempengaruhi dan memberi kesan kepada pengurusan bahan binaan yang efektif. Secara kesimpulannya, pengurusan bahan binaan yang efektif perlu dilaksanakan bagi meningkatkan prestasi projek pembinaan.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AVE	-	Average Variance Extracted
BOT	-	Built, Operate & Transfer
CAC	-	Cumulative Actual Cost
CBC	-	Cumulative Budgeted Cost
CB-SEM	-	Covariance-based Structural Equation Modelling
CCTV	-	Closed-Circuit Television
CEV	-	Cumulative Earned Value
CIDB	-	Construction Industry Development Board
CITP	-	Construction Industry Transformation Programme
CR	-	Composite Reliability
EFA	-	Exploratory Factor Analysis
EFQM	-	European Foundation of Quality Management
EPCC	-	Engineering, Procurement, Construction & Commissioning
ERP	-	Enterprise Resource Planning
EVA	-	Earned Value Analysis
GDP	-	Gross Domestic Product
GPS	-	Global Positioning System
GPRS	-	General Packet Radio Service
HK	-	Hong Kong
HOC	-	Higher-Order-Component
HTMT	-	Heterotrait-Monotrait Ratio
IBS	-	Industrialised Building System
ICT	-	Information and Communication Technology
JIT	-	Just In Time
KMO	-	Kaiser-Meyer-Olkin
LAD	-	Liquidated Ascertained Damaged

LOC	-	Lower-Order-Component
MRP	-	Materials Requirement Planning
NIOBMM	-	Nigerian Institute of Building and Materials Management
PAM	-	Pertubuhan Arkitek Malaysia
PCA	-	Principal Component Analysis
PLS-SEM	-	Partial Least Square-Structural Equation Modelling
PWD	-	Public Work of Department
RFID	-	Radio-Frequency Identification
SEM	-	Structural Equation Modelling
SPSS	-	Statistical Package for Social Sciences
TBC	-	Totalled Budgeted Cost
TQM	-	Total Quality Management
UK	-	United Kingdom
USA	-	United States of America
UTHM	-	Universiti Tun Hussein Onn Malaysia

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter introduces and presents an overview of the research. Firstly, an overview of the research background is discussed, followed by the research problem, and thereafter the research questions, research objectives, research limitation as well as the significance of the study. The chapter also highlights the research methodology adopted and lastly, describes the structure of this thesis.

1.1 Research Background

Construction materials contribute significantly to the cost of construction projects and represent the highest part of investments in construction resources (Dakhli & Lafhaj, 2018; Elghaish *et al.*, 2018). It has been established that the cost of construction materials in a typical contract ranges between 40% to 70% of the total amount of project cost (Formoso & Revelo, 1999; Fang & Ng, 2011; Okorocha, 2013b; Arijeloye & Akinradewo, 2016; Kulkarni, Sharma & Hote, 2017). In a prior study conducted by the Construction Industry Institute (CII), it was reported that 50% to 60% of project cost comprises of construction materials and installed equipment (Ibn-Homaid, 2002; Caldas *et al.*, 2014). According to Wan & Kumaraswamy (2009), the percentage is much higher for the specialist contract as it includes the cost of mechanical and electrical equipment that need to be installed. Hence, the contribution of construction materials to project cost is diverse depending on the type of construction contract.

In Malaysia, the Construction Industry Development Board (CIDB) reported that the value of construction projects for the year 2016 was RM 229,025.74 million

(CIDB, 2017). Given the aforementioned proportion, the contribution of materials cost to current projects value, accounts for a huge amount ranging from RM 91,610.30 million to RM 148,866.73 million. Since materials attribution entails a huge amount of money, managing construction materials requires attention from the key players in the construction industry especially contractor organisations.

Apart from the contribution to project cost, managing materials are one of the most important elements in project management. Previous studies reported that the successful completion of every construction projects relies on having a proper resource which includes materials, equipment and labours at the appropriate time (Abdul Rahman, Memon & Abdul Karim, 2013a; Barry, Leite & O'Brien, 2014; Zavadskas *et al.*, 2014; Reddy, Nagaraju & Salman, 2015). Evidently, numerous studies have also revealed that shortage and non-availability of materials at the appropriate time as well as poor materials management are among the issues that lead to time overrun, cost overrun, compromised quality, low productivity and wastage in construction projects (Majid & McCaffer, 1998; Frimpong, Oluwoye & Crawford, 2003; Enshassi *et al.*, 2007; Abd El-Razek, Bassioni & Mobarak, 2008; Hatmoko & Scott, 2010; Singh, 2010; Ahmadian *et al.*, 2015; Abas *et al.*, 2016).

Similar to the above findings, local construction projects are not an excepted from these issues. For instance, a study by Abdul Kadir *et al.* (2005) revealed that shortage of materials was the most important factor that affects the labour productivity and this shortage frequently occurred at the site. Zeb *et al.* (2015) affirmed that the shortage of materials is very common for construction projects in developing countries. Furthermore, findings from a study conducted by Abdul Rahman *et al.* (2013a) revealed that the shortage of materials was ranked third among the factors causing cost overrun. According to a study by Sambasivan & Soon (2007), materials related category was ranked first in causing a delay in project execution, while a study by Alaghbari *et al.* (2007) indicated that materials shortage was ranked fifth in causing delay to local construction projects. Also, studies related to waste generation in local construction projects reported that poor materials handling is among the top causes contributing to wastage (Hassan *et al.*, 2012; Abdul Rahman & Nagapan, 2015). In summary, the above-mentioned findings reflect that disruption of and poor materials management occur in both global and local construction projects and these have implications on the project performance.

Meanwhile, Navon & Berkovich (2006) pointed out that construction projects have the tendency to become unsuccessful due to poor materials management. Therefore, for these reasons, several authors affirmed that an effective materials management is the essence for the success of any construction projects (Berka & Conn, 1994; Stukhart, 1995; Kini, 1999; Assaf & Al-Hejji, 2006; Meeampol & Ogunlana, 2006; Patil & Pataskar, 2013; Abdul Rahman *et al.*, 2013a; Othman, Napiah & Potty, 2014; Safa *et al.*, 2014; Patel, Pitroda & Bhavsar, 2015; Arijeloye & Akinradewo, 2016; Naoum, 2016; Ezhilmathi & Shanmugapriya, 2017; Kulkarni *et al.*, 2017; Patare & Minde, 2017; Liu & Lu, 2018; Sinesilassie, Tabish & Jha, 2018). Indeed, effective materials management is a vital component to ensure the availability of materials, and it has significant implications for the success of every construction projects.

Likewise, the benefits of utilising effective materials management in a construction project have been widely acknowledged (Safa *et al.*, 2014; Thunberg & Persson, 2014). Among the benefits that have been highlighted are saving time, saving cost, minimising waste, increased productivity, and improved quality performance (Al-Otaibi, 1995; Stukhart, 1995; Ekanayake & Ofori, 2004; Kasim, 2011a; Hannure & Kulkarni, 2014; Safa *et al.*, 2014; Kokubu & Kitada, 2015; Arijeloye & Akinradewo, 2016; Lu *et al.*, 2016; Naoum, 2016; Ambrin & Arulselvan, 2017; Dakhli & Lafhaj, 2018; Liu & Lu, 2018). More importantly, several studies have proven these benefits to construction projects by quantifying them in term of cost saving, time-saving as well as productivity improvement (Bell & Stukhart, 1987; Thomas, Sanvido & Sanders, 1990; Agapiou *et al.*, 1998; Thomas, Riley & Sanvido, 1999; Strandberg & Josephson, 2005; Ekeskär & Rudberg, 2016). Therefore, it is apparent that effective materials management has a significant impact on time, quality, cost, waste and productivity performance of construction projects.

Apart from that, since the strategic thrust of environmental sustainability in the Construction Industry Transformation Programme (CITP 2016-2020) is about the issue of excessive construction waste, therefore, it appears that environmental sustainability is also related with materials management. This is because among the initiatives of this thrust are sustainable practices and improved construction waste management practices. In relation to this, the type of construction materials need to be considered while designing energy-efficient buildings and the benefit in reducing the procured materials by improving waste management practices will be evident (CIDB, 2015; Heeren & Hellweg, 2018). More importantly, the problems occur in local

materials management practices have been cited as partly the cause of the issue of wastage as well as contributor to poor project performance (Abdul Kadir *et al.*, 2005; Alaghbari *et al.*, 2007; Sambasivan & Soon, 2007; Hassan *et al.*, 2012; Abdul Rahman *et al.*, 2013a; Abdul Rahman & Nagapan, 2015). Therefore, an effective materials management may seem viable as potential solutions to mitigate these issues and concurrently enhance better performance.

However, despite the importance and contribution of materials management to the success of construction project, this area has been neglected and given less attention from academicians and researchers (Al-Otaibi, 1995; Kini, 1999; Navon & Berkovich, 2006; Donyavi & Flanagan, 2009; Singh, 2010; Okorocha, 2013a). As a consequence, many topics related to materials management are not covered such as information management, information technology, restriction of materials management risk as well as uncertainty, supply chain management and integration system (Thomas, Riley & Messner, 2005). Similarly, the local context also reflected the same scenario as only a few literatures in this area had been discussed over the past years (Abdul Rahman & Alidrisyi, 1994; Kasim & Ern, 2010; Kasim, 2011a; Mustapa *et al.*, 2012; Sahari, Tinggi & Kadri, 2012; Liwan, Kasim & Zainal, 2013). Due to limited literature, Abdul Razak *et al.* (2010) stressed that very little research had been carried out on the problems faced by the local construction industry. Indeed, materials management has become an interesting area of research as it requires substantial improvement to the local construction industry (Othman *et al.*, 2014). Therefore, this research is aimed at developing a mechanism for enhancing the effectiveness of materials management implementation in construction projects.

1.2 Problem Statement

Materials management issues are a worldwide problem (Naoum, 2016). These management issues occur as a result of several factors. Research literature (Thomas *et al.*, 2005; Nwachukwu & Emoh, 2010; Rivas *et al.*, 2010; Ren, Anumba & Tah, 2011) has revealed that problems associated with materials management are partly responsible for and contributes to poor project performance. According to Barry *et al.* (2014), the association of materials management with poor project performance has been raised as a concern within the construction industry. In the context of local

construction projects, the problems that have been reported include; delay in materials delivery, delay in materials purchasing, delay in informing materials specification by the site manager, lack of up-to-date materials inventory, inefficient documentation, delivery of wrong materials, poor handling of materials, coordination problem with suppliers, late supply of materials from the market, shortage of equipment, incorrect ordering and improper materials storage (Abdul Rahman & Alidrisyi, 1994; Abdul Kadir *et al.*, 2005; Alaghbari *et al.*, 2007; Sambasivan & Soon, 2007; Kasim & Ern, 2010; Nagapan, Abdul Rahman & Asmi, 2012; Liwan *et al.*, 2013; Abdul Rahman, Memon & Abdul Karim, 2013b; Othman *et al.*, 2014). As such, several authors asserted that these problems arise mainly because of ineffective materials management (Frimpong *et al.*, 2003; Thomas *et al.*, 2005; Hatmoko & Scott, 2010; Lu *et al.*, 2016; Naoum, 2016).

Alternatively, other authors have opined that many of the above-mentioned problems could be mitigated through an effective materials management implementation (Abdul Rahman & Alidrisyi, 1994; Fang & Ng, 2011; Kasim *et al.*, 2012; Sardroud, 2012; Okorocha, 2013b; Safa *et al.*, 2014; Fadiya *et al.*, 2015; Ekeskär & Rudberg, 2016; Kulkarni *et al.*, 2017). Therefore, there have been research efforts conducted to overcome these problems by introducing automated systems, automated models, integrated computer systems and technological as well as information and communication technology (ICT) implementation for materials tracking such as radio-frequency identification (RFID), barcode, global positioning system (GPS), general packet radio service (GPRS), closed-circuit television (CCTV) and so on (Song *et al.*, 2005; Navon & Berkovich, 2006; Ren *et al.*, 2011; Sardroud, 2012; Ma, Liu & Zhang, 2013; Safa *et al.*, 2014; You *et al.*, 2017; Elghaish *et al.*, 2018). Additionally, one of the suggested improvements that have been proposed is the use of a mathematical algorithm model. For example, a study conducted by Alanjari, Razavialavi & AbouRizk (2014), an algorithm designed to optimise materials layout in a construction site was introduced. Similarly, Zou (2012) suggested a mathematical model to improve inventory ordering. However, despite these improvement efforts, previous studies have highlighted several concerns related to the affordability/cost of technological equipment, the capabilities of the systems in complex construction projects, the uncertainty of return on investment, the competency of staffs and the challenges to practice the suggested mathematical algorithm model (Al-Otaibi, 1995; Back & Bell, 1996; Formoso & Revelo, 1999; Ibn-Homaid, 2002; Kasim, 2011a; Sardroud, 2012;

Ma *et al.*, 2013; Elghaish *et al.*, 2018). More importantly, the concerns that have been pointed out appears to be significant in the local context of materials management. This is because findings from previous studies conducted by Abdul Rahman & Alidrisyi (1994), Kasim & Ern (2010), Mustapa *et al.* (2012) and Liwan *et al.* (2013) indicated that ICT implementation in local materials management practice was still at an infancy stage, and the current practice of materials tracking is done manually. Therefore, the above-suggested improvements seem to have a major drawback in implementation across the local construction industry because the recommendations are for materials management practices to be integrated with technology tools, and these pose a challenge for the local construction industry as current local practices are limited in terms of technological exposure.

Hence, more effective and easily integrated materials management approaches are solicited for. Thus, it becomes crucial that an inquiry into the contributory factors for effective materials management be undertaken. According to Majid & McCaffer (1998) and Chan, Scott & Lam (2002), identifying these factors is an essential step to discover the appropriate solution. Besides, Kasim (2011a) highlighted that because this challenge exists for local materials management practices, an opportunity to explore more about its effective implementation has been created. As a result of the importance of the factors identified for effective materials management, technology integration and implementation is still too preliminary because current practices are done manually, and the challenge to use mathematical model may be cumbersome in the local context. Therefore, a factors model of effective materials management may become a viable mechanism for enhancing effective materials management implementation in the local construction industry.

Furthermore, several studies have pointed out that there is a need for a model that is detailed, explicit and incorporates all aspect of materials management (Ibn-Homaid, 2002; Choure & Apte, 2015). Moreover, a factor model of effective materials management that constitutes all aspect of materials management has not yet been established. Consequently, the absence of a model that integrates all aspect of materials management and reflect their effect towards project performance might hinder improvements in materials management. Therefore, the purpose of this research is to propose a factor model of effective materials management as a means of filling the identified gap in knowledge.

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